DRAWING LESSONS FROM WORD PROCESSING

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ABSTRACT

Word processing is universally successful as a computer application whereas computer-aided design is not. What can we learn from word processing? It tells us that, to be successful, an entry-level CAD system should be basic and focus mainly on drawing and manipulation of drawings rather than on sophisticated operations and automation. It should be simple, easy to use and moderate in cost. In architectural education, it should be used in the early stages of design to enhance design quality and design learning. To do this, we need to understand the characteristics of this new drawing and design medium. Software needs to be thoroughly learned in advance of studio use, and computer-based studio projects should take a computational view of design to enhance the effective use of computers in learning to design.

COMPUTER APPLICATIONS IN ARCHITECTURE

Computers are used in a wide range of applications. In architecture they include such things as word-processing, accounting, facility programming, 2D and 3D drawing, energy analysis, etc. While each application promises specific advantages, advantages can be broadly characterised as one or more of the following basic types of benefit: "enhanced productivity ...... error reduction, and enhanced design quality." (Mitchell, Reeder & Hamer 1984)

Productivity and error reduction have already been demonstrated in practice. However the impact on design quality is less clear and few architects are using computers for designing. As well, few schools are using computers in their design programs. In the schools that are, it is not at all clear whether the quality of design and design education has been enhanced.

On the other hand, word processing computers are everywhere, including architects offices, and are universally successful. Why this great success of the computer, in one case, and an apparent failure to deliver in the other? Does it stem from the characteristics of the different areas of application? I don't think so. In fact, I think that we can draw useful lessons for design applications from word processing.
Institutions of all kinds live on information contained in written documents. And for decades offices have been trying to cope with the deluge of documents through such methods as typewriters, copiers, filing systems, etc. Typewriters were a definite improvement over handwriting and eventually achieved universal acceptance. But they were limited in terms of their ability to modify or multiply information. Copiers could multiply information but they couldn’t modify it. Very sophisticated filing systems were developed to organize the information, but they took a lot of space, time and energy.

Then along came the word processor. It looked like a typewriter and a TV set (both, by then, familiar objects), and it had significant advantages over existing technology. While some new skills had to be learned, it entered information on a keyboard that looked much like the keyboard of a typewriter. Because words were stored as electronic data rather than as a physical document, information could easily be modified and multiplied. This made it easy to stay up to date which improved control of a project or a business. Word processors could also organise, store information and retrieve information. This meant that information could be re-used.

Some of the benefits resulting were not only error reduction but also improvement in quality. Rather than having to put energy into inventing or re-creating information each time, the effort could be spent on improving the quality of the information. This also led to improved productivity. But another factor also improved productivity. It was known that typists slowed down as they neared the bottom of a page: they didn’t want to make a mistake and have to type the whole page over. Because information is stored electronically and can be easily changed, there is no worry about mistakes on a word processor, and no slow down.

Word processors also introduced some new capabilities that were difficult or not possible with the old technology. They could automate the organisation of labor-intensive aspects of documents such as footnotes, tables of contents, and form letters, as well as operations such as sorting and numbering. Some programs could also accept illustrations and generally produce a much richer variety of graphic effects than was possible before.

These were attractive advantages. But there were also other characteristics that contributed to the widespread use of word processors. First and most important was their ease of use. The word processor used a keyboard that looked much like the keyboard of a typewriter. True, some new skills had to be learned such as giving commands to the machine. But some computers made it easy by showing the commands in "menus" right on the screen. Also early programs were fairly basic; they couldn’t do a lot of things that can be done today. That probably contributed to their success. They weren’t complicated; they could be learned fairly easily.
Another factor contributing to their success was reasonable performance expectations. Word processors addressed the basic issues of creating, modifying, storing and retrieving information; they didn't try to do much more. Even today, when word processors are more powerful, word processing is not confused with desktop publishing. This keeps word processors fairly easy to use and to learn. It also influences another characteristic that is an important reason for the success of word processors, and that is costs of both hardware and software are moderate. This is major factor in the widespread use of word processors.

