INTEGRATING COMPUTERS INTO THE DESIGN STUDIO
A CRITICAL EVALUATION

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ABSTRACT
This paper presents a critical evaluation of two years of experience in using computer aided design as the primary graphic tool in an architectural design studio. In addition to significant benefits being realized, it was found that in a number of circumstances the graphic tool seemed to place unnecessary or inappropriate constraints on the designer. A critical examination of this tendency revealed that there may be a discrepancy between the theoretical framework in which computer aided design systems are developed and used, and the conceptual framework of contemporary architectural thought. These issues arising from the studio experience, are discussed and placed within the context of current theoretical concerns in architecture.

INTRODUCTION
The Faculty of Environmental Design at The University of Calgary has been involved with computer applications in architecture for the past fifteen years. Like most schools the majority of the work completed during this time was highly research oriented and involved relatively few students, most at a very senior level. In the past five years, again following the trend of most major architectural schools, there has been a concerted effort to move the computer out of the lab and into the mainstream of the architecture curriculum, introducing the computer to a wider audience at a more junior level. In the past two years, three architectural studios comprising some fifty students have been conducted using computers as the primary graphic tool.

The studios in which computer aided design was used were comprised of approximately fifteen junior level students and undertook projects of medium programmatic complexity. Prior to beginning the studio all of the students had completed an introductory computing course with minor training in computer graphics. ANVIL, a powerful but rather antiquated three dimensional boundary representation package, was used on a HARRIS minicomputer. Students had access to six graphic workstations and a 36 in. plotter.
Three dimensional site models were prepared on the system and a copy given to each student onto which proposals were modelled. Over the course of the term schematic design, design development, as well as interim and final presentations were completed on the computer. Desk crits were either at the screen or with hard copy output.

The ratio of three students for each terminal necessitated that a certain amount of design be done away from the computer. This developed into a working method in which design alternatives could be traced over orthogonal, axonometric, or perspectival hard copy. Selected changes could then be made to the computer model and another set of drawings produced. Final and interim presentations were produced by tracing or direct coloring of hard copy.

This paper presents a critical evaluation of the experience gained from these three studios. A number of significant issues have arisen as a result of integrating this technology with the concerns of architectural design and the implications that these issues bring forth have had a major impact on the future development and use of computer aided design within our faculty.

EVALUATION

The studios were, in general, favorably regarded by both students and the majority of faculty. The advantages gained from creating a three dimensional model instead of a series of discrete drawings was seen as the most positive result. This promoted a greater awareness, and resolution, of the inter-relationship between the various orthogonal views and produced a much 'tighter' final project. There was also an increased degree of three dimensional exploration for students at a junior level.

From a teaching standpoint, conducting the studio on a computer graphics system afforded several advantages. First, was the ability to standardize the site information used by each student. Not only was there a great time saving achieved by placing in each student's file a copy of the three dimensional site model, it also seemed to encourage students to incorporate the site much more readily into their earliest design ideas. Another major benefit was found by conducting individual criticisms at the computer screen. The ability to easily change viewpoints, to look at the project in its entirety or in a specific area, seemed to greatly enhance both the efficiency and effectiveness of the criticism. In addition, with faculty able to request specific views there was less opportunity for the students to focus too much on one particular aspect of the project.

Finally there was general agreement that the use of computer aided design was more efficient than more traditional methods, notwithstanding the considerable amount of time required to get sufficiently familiar with the system. In particular, there was
considerably more time available for design as the time expenditure to prepare for interim and final presentations was greatly reduced.

Of the negative aspects encountered during the studio, a number were anticipated as an unavoidable, but temporary, consequence of mounting a studio course of this kind. The most common were the usual complaints about scheduling of machines, storage capacity limitations, and a host of technical problems that arise whenever computers are used extensively by non-computer specialists.

There were also considerable difficulties encountered in the training and actual use of the machines. It was found that it took approximately fifty hours of instruction and practice to become familiar enough with the system to be able to do useful work. Although the majority of the students were willing to put in this extra time, the time constraints already present in a design studio precluded the effective training of the students in this time slot. It was found that initial instruction was best given prior to the commencement of the actual studio, complemented by additional, more specialized training as required during the actual execution of the project. However, even with sufficient experience most students noted difficulties, ranging from mild to severe, with the interface between designer and machine and the clumsiness with which graphic ideas must be input. It was noted that satisfaction levels increased significantly when activity was predominantly revision and alteration of an existing model.

