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The tools designers use: what do they reveal about design thinking?

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Abstract

This paper investigates the nature and use of existing tools during a design task as a means of gathering information concerning practitioners' conception of that activity. Two case studies are reported which focus on the final year projects of undergraduate designers enrolled on a B.A. in Interior Design. Based on these studies a number of conclusions are drawn concerning the nature of design tools and in particular the interdependencies revealed between drawing, modelling and CAD. The role of visualisation within design is considered in the context of its support by these tools and critically how the various techniques developed by the designers impact on their conception of the design activity. The paper concludes by outlining a number of nascent requirements for the design of technology aimed at supporting the early creative phase of design.

1 Introduction

Technological support of creative design has, to date, remained illusive. While Computer Aided Design (CAD) systems have been successfully deployed in many professional practices and are incorporated into teaching programmes, their contribution has, in the main, been at the latter phase of the design cycle. This emphasis on drafting has resulted in systems which enable ever more sophisticated ways of representing design ideas, rather than tackling the issue of how technology might usefully contribute to the production of those ideas. Indeed the view that technology should contribute throughout the whole design cycle was proposed in the 1960s, most notably by Mann and Coons (1965) when they characterised the relationship between human and computer, in the context of design, as one that should be based on co-operative partnership. Clearly what has transpired in the intervening years has not achieved this aim, although the magnitude of the task should not be underestimated. If the design of technological artefacts is to move toward supporting the early phase of design, then a necessary foundation will be to study both the practices of designers and more particularly their use of existing tools.

A number of studies have addressed this issue through the investigation of expert designers

(Candy and Edmonds 1996, Cross and Cross 1996, Lawson 1994 and Roy 1993) and have contributed to an increased understanding of the processes underpinning creative design. The study reported in this paper differs from the previous work in two important ways. Firstly, it investigated the behaviour of student designers as their interaction with design tools was thought to be more explicit than that of experts. Secondly, a tool mediated perspective has been adopted through the explicit study of existing tools and how these influenced the way designers' conceived of tasks and as a consequence, how they think about the activity of design. In short, the aim of this study was to better understand the use of existing tools within design and thereby contribute to the design of future software tools aimed at supporting the early phase of the design cycle.

2 Method

As part of the BA in Interior Design at Napier University, final year students undertake a design project in the second semester. The projects typically address the re-design of an existing building. Two students agreed to participate in a series of fortnightly interviews during the course of their projects. Each participant was assured that the study would not impact on the final mark allocated to their project. Interviews were conducted in the designers' normal working environment over

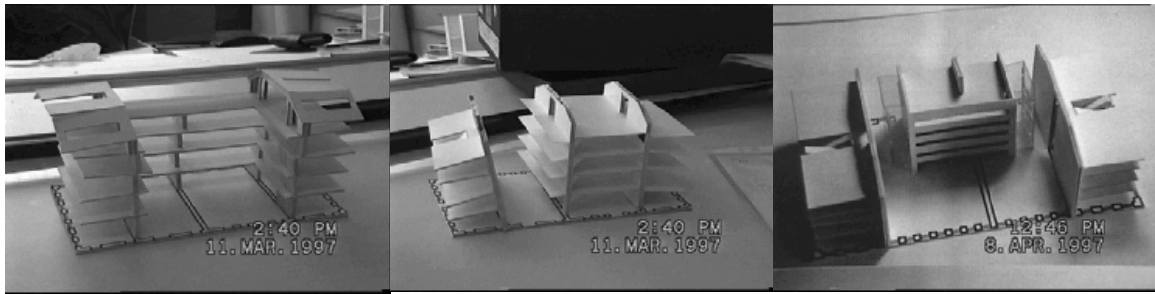


Figure 1 Initial development models

a 3 month period and were videotaped. What follows is an account of the activities undertaken by each of the designers as they sought to complete their respective projects.

2.1 Case study 1

This project involved the refurbishment of an 1813 warehouse in the Leith district of Edinburgh. The building consisted of a four stories which, together with a bonded vault basement, formed an enclosed block. The aim of the design was to create alternative housing, design studios and a gallery where artists could both live and work. The designer described the aim of the project as follows:

“the creation of a community that lives and works but also invites the public in.”

The initial planning stage of the design was characterised by the construction of a series of development models (Figure 1) with the purpose of enabling a better feeling for the actual space and possible locations of elements within the building.

