Contemporary Digital Techniques in the Early Stages of Design
The Effect of Representation Differences in Current Systems

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Abstract: This paper reviews the role that computers can play in the early design stages and considers how far recent developments in commercial software have enabled designers to improve design performance through interaction with a CAAD system. An experimental approach is reported on.

1 INTRODUCTION

Studies, reported some years ago that looked at using the computer early in the design process frequently reported on substantial constraining effects that CAAD systems imposed. The hardware and software was relatively expensive but it was also relatively user-unfriendly (Richens 1988, 1992). Early systems were developed in a way that emulated the drawing processes evident in conventional ways of working in the later stages of the design. The computer was simply an electronic drawing board and in some ways it has been difficult for CAAD software to break free from that heritage and embody the enhancements that digital systems can offer over conventional tools.

One of the strands of development that has attempted to aid the idea of breaking free from the heritage and employing the computer as a more creative aid has been work, over the past ten years or more, on accomplishing the goal of the computer as effective digital sketching device. Brown and Horton (1990) reported on the different kinds of drawing associated with different stages of design activity, analysed sketching techniques and showed how contemporary software could be
modified to accomplish sketching more efficiently. Early in this strand of evolution Daru (1991) stated that “Sketching plays a manifold role in design and design education now as much as it did in the computerless days. Design sketching is indispensable during the early phases of the architectural design process”.

In terms of actually implementing sketching tools and interfaces there have been, more recently, interesting developments such as the Electronic Cocktail Napkin project and subsequent developments (Gross and Do 1996) or Digital Clay. (Schweikardt and Gross 1998) and Mase’s (2000) very interesting work on the Moderato system. All of these programs and environments take the approach of trying to give designers digital replications of traditional tools (pen or pencil and paper) to use in a manner that mirrors the traditional way of design; but with the assistance of the computer to enhance and augment the process. However, if we ask architects and design tutors alike how digital techniques are being applied in the design process, the notion of originating ideas or sketching of ideas is still alien to many. This is probably because the typical contemporary CAAD system still fails to offer an adequately design-oriented environment for design sketching. Recent software developments and more powerful computers have started to change this, but there still appears to be a long an ingrained perception in the profession, brought about by years of production orientated software, that it is not possible to ‘design’ in the computer. Today the picture is changing. Many, if not most, architectural students start their earliest design investigations quite naturally using the computer.

This still leaves many questions unanswered and poses many others concerning the relationship between architectural design and the computer. Why do we always have to sketch when we start thinking of a design? Is it because it’s the ‘natural’ thing to do or is it because we are taught to design using pen and paper? Some architectural schools only introduce students to computers in the second year of their studies, and those that do introduce it earlier are often not using it in the early design stages. So what would happen if we started to teach our students from the outset to design with the computer? Will it increase their design capabilities, or might it hinder their ability to generate design ideas: might the change to digital sketching be an unnatural one that ends up constraining rather than freeing ideas? Is there not also a case for quite naturally starting with the computer when it is omnipresent in every aspect of both work and daily life?

This paper looks at the application of current design software in a contemporary design environment. The methodology of the study is based on a structured design problem based activity that investigated the effects of the use of CAAD early in the design process. We were interested to see whether designing wholly on the computer would produce substantially different results to those produced via a more traditional design process. Rauhala, (2003) stated that “It seems impossible to use computers as a creative adviser or as a generator of totally new design solutions. Likewise using computers for generating new and creative associations seems to be in principle infeasible.” We were interested in challenging this assertion. In addition it is interesting to note that researchers such as Abdelhameed et al. (2003) have looked at the issue of assessing the impact of media on the design capabilities of architects.
Part of the issue is to do with effectiveness of the software, and its mode of operation or interface. But part of the problem is to do with perception. If a designer has a preconceived antipathy towards digital sketching, and is resistant to the idea that a digital sketching environment can be helpful and productive, then clearly an objective view will be difficult to obtain. So, in addition to the structured design problem a perception study has been undertaken to gauge the response of different groups such as architect and non-architect, student and graduate, to the kind of representation and interface that the kind of software described offers.

2 THE PROJECT

The work in this aspect of the paper is based primarily on two collaborative exercises that took place between two European University Schools of Architecture. An initial exercise took place in February 2004 with students of the Department for Urban Design, Technical University of Graz and the School of Architecture, University of Liverpool. The promising initial findings have prompted a more detailed study. The premise of the exercise is to use the same design problem with two different groups of first year students from, one designing wholly in a 3D CAAD environment, the other working mainly, and initially with traditional tools, but with a CAAD presentation requirement in the later stages of the process.