**DRAWING LESSONS FROM WORD PROCESSING**

Where administrative activities live on written documents, architectural design lives on drawings. Like written documents in offices, the number and complexity of drawings have multiplied. Before the advent of computers there was little change in the way drawings were created for perhaps a hundred years or more. Paper improved over the years, and some new types of applied media and reproduction methods became available. Systems drawing was a notable development. But it is ironic that this method, in effect, anticipated computers: it tried to do manually what can be done much more easily today by computer. In any case the basic problems remained. The creation of drawings was still a slow, labor-intensive process. Change was not only slow and laborious, it was a source of errors. Organization and storage of drawings and the information in them was generally primitive. Often, after the completion of a project, the information in drawings was effectively lost because it was difficult to locate and physically cumbersome to retrieve.

Then, along came the computer and offered the same sort of benefits that were found on word processors. The impact of computers on creating drawings is not quite the same as that on creating written documents for reasons that will be discussed at greater length below. There are various views about the benefits. For example there are differing views about the benefits to the activity of creating drawings. However, the benefits to the activity of changing drawings are clear: because drawings are stored as electronic data rather than as a physical document, information can easily be modified. This is a significant benefit because change is a major activity in architectural design.

The easy storage and retrieval of drawings and drawing information is also a significant property. Some of the benefits resulting are not only error reduction but also improvement in quality. As in word processing, graphic information, elements, arrangements, etc., can be re-used rather than having to recreating them each time. This is likely to lead to improving the quality of the information each time it is used as well as to improved productivity.
But another factor that has an impact on productivity in word processing has a different impact on architectural design. As a manual drawing develops, architects fear the spoiling of a drawing much as typists, nearing the bottom of a page, fear a mistake. While this affects productivity in word processing, in architectural design done with manual drawings, it tends to discourage exploration of possibilities, especially as drawings get more complex or finished. However, the ease of making changes in computer-based drawings, and the way information is organized, reduces the fear of spoiling a drawing and thus encourages exploration. Since the amount of exploration has an impact on the quality of the design, it is reasonable to suggest that a benefit of computer-based drawing is improved design quality.

Computers have also introduced some new drawing capabilities. Design elements can be duplicated, reflected, rotated, strung out in lines, etc to create designs. Information can be combined, separated and recombined in new ways to create new designs. Tones and textures can be automatically added to drawings. Written information can be placed in the drawings in various sizes and typefaces by typing instead of printing by hand. Above all, and most difficult to grasp, computers are a new design medium, and drawing with them is quite different from manual drawing on paper. This change of medium is both the source of the main benefits and the main problems.

“Architectural design and drafting is one of the most traditionally practiced professions; in many ways, it is the same craft that it was a hundred or more years ago. The introduction of computers into architectural practice is bringing changes that are potentially as jarring as the appearance of the printing press was to the bookmaking craft of the Middle Ages.” (Crosley 1968)

Office workers have been learning to cope with typewriters for over 100 years. But during the same period, architects have continued to make drawings in much the same way. The introduction of computers to architectural drawing, then, is a much greater change than the introduction of computers to the written word. Quite new skills are needed along with new ways of thinking. This transition, therefore, is a difficult one to make.

Another problem of introducing computers to architecture is performance expectations. Computers are very glamorous and exciting; they can do so many things such as 3D modeling, drawing in color, visualising light & shadow, simulating movement through in space, etc. Architects get excited by these possibilities and want to have them all. The problem is that many of these applications are difficult to learn. And if they are difficult to learn they are that much less likely to be used. Even more important, these applications are expensive, especially in terms of hardware. Surveys of architects have shown time and time again that cost is given as a major reason for not acquiring a CAD system. (Teicholz 1985).
One of the first lessons one can draw from word processing is to address the basic needs of the activity. Just as the basic need in word processing is to create and manipulate words, in architectural design the basic need is to create and manipulate architectural drawings. The operational word here is "basic." Computers can do many sophisticated things with architectural drawings: design elements can be generated and organized in complex ways, views can be lighted, colored and linked in various ways, different kinds of information automatically extracted, etc. These more sophisticated and complex applications are usually called computer-aided design. The use of such programs should be built on a good understanding of more basic computer-aided drawing programs. To distinguish between the more complex applications which can do a wide range of things and the more basic applications that focus mainly on drawing, I will refer to the first as CAD and the second as CAd. And just as word processing is not (or should not be) confused with desktop publishing programs, CAD should not be confused with CAd. The first lesson to draw from word processing, then is to focus on CAd.