As part of this phase a model was developed using a CAD system¹, the designer considered this as vital to the study of both size and scale of the building. This activity, referred to as building, provided a means to reflect on design ideas. Interestingly, the explanation provided for both the development models and the CAD based model were similar, namely that of enabling a more detailed understanding of the proportions of the space. The CAD system was considered to have the further advantage of enabling visualisation due to the ease and speed with which views and sections could be created.

The planning phase was characterised by a two stage process where development ideas were

sketched by hand and then input into the CAD system. This second step enabled the designer to accurately visualise how the proposed element might fit within the building, it was only after the successful conclusion of this activity that the designer felt that the idea could be incorporated into the ongoing CAD model of the building. The ability to save the model of the building and then to use it as a basis for exploring the viability of alternative designs was an important facility of CAD. Interestingly, this process appeared to occasionally act as a catalyst for the generation of new ideas. This might be linked to the speed at which perspective views could be generated and the greater understanding of the building space and proportion that these offered. The approach was succinctly summarised by the designer in the following phrase:

“precision is everything.... if I put it on the computer then I will know for definite”.

The designer summarised the advantages of CAD as follows: the explicit accuracy associated with output; the fact that such output could be used as the basis for freehand sketches; the resulting speed of idea articulation; and the production of cleaner, clearer drawings, which aid the communication of ideas. Two problems were also identified: firstly, the continual need to zoom in and out, resulting in the loss of sight of the building and secondly an inability to see all of the information. A possible solution was suggested by the designer when they commented that,

“...it’s as if the computer screen should be the size of your whole desk”.

These comments were considered to be indicative of the integration of CAD into the

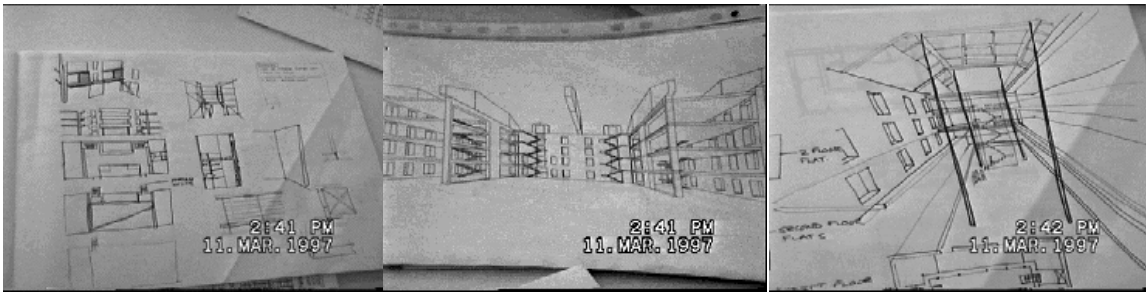


Figure 2 Examples of an early freehand sketch, a perspective view generated by CAD and a combination of the two techniques

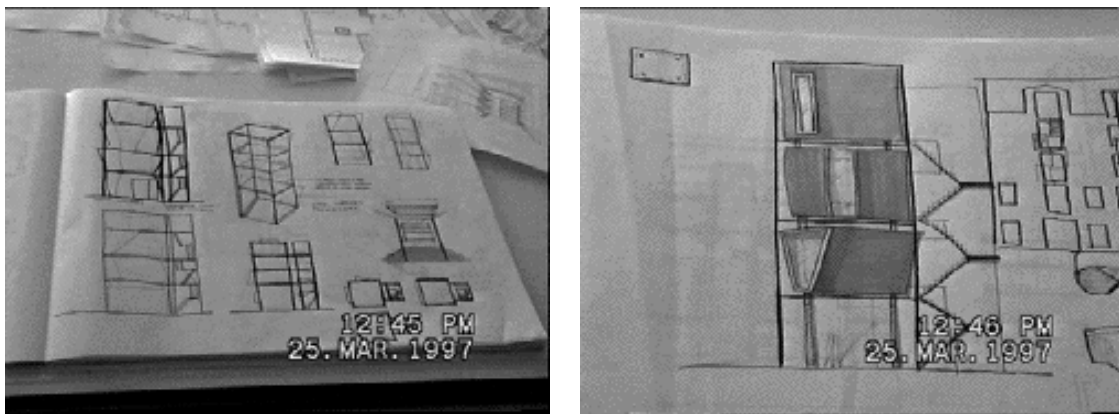


Figure 3 Development sketches of the proposed gallery

designer's repertoire of visualisation tools, the output from which is illustrated in Figure 2.