The difficulty with modelling procedures led, in certain circumstances, to students simplifying their ideas to facilitate their input into the computer. It was also noted that there was a tendency for students to work by resolving specific areas or problems as discrete entities without regard for the whole. Thus there was a tendency for the solutions to be less integrative and more episodic than had been anticipated given the computer's ability to model projects in their three dimensional entirety.

In retrospect, the technical difficulties and many of the training problems could be attributed to systemic weaknesses within the faculty. The acquisition of more workstations running higher generation software and the tailoring of the introductory computing course to better prepare students entering the studio should significantly reduce most of these problems.

However, in addition to these difficulties, another set of issues arose that could not be as easily rationalized or solutions prescribed. Upon closer examination it was also discovered that these issues paralleled a growing concern amongst the design faculty associated with the studio about the appropriateness of using computers for architectural design. Broadly speaking, these issues appear to be the result of a discrepancy between the theoretical framework in which computer aided design systems are developed and tested in the laboratory and the conceptual framework of contemporary architectural thought. The result seems
to be that unnecessary or inappropriate constraints are being placed on the designer by some of the fundamental assumptions on which the tool is founded.

The remainder of this paper will explore the implications of this apparent lack of fit between the tool and its proposed use. The issues that arose from the studio experience are discussed and an attempt is made to place this discussion within the context of an understanding of contemporary architectural theory.

THE MYTH OF REPRESENTATIONAL OBJECTIVITY

During the course of the studios, and especially during the final criticisms, two observations were made regarding the nature of computer generated representations. First, an unreasonable amount of faith seemed to be placed in the rationality and objectivity of computer generated representations. There seemed to be a greater willingness amongst both the students and faculty to unquestionably accept the model, or any drawings produced from it, as appropriate and sufficient representations of reality.

For example, the apparent objectivity of a perspective computationally generated by a sophisticated algorithmic manipulation of 'rational representations' (i.e. plans, sections, and elevations), seemed to suspend the critical attitude towards representations usually found in design studios. There appeared to be an uncommon reluctance to challenge the sufficiency of these representations or to engage in a critical discussion of their nature.

This attitude is uncomfortably similar to the second observation made in the studio. There appeared to be a tendency for students to forego the usual and important step in a design project of determining the appropriate type of representation and the nature of their presentations in lieu of the mass production of those drawings easily made by the computer. There was a rather disturbing desensitization to the meaning and appropriateness of drawing types and the implications of different representations.

This distinctly contrasts with the critical attitude prevalent in contemporary architectural thought in which the question of representation is of great importance. It is generally accepted that the real is not representable but only demonstrable and that representations are in fact highly subjective instruments of the designer's intentions.

"In the process of representation, there is a reduction, a loss of some qualities or attributes and then there is a choice, a preference for others which, by being chosen, occupy 'more space' as it were, the space of the missing attributes, and become more apparent, marked, and insightful" (Silvetti 1982, p. 170).

Moreover, in his book "Perspective As Symbolic Form", Panofsky has demonstrated that the type of representation has a meaning...
that is independent of the subject matter being depicted. Thus the choice of how to represent an idea not only becomes an important design decision, it has the potential to affect the manner in which one thinks about the problem.

"If one point perspective has allowed us to produce the architecture of the Renaissance, the two point contributes the more pragmatic idea of continuity of the Baroque without which the modern idea of urban design would be unthinkable...where the central point is not so important as the persuasive effect of images; and finally space escapes altogether in the axonometric. The sensible dimension of the cone of vision (of the spectator) is discarded in favor of the sensible dimension of the real infinitude, social and physical, of space and by the realization of a universe in which we are not alone. Without it, many modern ideas of cities and their corresponding social models of socialism, equality and total democracy would not have found their physical expression" (Silvetti 1982, p.175).

However, in the studios it was found that, in addition to plans, sections, and elevations, most presentations consisted primarily of perspectives, not because they were the most appropriate form of representing the student's ideas, but because they could be easily and quickly generated by the computer. This is not to imply that this attitude is caused by the computer aided design tool itself, or that the researchers developing the software were not aware of the limits of their abstractions. Rather it is noted as a reaction amongst a group of non computer-specialist users (i.e. architectural designers), when confronted with the computer and its computational manipulations.