The software used was Sketchup, which has a feature of user-defined settings for the appearance so that digital representations can be made to look similar to manual sketches. Added to that the mode of operation and geometry definition is relatively free and immediate, with lines, shape and form defined directly by hand movement (via a digital pen or mouse) rather than by keyboard entry of coordinates. As such we can categorise this as a sketching interface. But clearly there will be different views (Chastain et al. 2002), both on whether the digital sketch has to look like the manual sketch, and on what the associated qualities are that give a particular environment the facility to act as a supportive visible counterpart to the creative mental processes in early stage design.

2.1 Initial Study

The initial exercise involved two groups of first year architectural students working on a common site and design problem, one working wholly in CAAD, the other working wholly manually. The CAAD students worked in pairs in an intensive studio starting with introductory tutorials in SketchUp and culminating five days later in wholly computer based presentations. Students worked intensively every day on the project. They were encouraged to experiment with the program using mistakes, correction and unintentional events as design generators and parts of the design process; in other word mimicking the affordances that conventional media support (Tweed 2001).
The brief called for a house for an artist on a small, urban corner site in Graz. A detailed brief was not established; the house had to be able to provide suitable spaces to live, work and present work. The students could choose their artist (client) and describe the artists’ requirements first and develop their own brief in discussion with the tutors. The site was adjacent to a party wall and was set on a small slope and a large single tree, all of which presented quite a demanding task for inexperienced first year students.

The 36 students who worked only with digital techniques took part in a five day intensive workshop, working in pairs. They had five days to both learn a new piece of software (SketchUp) and produce a wholly computer-based presentation. Students worked intensively every day on the project. A problem with this kind of study is clearly that for those working in the digital environment a new skill has to be learned, whereas traditional skills such as drawing and model-making are familiar to students. One the one hand the novelty of a new approach to representation might appeal, and bias views towards that environment. On the other learning a new skill means that the flow of information between medium and mind is likely not to be smooth.

Figure 1 (left) Traditional and Figure 2 (right) digital-supported design

The students working traditionally worked in a different way to the digital group; a study tour introduced the city and the site. The project was five weeks in duration, but with only two studio days per week dedicated solely to it. Students worked traditionally through sketches, drawings and models, but a SketchUp model was a prerequisite of the final presentation. The computer was not used as a counterpart to the design process, but simply as a modelling and representation tool at the end of the process.

Whilst it was not possible to have identical presentation requirements, to demonstrate an understanding of the resulting internal spaces, the students working in wholly digital environments were required to create a walkthrough from street to the major space in the design, whilst those working traditionally were required to produce a serial vision walkthrough from the street level through to a major space in their building.

There were some interesting observations made during the initial phase of the workshop. Firstly, some of the students resented starting from scratch with the computer; they hunted around to try to find a piece of paper to sketch their first ideas. Subsequently it was found that these were mainly the students who already
gained some design experience earlier in their previous education. The second interesting point relating to the digital group was that the students who had experience in other more traditional CAD packages such as AutoCAD, had significant problems using SketchUp. They tried to work in a similar way to the way that they had learned with the program that they were familiar with. This turned out to be a significant hindrance, and the CAAD experience proved to be a handicap to developing a design in a wholly digital environment, rather than a help.

These observations are in line with those made much earlier by Richens (1988, 1992). As we know skill in CAAD software is not universally transferable. Like spoken languages, in some cases, knowledge of one does not guarantee rapid assimilation of another. But this is not unique to working in a digital environment. The ability to produce good quality line drawings with ink drafting pen on tracing paper, does not guarantee an adeptness to produce high quality charcoal on paper drawings.

The heritage mentioned earlier still continues to influence the language of CAAD, and issues such as those relating to Human Computer Interface are still very significant in terms of the introduction of software that attempts to take on the role of counterpart to the design process in the early stages of design. It seems that there is still a widespread expectation that new software will work in ways, and look like that body of established tools.

In order to test this view and to establish if there were identifiable differences across a range of groups with different characteristics a parallel study has been undertaken. This study has taken a large number of respondents and is aimed at obtaining views on the reaction to different representational types.

One matter that we are concerned with is the perception of, and reaction to, digital representations that emulate the physical sketch and sketch model. Respondent data for a number of comparator groups has been collected and analysed. Amongst other things this data allows us to comment on the differences in reaction to sketchy interfaces between pairs of groups such as architect and non-architect, architecture student early in their education and at the end, and male-female differences.

2.2 Linked Study

In the study described above we considered how the nature of the architectural representation changed the perception of the user in terms of their reaction to the architectural object being depicted. We used a Semantic Differential Scale from 1 to 7 to collect and analyse the responses. 1 and 7 represented bi-polar adjectives at extreme ends of a spectrum (such as boring to exciting) with 4 measuring a neutral response. The study groups were divided into architects and non-architects, with subdivisions within each group so that we could make finer distinctions. In the study three principal rendering types were used; sketchy line, non-photorealistic and near photorealistic. One line of questions asked about the character of spaces represented, in particular how real or abstract the participant felt them to be. What was interesting for a sketchy line representation is that there was a noticeable difference between
male and female respondents. In Figure 3 male responses are shown in grey bars and female in black. Females appear to regard the sketchy representation as relatively realistic, whereas males interpret it more as an abstraction.