The proposed gallery design posed problems throughout the project. Previously the decision had been made to place the gallery on stilts in order to enhance the overall feeling of openness within the courtyard (Figure 3). Critically, the decision was made to set the structural columns back within the gallery itself thereby reducing the sense of heaviness

associated with the structure. Internally the gallery was felt to be overly complex. For example, one idea was to incorporate moving partitions. These ideas were developed by means of a balsa wood model, which was later rejected (Figure 4). Interestingly, a physical model was built to enable the consideration of the problem in the context of the whole structure, whereas CAD drawings were felt to sometimes result in failure to include certain elements that might impact on the viability of

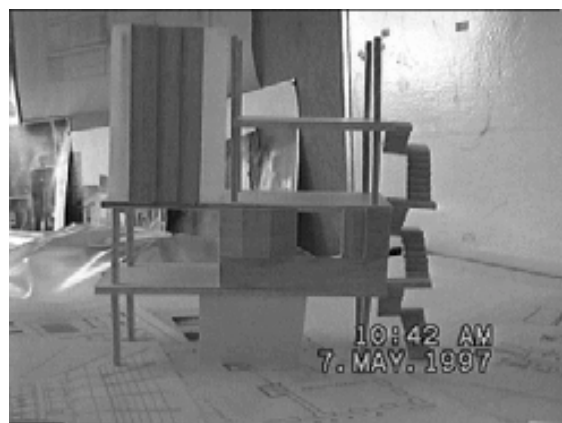


Figure 4 A model of the gallery, later rejected as too complex

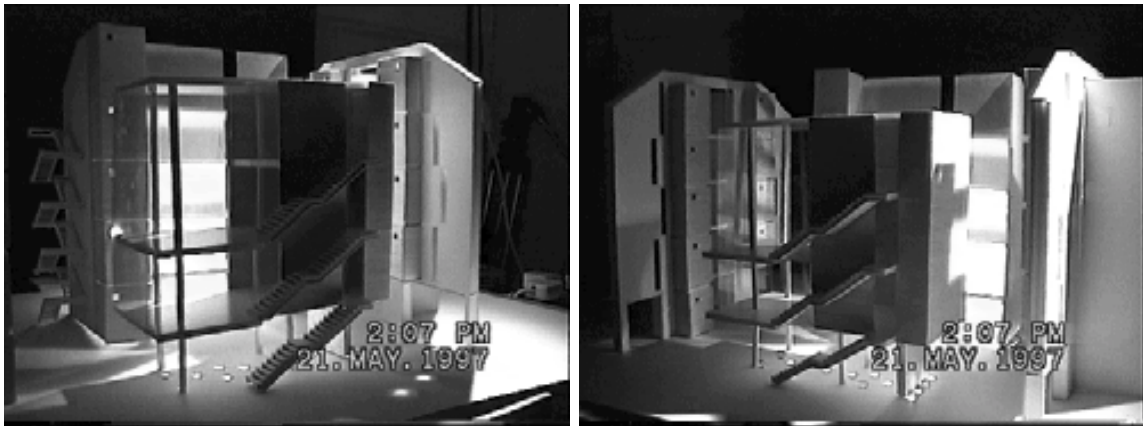


Figure 5 A lit model of the building and gallery complex

the idea. The conclusion of the design was marked by the completion of the gallery (Figure 5).

2.2 Case study 2

This project addressed the refitting of a 1912 building in Glasgow into a recording studio. The building comprised a basement and a ground floor. Initial concept drawings were produced by tracing the original plans for the building (Figure 6). These drawings facilitated visualisation and were a preliminary activity prior to the generation of scale plans.

At this stage a physical model was constructed with the purpose of enabling the designer to manipulate and consider the building space. The designer also expressed a desire to utilise CAD early in the design process, but admitted that there was no intention to use it for planning, only for visualisation. The designer described a number of advantages offered by the building of physical models against those

of CAD: faster to produce, this was later acknowledged as possibly due to the designer's inexperience with the use of CAD; the ability to physically manipulate and therefore visualise the space; particular elements could be added in order to get a feeling as to their viability and finally the ability to generate a photographic record of the model's development. The designer concluded by making the following distinction:

"physical models are good for manipulation, CAD provides the illusion of manipulation."