Similar observations have been made outside the field of architecture and it has been suggested that this type of attitude may be the result of a larger cultural belief that mathematics and mathematical understanding is the key to obtaining objectivity in the real world. If a subject can be mathematized, this automatically guarantees objectivity and objectivity is the only valid claim to understanding reality. The dangers involved with this kind of thinking have been identified by Hanna Arendt.

"Most commentators see technology, science, as an instrument for the self assertion of reason, which, itself, needs no additional justification... Modern times, dominated by technology, are characterized precisely by the fact that reason, in the sense of an originally given self revealing understanding is lost, and is replaced by a detached (technology), actively preoccupied with abstract mathematical theory and physical replication" (Arendt 1958, p.248-304).

In the studio there appeared to be a strong tendency for students, and even some faculty, to suspend their usual critical judgement with respect to the representations they made with an almost implicit reliance on the objectivity of the computer to make the right decisions.
THE LEGACY OF THE RATIONAL IMPERATIVE

This interpretation was reinforced by another set of issues identified in the studio experience in which the use of the computer more directly influenced the subject being modelled. These issues emerged from a close comparison of the student projects with the characteristics of the modelling procedures used by the software. There appeared to be a tendency for the modelling procedure to have a direct effect on the student work. Many decisions and solutions seemed to be more a consequence of having the ability to make multiple copies, mirror, scale, rotate, or extrude, than as a response to some architectural issue.

This tendency towards utilizing the inherent characteristics of the computer system is not necessarily bad, nor was it totally unexpected. Certainly the tool will affect the product, and justifiably so. However, a problem arises when a formalized set of methodological procedures defined by the tool transcend architectural issues as the means of making decisions. It was found that there was a tendency for students to lose control and begin to make decisions more on the basis of available techniques rather than as responsible designers.

This matter becomes more disturbing when this predilection towards formalism is examined in light of contemporary architectural theory. Gomez suggests that the crisis that architecture currently finds itself in is a result of this type of formalized approach to design.

"The assumption that architecture can derive its meaning from functionalism, formal games of combinations, the coherence or rationality of style understood as ornamental language, or the use of type as a generative structure in design marks the evolution of Western architecture during the past two centuries.... Western thought seems to be floundering in the excessive formalism of systems, unable to accept the reality of specific phenomena. The poststructural content of reality, the apriori of the world, which is the ultimate frame of reference for any truly meaningful architecture, is hidden beneath a thick layer of formal explanations " (Gomez 1984, p.4-6).

This is not meant to imply that this is a direct causal relationship to computer use. The problem that Gomez articulates has been developing for two hundred years and is undoubtedly present, to a greater or lesser degree, in the vast majority of design studios across the country, whether computer based or not. What is important, however, is that the use of the computer, or rather the computer graphics system, tends to exacerbate an existing problem. This concern can be placed within a larger context. Davis and Hersh speculate that the very nature of computation with its precise languages and methodologies leads to this type of situation in which the underlying significance of what is done becomes secondary, resulting in a series of formal actions devoid of any larger meaning.
Finally there was an additional concern founded primarily amongst the studio critics and reflected in the work of the most advanced students with respect to the method of abstraction used by the computer aided design system. The three dimensional Cartesian coordinate system served as the basis with which the multifariousness of reality was reduced to a set of mathematical codes. For the architectural designer this implicitly imposes a particular type of abstraction and thus a particular view of the world.

For the majority of students this was an acceptable framework within which to work. However, for a very limited number this system became a limitation and a liability. In contemporary architectural theory, as in many other fields of human endeavor, Cartesian determinism has been examined and found wanting as a viable framework for describing reality.

Benjamin Whorf has hypothesized that the structure of our language determines our perception of the world (Davis and Hersh 1986). Said another way, you will have difficulty talking about something if you don't have a word for it. When applied to the discussion at hand it implies that the pursuit of architecture that transcends Cartesian abstraction will be very difficult, if not impossible, within a structure which not only does not have the expressions necessary for the discussion, but is fundamentally biased towards the Cartesian framework.

While this condition limits, perhaps unnecessarily, certain areas of architectural exploration by the computer, there is the potential for a much greater danger. A naive user might be deceived into believing that this one type of abstraction is unconditionally acceptable simply because it is used by the computer, or even more importantly, fails to recognize the existence of the abstraction because it is so deeply imbedded within the framework of the system. The implication of this for the creation of meaningful architecture is profound as it extends the positivism and determinism criticized by many theorists (Gomez 1984, Husserl 1960). However, aside from these theoretical implications, there is an inherent danger any time that architects are misinformed about the nature of the problems they are asked to solve.