Figure 3  Effect of gender on perception of sketchy line scheme

Another line of questioning looked at how expressive the different representations were felt to be. The graphs for the sketchy representation and the near photorealistic representation are shown in Figures 4 and 5.

The possibly surprising result here is that near photorealistic representations are regarded as ‘expressive’ by a significant proportion of the survey group. In the physical equivalent a sketchy representation tends to be regarded as expressive, whereas more geometrically accurate representations tend to be regarded as lifeless and uninspiring.

Figure 4  Description of character (range from dull to expressive) for sketchy line scheme
The perception studies outlined above have been extended and the group sizes increased to ensure that the data is statistically significant (Hannibal et al. 2005), especially given that some of the findings are counter to what was expected from the results of previous studies such as those conducted by van Bakergem and Obata (1991), and Bassanino (1999). But what this work shows is that care is needed in drawing conclusions from future studies of designing in what we might contrast as sketchy and non-sketchy environments.

2.3 Second Study

A second digital versus traditional study has been undertaken using a similar premise as before; two groups of 16 students each, one working digitally and the other traditionally on the same scheme on the same site. Both worked on the problem simultaneously in an environment that allowed a much more controlled analysis. However, in order to minimise cultural and pedagogic differences, students from each institution were paired and worked with tutors from both institutions. The digital group were not be allowed to use any analogue means in the initial design phase and the analogue group was not allowed to use the computer. Both groups of students were again, first year level who had similar levels of both CAD and traditional skills.
Figures 6 and 7 show how two typical schemes developed when students used wholly traditional and wholly digital techniques respectively. The evolutions show a number of contrasting features that can be summarised as follows.

In the manual scheme much of the development was through 2D sketches (e.g. Figure 6 left) and exploration in drawn 3D (e.g. Figure 6 centre) are rarer events. A 3D model may be produced, typically only once or twice in the life of the design (Figure 6 right). Changing to focus on a detail at a larger scale is easy and relatively common. In the wholly digital scheme the majority of the evolution is in 3D and begins with a more complete description of the site (Figure 7 left). This is to some extent necessary, but could be a virtue that the CAAD system directs the user towards. Design alternatives are tested in 2D rather than 3D (Figure 7 centre left and centre right). Alternatives are usually tested in the context of the site and building rather than in isolation.

3 CONCLUSIONS

We posed some questions early in this paper. Why do we always have to sketch when we start thinking of a design? Is it because it’s the ‘natural’ thing to do or is it because we are taught to design using pen and paper? Researchers have debated these issues and the answers are still equivocal. So, devising CAAD systems that best support the initial, creative phase of design is a difficult task. The specification is vague. Not only that, there may be more than one ideal specification.

The results of the perception studies reported here indicate that there are gender differences in the value and interpretation placed on different architectural representations. The results of perception studies also tentatively indicate that there is an increased willingness to value the digital representation; and that the elevated value placed on hand rendered, conventional representations evident in studies some years ago no longer necessarily hold. This has significant consequences for the application of digital processes early in the creative ‘sketching’ phase of design.

Daru (1991) posed four criteria for the assessment of computer based sketching:

- **Is computer based sketch designing didactically correct?** The aim of both methods is to further design education and not just produce aesthetically pleasing or challenging images.
• **Is it useful?** If use of computer tools either gives additional possibilities or shortens the design learning period then the answer is positive.

• **Is it sufficient?** Can computer-based sketching replace traditional hand methods?

• **Is it harmful?** Are such design methods detrimental to the traditional sketching experience?

Given the reservation it is possible to make some general observations from the studies described in Section 2.1 and 2.3. It would appear that the stronger CAAD based students produced designs which they might not have been capable of working through a wholly traditional design methodology and that the CAAD students had a better grasp of the quality of internal spaces. The stronger students who were working traditionally produced designs that would have been very difficult or impossible to produce with their limited CAAD knowledge.

It has been said (Schon and Wiggins 1992, Bailey 2001) that sketching is about the iterative, reflective conversation that occurs with that act of drawing, and that understanding this conversation is the key to understanding. The observations that we have made during the initial part of this research lead us believe that, with new students at least, sketch designing with current software tools is becoming more accepted and useful.

Established software has created an environment in which it is difficult to break free from the shackles of expectation that new software will work in ways, and look like that body of tools. Like the horseless carriage (Chastain 2002) the vehicle is still not the right shape and the driver is still not in the best position to take charge of a design that is powered by a digital engine, but an evolution appears to be happening.

**REFERENCES**


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