In order to facilitate the planning phase of the design, in particular the location of equipment associated with a recording studio, the designer opted to use freehand plan sketches but acknowledged that these were not to scale and there was always an element of doubt as to whether the planned layout would indeed fit into the building.² Plan sketches produced

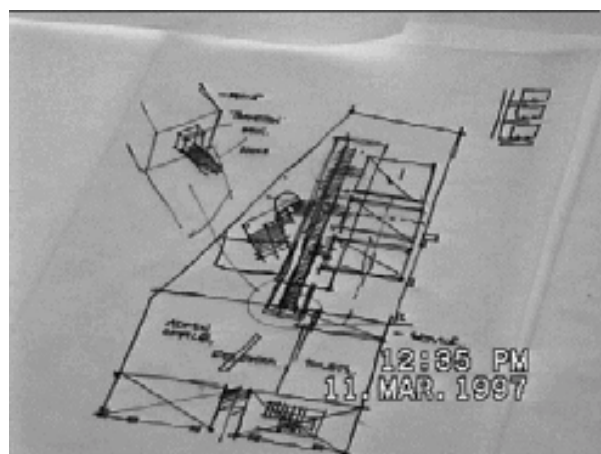


Figure 6 2D plan concept drawing



Figure 7 Perspective drawing produced by CAD, then hand rendered

by freehand were used to visualise possible layout combinations as these were considered to be fast and easy to produce. The designer's strategy was to iterate through the sketching process, in conjunction with building the physical model. This phase of the design would be completed by building the model in the CAD system for the purpose of generating perspectives. A hand rendered version of one such perspective is provided in Figure 7. This method was reported as being quicker than building a physical model, and the designer commented on the ease of calculating the perspective viewpoint. The ease with which CAD could generate more complex perspectives was viewed as a positive advantage and it was considered that their interpretation was increased markedly when rendered by hand. The designer commented that such perspectives appeared to provide a similar level of both explanation and exploration as physical models. CAD was seen as adding the further advantage of enabling

the validity of concept ideas to be easily checked in the context of the scaled building.³

Throughout the project the reception area remained problematic, late in the project some major amendments were made to its layout. The rationale for this reflected a dissatisfaction with the previous solutions but perhaps more interestingly revealed an acknowledgement of the designer's difficulty in breaking out of the previously unsuccessful ways of thinking about the problem. In their own words:

"I just had an idea and stuck with it maybe I should just ... every time I did a new drawing I just used that (idea). I should have just started again."

The revised layout for the reception area now included an opaque glass panel which divided the private offices from the public reception area (Figure 8). It was envisaged that such a panel would incorporate lighting from below.

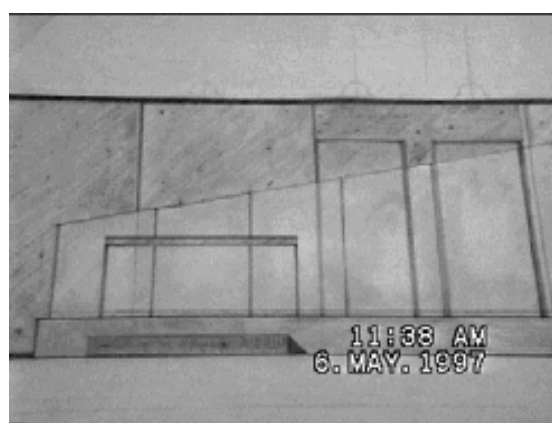


Figure 8 Development sketch and rendered elevation of partition in the reception area

A series of elevations were produced to explore the validity of the solution. The resolution of this issue marked the completion of the design.

2.3 Discussion

A recurrent theme of the case studies was the support of visualisation offered by design tools. Visualisation was characterised in relation to the designer, where it was conceived of as a means to explore the problem at hand and in terms of the client, where it was described as providing a vehicle for explanation of the design. The study revealed how the designers conceived of the roles of these tools within the design process. Perhaps the most ephemeral findings were attributed to the part played by physical models which were characterised as enabling the consideration of the problem in the context of the whole building, rather than the more limited views provided by drawings and CAD. A further quality attributed to physical models was that they enabled the designer to manipulate through touch a 3D representation of the building space. The sense of engagement provided by such models was viewed as something qualitatively different to that provided by drawings, whether produced by hand or by CAD. The characterisation of the designer as 'thinking with their hands' while creating or manipulating physical models supports the findings of Candy and Edmonds (1996) and Roy (1993) and echoes the sentiment of Schon (1983) when he described the act of drawing in terms of the designer conversing with an image. Such an intimacy between the designer and the tools for visualisation will clearly have a profound impact on the nature of input/output devices associated with technology aimed at supporting the early phase of the design cycle.