CONCLUSION

Contemplating the implications of these observations and the discussion that has ensued leads to the conclusion that the computer aided design system is not simply analogous to any other tool that the architect uses to model and represent his thoughts. It is not a neutral design tool, but comes with a dense set of underlying assumptions regarding the nature of reality and the design process. These assumptions appear to condition, to a certain degree at least, the design response of the architect utilizing the system.
To a great extent, the problems identified in the studios were a result of these underlying assumptions being taken for granted. The theoretical framework within which computer aided design systems are developed has not been examined in terms of its compatibility with the conceptual framework of contemporary architecture. The situation is made worse because of the apparent cultural predilection in Western society to believe in the ultimate rationality and objectivity of the computer. The result has been the implicit acceptance of these assumptions without the necessary critical investigation into their nature, appropriateness or sufficiency with respect to the larger context of contemporary attitudes in architecture.

The brief examination which this paper has undertaken has indicated some of the discrepancies between the theoretical foundations of computer aided design and contemporary architecture, as indicated from our studio experience. These discrepancies raise serious questions about the role of the computer in architectural design and its future will depend, to a certain extent at least, on the attitude taken towards discussions of this nature. Three options appear to present themselves.

First, this discussion, and its philosophical implications, could be ignored. This would run the very real risk that computer aided design would play an increasingly smaller and smaller role in the creation of architecture and eventually become little more than an efficient production tool for prosaic construction. A second option would be to reject the computer on philosophical grounds as the ultimate manifestation of Cartesian determinism, a philosophical model considered by some to no longer be a viable framework in which to create meaningful architecture. Finally, there is the option of maintaining the viability of computers in architecture by critically examining, understanding, and, where necessary, altering the theoretical framework within which they are developed and used so as to make them more compatible with the mainstream of architectural thought.

After much discussion, our faculty has made the decision to pursue the third alternative. While it is far beyond the scope of this paper to debate the relative merits of each of these scenarios, or describe in detail the implications of our decision, it is possible to describe briefly the manner in which this discussion has altered the approach with which computer aided design will be offered at our institution beginning in the fall of 1987. One of the primary components of this new approach will be a greater emphasis on gaining an understanding and awareness of the philosophical framework, its implications and biases, of the computer aided design tool being used. Thus, an understanding of the 'why' will be a prerequisite for a thorough grounding in the 'how' of computer aided design. It is hoped that through this type of critical evaluation and discussion users will be aware, and thus better able to avoid, some of the potential dangers observed in the studio work to date.
Combined with this emphasis on theoretical understanding will be a more liberal and creative attitude towards alternate abstraction models and modes of representation. The computer has the potential, as a new modelling tool, for expressing and developing the potentialities of the architect's imagination in ways never before seen in the history of architecture. Up to the present, and like most new tools, it has done little else but replicate procedures and techniques that can already be done by hand, albeit more efficiently. However, at some point, if it is to become a viable tool in its own right, the unique aspects and potentials of computer aided design will be utilized to do something new, something that has never been considered or perhaps considered possible before.

An insightful analogy into what this might be, and one which we will be pursuing in the fall studio term, is made by Davis and Hersh in a discussion about their dissatisfaction with current computer art.

"... if computer art has a future as an art form in its own right, it is to be found in the dynamic, the animated, the interactive. It should not look towards Rembrandt, but towards Verdi's 'Aida'. Not just the classical 'Aida' but an 'Aida' with the audience singing along and scrambling onto the backs of the elephants on stage. Chaos? No. Total theatre" (Davis and Hersh 1986, p.53).

In conclusion we, as scholars, educators, and users of computer aided design, need to explore the possibilities and potentialities of extending the field beyond its positivistic engineering roots in an attempt to create a tool that is more sympathetic with the theoretical framework, as well as the practical needs, of the creative architect. At one level computers will always be, and justifiably so, simply an efficient time saving device. However, if they are to contribute meaningfully to the creation of architecture, as opposed to mere prosaic construction, it is necessary to push beyond this practical justification.

How should this be attempted? This paper has presented only the briefest of outlines of one of a number of possible directions. The validity of one of these over any other is not as important at this particular time as a recognition of the need for some kind of larger critically theoretical discussion, and, ultimately, a more appropriate integration and understanding of the role of computers in contemporary architecture.
REFERENCES


