Design tools as agents of disclosure

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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. Three case studies are reported and a number of conclusions are drawn concerning the nature of design tools and in particular the interdependencies revealed between freehand drawing, physical 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 considering the relationship between designer and technology as a co-operative partnership and outlines a number of nascent requirements for the design of technology aimed at supporting the early creative phase of design. © 2000 Elsevier Science B.V. All rights reserved.

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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 [1] 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 [2–5] 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 Architecture 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. Three 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 a three 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: a ski centre

This project concerned the refurbishment of the visitors centre at the Cairngorms Ski Centre, a four floor 1980s building situated on a slope. The aim of the project, as stated by the designer, was to alter the circulation pattern of the space. Initially a physical model (Fig. 1a) was produced to enable a better understanding of the space and critically to provide a means of visualising the relationship between each floor of the building. The act of building the model provided an opportunity to reflect on the design, while the completed model provided a tangible representation of the building, which could be physically manipulated by the designer in conjunction with the production of plan drawings. As a means of generating ideas, the designer produced reduced scale plan and sectional drawings (Fig. 1b). The designer commented that the reduction acted as a focus, and concentrated the mind on the task at hand, and provided less opportunity for interruption due to the speed of production. Once a number of these alternatives had been generated, usually 4–5, the cycle was completed by drawing the chosen solution to scale.

To illustrate volumes of space, a series of diagrammatic models were produced and colour was utilised to indicate particular attributes of the internal space. Fig. 2 illustrates such a model which was produced later in the design process in order to clarify the demarcation of private and public space within the building. It was interesting to note that, as a result of producing this model, a decision was made to locate all the public spaces to the front of each level of the building. The designer commented that they considered the act of constructing such a model as central to this design decision. The rationale for such models was one of speed of development, for instance, rather than including all walls, colour could be quickly applied to distinguish location and functionality. The ability to rapidly articulate design ideas in tangible artefacts, which could then be examined and discussed, whether in the form of sketches or models, was a recurrent theme during the early stage of the design activity. The models were described as having two main purposes, that of enabling exploration of the problem and providing a basis of an explanation of the problem.

As the design progressed an increased number of sectional drawings were produced which were indicative of an important transition phase in the design. The move from rough sketches which, by their nature reflected a degree of uncertainty in the designer’s mind, to the formality of the sectional drawing suggested an important crystallisation phase. As a complement to this activity, a number of small-scale internal perspectives were produced. These were primarily internals of the building which were coloured to aid clarity. The sketch in Fig. 3a was one of a series of drawings produced in order to visualise the main public area of the building and to consider the requirements associated with such a space.

A further element of the design was prompted by the realisation that the public space would have to meet certain requirements associated with the overall function of the building, for example the provision of tourist material.
Early attempts to design holders, for paper based information material, focused on the use of metal pillars which supported the structure and the development of pod like containers which could be fixed to the pillars. The concept sketches for these elements were produced using a markedly thicker pen (Fig. 3b), which was considered to be quicker and better for the consideration of the overall form. The sketches were annotated and acted as a means of articulating not only the form of the furniture but also the possible function.

The sense of design progression was further suggested with the production of a more detailed balsa wood model of the building. Each floor was constructed separately and could be removed to reveal the layout of the lower floors (Fig. 4). Interestingly the material chosen to construct the

Fig. 3. (a) Rendered perspective of the main public area and (b) examples of concept sketches for information holders.

Fig. 4. Balsa wood model enabling the visualisation of each floor within the building.
The model influenced the designer’s thinking about the choice of finish for the building.

The model enabled the designer to view the building with a natural wood finish and the overall effect was considered to be more appealing than the original idea of utilising colour. The change of approach illustrated the profound influence that model making can have on a design solution, by both enabling the designer to view and manipulate the design, but also to implicitly reflect on the design while constructing the model and so open up new avenues of thought not perhaps available when drawing.

2.2. Case study 2: accommodation and gallery space for artists

This project involved the refurbishment of an 1813 warehouse in the Leith district of Edinburgh. The building consisted of 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 (Fig. 5), 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 system. 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

1 The CAD system used by the designers in case studies 2 and 3 was Architrion V5.8 produced by BAGH of Canada.
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 impor-
tant facility provided by the use 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 the problem of information loss due to its location in various layers of the CAD model. A possible solution to the initial problem was suggested by the designer when they commented that

its 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 designer’s repertoire of visualisation tools, the output from which is illustrated in Fig. 6.

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. Examples of development sketches are provided in Fig. 7. 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. 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 the idea. The conclusion of the design was marked by the completion of the gallery and its integration into the building complex (Fig. 8).

2.3. Case study 3: a recording studio

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 (Fig. 9). 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
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, although 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. Plan sketches produced 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 Fig. 10. 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 the interpretation of such drawings 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.

Throughout the project the reception area of the recording studio 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 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 (Fig. 11). It was envisaged that such a panel would incorporate lighting from below. A series of elevations were produced to explore the validity of the solution. The resolution of this issue marked the completion of the design.

2.4. 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. The designer in case study 2 considered the role of CAD as being integral to this process specifically because it addressed the issue of precision associated with design ideas. The designer in case study 2, used a similar procedure for validating equivalent concept ideas. Critically, the level of detail associated with the freehand drawings of the designer in case study 3 was much higher than those produced by the designer in case study 2, prior to inputting the information into the CAD system.
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. Freehand 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 [1].

In the context of design, Donald Schon [6] 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 [8]. 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 cooperation [9]. 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 be addressed by technologists. One mechanism for generating alternative solutions is the use of Shape Grammars, as proposed by Stiny [10]. 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 [4]. 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 into Tangible User Interfaces.

This work seeks to augment the real physical world by coupling digital information to everyday physical objects and environments [11]. 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 [12].

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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References