The second lesson is related to the first. A major reason for the success of word processors is that they are easy to use. Similarly, architectural graphics programs must be easy to use. If we focus on CAd rather than CAD, that is, on drawing rather than automation and a range of sophisticated design capabilities, the program will be relatively simple and thus, easy to use. (The battle between simplicity and ease of use is already joined.) In many schools of architecture where there are IBMs and Macintoshes, for example, it is the simple and easy-to-use Macs that are used first and most, rather than the more powerful, but more complex IBMs. For computers to have an impact on architectural design, they must be actually used. While this might seem obvious, the fact that IBM has been the standard in many schools of Architecture makes one wonder.) Simplicity will make it easier for CAd to achieve one of the other characteristics of word processors responsible for their success, and that is moderate cost. Costs of both hardware and software must be moderate if CAd is to become as widespread as word processing.

ARCHITECTURAL EDUCATION

Surveys of why architects acquire computers report reasons ranging from "to impress clients" and "to be up-to-date" to "reduction of staff" and "improved productivity." (Teicholz 1985) Most architects with graphics programs use them in production. Some architectural offices are using computers for design as well as production. For many of these the main benefit is still productivity. But what are the reasons for bringing computers into a school of architecture? None of the above reasons are significant for architectural education.
There are various possible areas of computer application in architectural education such as design, technical courses, research, etc. Since design is considered central in most schools of architecture, and is the most likely area for a CAD program, let us concentrate on the design studio. But we are not likely to derive real benefits from CAD either from trying to serve the whole range of studio activities nor from avoiding making a choice of emphasis. If a design studio is about learning to design then CAD should reinforce this and focus on the design stages (as opposed to drafting or presentation drawing).

A design studio is also about design quality. The most important design decisions are usually made in the early stages of a design project. They tend to fix the main outlines of the design while subsequent decisions develop and refine it. (Lockard 1974). Thus early decisions have a strong impact on design quality and, as Mitchell notes, "most of the design quality benefits of computer use will follow from software that applies at early stages in the design..." (Mitchell, Reeder & Hamer 1984). The CAD application, then, should focus on the design, specifically on the early or schematic phase of design.

DRAWING ON COMPUTERS

Schematic design is an important stage not only for the reasons noted above but also because many studio projects spend a good deal of time on it. Yet some architects feel that the computer is not appropriate or feasible in this stage. They cite the "mechanical" quality of the drawings. Yet typists today don't worry that their work does not look handwritten. (They did at one time. When typewriters were introduced 100 years ago many recipients of typewritten letters resented and resisted the fact that they weren't handwritten. (Monaco 1988)). Some architects are concerned that the line quality doesn't reflect the tentative nature of a schematic design. Yet no one has trouble with neatly typed drafts of a written document. A similar but more general problem is implied by such comments as "I can do it more quickly by hand." or "I don't think that way."

Why the difference in attitude between written documents and drawings? In my view it stems less from the nature of the two media than it does from the level of their technological development. Typists and typewriters have made the transition from handwriting to machine made writing and have adjusted their expectations. Some architects, however, are still applying manual drawing criteria to computer based drawings. This attitude to CAD is not surprising. For the first 50 years of printing, typefaces were modelled on (handwritten) manuscripts. (Burke 1985). Then new typefaces began to emerge that had little to do with hand processes. The attitude to CAD, then, is not surprising but it is inappropriate. It needs to be recognised as an attitude of mind rather than a problem of the medium before computers can be used effectively in architecture.
Drawing on computers is quite different from manual drawing and we need to understand the differences. In manual drawing, we pick up a pencil and draw. The "interface is practically invisible." (Nicholson 1987). It may be practically invisible but it is not necessarily intuitive to a beginner. Nor is CAd to a beginner. But once one is used to drawing with CAd say, using a mouse, it becomes just as intuitive. It is a question of practice, facility and expectations. If one expects to pick up a mouse, for example, to draw with, then it is just as intuitive as using a pencil.

The interface in CAd may be as intuitive as in manual drawing, but it is not quite as invisible. But that is a strength rather than a problem. The medium of manual drawing makes strong demands on the manual skills for creating lines, but it makes few other demands on the designer. There is little structured information built into a manual drawing by virtue of the medium. The medium allows the designer much flexibility, putting no barriers in the way of ambiguously shaped, poorly organized or illegible drawings. Manual drawing makes so few demands of this kind that it does little to encourage designers to think about the discipline of drawing, that is, the definition and organization of information in drawings. Thus we can make drawings that are Beautiful but whose information about space and form is not very clear.