Throughout the case studies drawing always took place. In the early creative planning phase of the design, drawings were usually in the form of 2D plan sketches. While varying in terms of scale and degree of content, these sketches enabled a rapid articulation of design concepts. The complementary features of flexibility and speed associated with hand drawn 2D sketches were considered by both of the designers to be critical factors during

this phase. In particular, the ability of such sketches to support both the parallel lines of thought necessary for the exploration of alternative design solutions and the marked changes in tempo characteristic of this phase of design. The latter observation supports the findings of McNeil and Edmonds (1994). As design concepts became more concrete, different drawing techniques were adopted. Sectional and perspective drawings played an important role in both identifying and checking planned elements within the building space. Sketching still took place and was indicative of the continual movement between abstract and concrete ideas throughout the design cycle. The use of CAD provided advantages in terms of speed and ease with which perspective views could be generated, although it was the more experienced user who employed the technology earlier in the design cycle. This designer had over a period of time developed a sophisticated method for integrating the rigidity of CAD into a process for the validation of early concept ideas.

3 Technology and design: a co-operative partnership

The requirement for visualisation of both the problem domain and partial solutions was a theme which emerged from this study. Hand drawing, physical modelling and CAD achieved these in particular ways. Both in terms of their representation and their consequent ability to portray certain elements of the problem, and also by their engagement of the designer during the process of production. The process for achieving visualisation would appear to be as important as the end product itself, particularly during the generation and selection of alternative solutions. Indeed, the ability to both generate and present alternatives represents a critical juncture in terms of both the design process and co-operative behaviour. The paper will conclude by outlining a series of research issues which are considered central to achieving the co-operative partnership between designer and technology envisaged by Mann and Coons (1965).

In the context of design, Donald Schon (Schon, 1983) described the presentation and acceptance of alternatives as a move from the

'what if' to a decision which becomes a design node. Design nodes provide a platform with implications for further decisions. Thus there is a continually evolving system of implications within which the designer 'reflects on action'. Similarly, a principal element of co-operative behaviour during problem solving is the creation and maintenance of an environment where solutions can be refined through logical argument and the resolution of different perspectives (Smyth, 1995). Through such discussions the very essence of the problem will be revealed. Essential to this view of co-operative behaviour is the ability of any participant to generate and communicate alternative solutions, as it is these which will spark the iterative process implicit in co-operation (Broadbent, 1973). Alternatives and partial solutions become the currency of communication. In short, different but sympathetic beliefs are vital to a successful and productive co-operative relationship.

If design is conceived of as an active co-operative process, where the role of alternatives are pivotal to progression within the conceptual phase, then it is critical that this issue must be addressed by technologists. One mechanism for generating alternative solutions is the use of Shape Grammars, as proposed by Stiny (1980). This technique seeks to formally represent the rules and objects associated with a particular design style. In terms of its application to technology the approach offers a number of advantages: a method for formally representing existing design styles; a generative capability and an opportunity to apply the reasoning capabilities of knowledge based systems. These rules might be used to generate new shapes in the language of the original. Furthermore, by the provision of a 'meta grammar', it might be possible to provide designers with a mechanism whereby transformations could be applied to produce new shape grammars defining new styles.

A further long term area for research was suggested by the sense of engagement provided by design tools utilised within this study, in particular the haptic qualities associated with physical models. How might technology provide designers with such

essential attributes? Indeed, the level of indirection that technology introduces between users and their workaday world has been an important factor in its failure to significantly contribute to the early phase of design (Lawson, 1994). Designers demand tools which provide direct engagement. Current mainstream technologies fail to meet this basic requirement. Possible leverage on this problem might be found in research currently being undertaken at MIT into Tangible User Interfaces. This work seeks to augment the real physical world by coupling digital information to everyday physical objects and environments (Ishii and Ullmer, 1997). Translating this approach into a design context prompts the following question: why should the act of building a physical model or drawing a plan sketch not also act as a method of inputting that information into a knowledge based system? A similar question was asked by John Frazer during his study of physical design models as input devices, in particular his work on the Generator Project and the Walter Segal Model (Frazer, 1995).

The image of a co-operative design partner, ever willing to provide pertinent and timely alternatives and to which the designer communicates by means of building physical models or sketching, may indeed be beguiling. But the difficulty of creating such an environment should not be underestimated and it serves as a timely reminder as to why computer aided design (*sic*) poses such a challenge to designers and technologists alike.

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Notes

- 1 The CAD system used by the designers in case studies 1 and 2 are Architrion V5.8 produced by BAGH of Canada.
- 2 Interestingly, the designer in case study 1 considered the role of CAD as being integral to this process specially because it

addressed the issue of precision associated with design ideas.

- 3 The designer in case study 1, used a similar procedure for validating equivalent concept ideas. Critically, the level of detail associated with the drawings of the designer in case study 2 were much higher than those produced by the designer in case study 1, prior to inputting the information into the CAD system.

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