Most CAd programs use shape primitives and specific operations as a method of drawing. One chooses a shape such as a square or circle, for example, and drags the mouse (a fairly intuitive drawing action) to create as well as modify the shape. To duplicate, rotate, reflect, etc., the shapes, one must do consciously in CAd by choosing operations from a menu or keyboard. This deliberateness, seen as a barrier to architectural ideas by some, is actually a strength for architectural education. Elements - spaces, walls, columns - and their relationships are the stuff of architecture: understanding them and how you manipulate them is the essence of architectural education. Manual drawings neither readily reveal these relationships, nor make the elements easy to manipulate. CAd, because of its deliberate nature, not only reveals the structure of space and form, it makes it easy to manipulate. CAd thus enhances understanding and learning.

It also seems likely that the computer as a drawing medium has an impact on how we think about space and form. For example, sculptors who work in clay build up form; they think in an additive way. On the other hand, sculptors who work in stone think in a different way. They think in terms of what must be cut away to reveal the form. In some ways, manual sketching can be seen as analogous to sculpture in stone. Drawings are made over one another until the main outline of the design emerges from all the other lines and reveals the "underlying form." CAd seems to be more of an additive way of working, adding and modifying elements until the design is built up. Manual drawing is linear and represents space and form by means of edges. Because toning takes some effort, it often does not deal with the surface qualities of form. The shape primitives available to CAd and the ease of
adding tones and textures makes it more of a planar medium and one that can easily represent surface qualities.

It is not clear what the impact on architectural form might be. Radford and Stevens, writing before the emergence of modern, micro-based CAD systems, speculate that computer-aided design could lead to "a rich diverse architecture...a sculptural architecture, freed from the need to be strictly rectilinear, without the pressure to give stock answers to standardized design problems." (Radford and Stevens 1983). Mitchell, writing later, suggests that "A strict classical architect would be very happy with the assumption, made by most of todays CAD systems, that designs have well-defined, discrete elements that are grouped to form a hierarchy of well-defined, discrete subsystems... On the other hand, a Mannerist or Baroque architect concerned with the poetry of complexities, ambiguities and multiple readings of architectural form would be unlikely to find such a medium congenial." (Mitchell 1986)

Manual drawings often look somewhat "loose," indicating that the design is preliminary and not fixed. While it is possible to draw this way on the computer, there is no benefit to simulating hand processes, especially when it means creating patterns (pixel maps) with limited manoeuvrability rather than elements (object oriented drawings) which have much more potential for architectural manipulation. On the other hand, object oriented drawings tend to be somewhat more exact in both their content and appearance. Some architects feel that the more finished looking drawings, made by CAD, suggest fixed designs, making it unsuitable for the early stages of design. But this is another case of applying craft criteria to machine drawings. The 'looseness' of manual drawings is more a reflection of the medium than the state of the design. The drawings reflect both imperfect manual skills in shaping designs and the tendency to make drawings over one another. In CAD, on the other hand, the machine provides a higher degree of skill in shaping and finishing designs, and the ability to duplicate and manipulate elements of the design makes it unnecessary to place one drawing over another (which is really a short-cut in manual drawing). CAD makes more finished, not more fixed drawings. This is a different look for preliminary designs. We need to learn to read new graphic signs.

COMPUTERS AS DESIGN MEDIUM

Not only is CAD different in terms of how one draws, it also has an impact on how one thinks. A manual drawing is static; it stays on the paper where it was placed and the way it was shaped. In effect, you have to get it right the first time. And that depends on time and manual skills. So considerable manual effort must go into making the drawing. But CAD is different. The computer provides a high level skill in making shapes. In fact, we draw mainly by choosing shapes and organising them. CAD thus emphasises conceptual skills of choice and manipulation of elements, whereas manual
drawing focusses on generating patterns and on the craft of drawing, that is, CAD emphasises organizing, and manual drawing, making.

It's easy to pick up a pencil and start drawing without knowing exactly what we are going to draw. We may sketch, that is, make various lines on paper and hope that something will develop, that we will see a pattern or order emerging. In this type of drawing (and in the thinking associated with it) order tends to emerge later rather than earlier. With CAD, one may also sketch without having a clear idea in advance of the outcome. But the more deliberate way of drawing with CAD, that is, the fact that one draws mainly by choosing shapes from a "palette" and then manipulating them in deliberate ways, encourages a different approach to drawing and thinking. This approach tends to put more emphasis on order in the drawing and to make this emphasis felt earlier in the design.

Our thinking is influenced by our experience. Traditionally designs developed on paper. The design was something that we could hold in our hands; it was a document. Along with that went a whole lot of (usually implicit) expectations of a architectural designs such as a particular handmade look, fixed content, transmission and storage of something physical, etc. Computer-based designs are very different. They aren't fixed in a document. They don't have physical substance but are stored as electronic signals which we can't see. But they do help us to see designs in a different and productive way. "The architect's product... is information not drawing" says Stoker and Weingarten of IBM (Doublet 1984).

This has many implications that will take some time for us to uncover. For example, information can be built up in databases, it can be used in many ways such as in other versions of a design, in other drawings of the same design and at different scales, it can be transmitted from machine to machine without ever becoming "material", etc. This also produces new concerns. We can't search a computer for information the way we can physically search an office for drawings. So we need to think more carefully about organization of information.

There are also significant differences in thinking between craft-based and computer-based design processes. Manual drawings take some time and skill to create, and once they are done they are not easily changed. So it is not surprising that manual drawing is often associated with "answers," with a way of thinking that says "This is it." The dynamic nature of CAD, on the other hand, the ability to more easily make changes, encourages an attitude of "What if," of exploration of alternatives.

These new emphases - on organizing rather than making, on order, on information rather than drawings and on alternatives rather than answers - are some indication of the new design thinking encouraged by the computer as design medium.
INTRODUCING CAD

"It's possible to use computer-aided drawing without really taking advantages of its capabilities. Even some experienced CAD users have simply transferred all their manual-drawing habits over to the computer. It's like buying an airplane and driving it down the highway rather than learning to fly. It requires an effort to learn to fly, but if you don't bother, you might as well stick with your car." (Crosley 1988)

It has been suggested that to bring computers into the design studio, it is enough to make them available and let people use them as they wish. Leaving people to pick up skills that are so central to the enterprise is to doom it to failure before it starts. There appears to be some concern that if the applications are formally taught, they will have an impact on a student's design process. In my view, if they don't have an impact, then resources are being wasted. In Crosley's terms, the airplane is still on the ground.

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. This means learning them in advance of their use in the studio (or anywhere else). This doesn’t mean learning every tool and operation in the program. Many programs were not intended solely for architectural use. And since learning even simple programs well takes a fair amount of time, that approach would diffuse and weaken the learning process. Rather it means learning thoroughly those tools and operations that are relevant to architectural use.

"Learning thoroughly" should also mean something more. It is not enough to just learn the software, that is, the tools and operations. It is desirable to anticipate their architectural use, and in terms of the new medium. I've tried to indicate that computers invite a different view of space and form and its representation. Any course on CAD should be framed in terms of this different view. For example, pattern-making is basic to all designing. (While this is not new, it is a view that is strengthened more by computers than manual drawing.) Pattern-making can be based on a few elements and a number of simple moves. This concept can be used as a framework to learn and explore the use of some tools such as basic shapes and some operations such as duplication, rotation, reflection, etc., in a CAD program. Other properties of CAD programs and the architectural issues that they can be used to explore are such things as "View" (or scaling) operations and levels of design abstraction, "Layering" operations and architectural systems (physical or conceptual), "Symbol Libraries" (or databases) and design precedents, etc. (Rubinger 1988). Not only does this allow progressive learning of the software, it provides some coherence to the tools and operations selected and some architectural focus to the exercises.
The aim of learning CAAD software is to apply it. In the design studio, this is what the projects are for. They are vehicles for learning to design. In a computer-oriented studio, they are vehicles for learning a “computational view” of architectural space and form [Mitchell 1984]. The projects, then cannot be neutral; they should be framed in a way that invites the exploration of this view and the computer’s capabilities to do it.

CAAD should be the introductory level for computer graphics applications. Fluency should be required at this level before going on to more sophisticated applications. Above all, for computers to have an impact on architectural design and learning, they must be used.

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