A Virtual Design Platform

Bridging Barriers When Designing with Computers

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Abstract: *The paper summarizes the results of a diploma thesis. Taking the potential of computers to be an ultimate design-medium as its premise, the thesis examines how to enhance the way we use digital design tools. It identifies central characteristics of the design process that need to be considered in a digital design environment. Based on a conception of design as a cyclic process involving appropriate design tools, the paper singles out usability, in the sense of ease of use of such tools, as a key criteria for overcoming problems associated with designing on and with the computer. Drawing on these considerations a prototype has been developed which attempts to bridge barriers between the use of different design tools using an existing software framework.*

Keywords: *Design theory, design process; interface-design; freehand sketching; collaboration.*

The potential of the computer as a medium for design

In the last two decades computers have evolved from simple "drawing machines" to become a widely-used "design-medium". Computers offer a vast amount of different design tools. Here, one can distinguish between design-editing tools and tools that support the design process: those with which the designer actively forms and creates his design (sketching, image processing, drafting, modelling, etc.) and those where the computer supports the design process based on input given in the design editing phase (analysis, simulation, research, generation, etc.). Altogether, the potential lies in integrating all the various aspects of a building design in one single medium. Furthermore this medium is not just an extension of the actions of a single person, but also an extension of the contributions of all the other participants in the design process. Designing with computers offers enormous potential, but we have yet to learn to harness it fully.

In this paper, the ideal scenario for designing with the computer is understood as a symbiosis of these two fields together with the ability to communicate seamlessly between all the parties involved in the design process. As promising as this may sound and as convincing many manifestos in the field may seem, this aim has still not been reached in architectural design and planning practice. Once the building has been created and edited with the computer, the most important decisions have already been made. This has several reasons. One of these is the design of the interface between man and computer, which is not conducive to the natural character of designing. Although recent CAAD-research deals

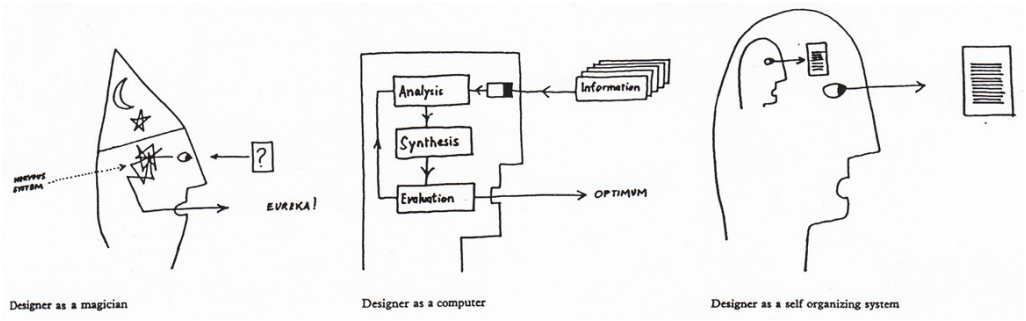


Figure 1
Different theoretical conceptions of the design process over the course of time (Jones, 1968, In: Weckherlin, 2005)

with new, effective or specific design support systems, they only rarely consider how these systems can be integrated in a digital chain, that is, into the process of designing. This question, however, is central to the success of such tools, just as the question of whether and how well thoughts and ideas can be developed on a digital screen. To maximise the potential of this design-medium, it is necessary to examine what characterises the process of designing in order to consider these in the context of a digital design process.

Theoretical aspects of the design process

Many different theories have been formulated about the process of designing. Broadly speaking, one can summarise their development from initial attempts at systematisation using various methodologies (Design Methods Movement), to insights into their inadequacy (Rittel) to a more differentiated understanding (Schön, Lawson, Gänshirt). Here we will examine three main characteristics of the design process in more detail that are crucial for the development of digital design environments.

Design problems are complex

The first aspect to consider when supporting design with the computer is to recognize that design problems are, to a great extent, not operationalizable. Solving each individual part of a design problem, as the first generation of design methods attempted to do, does not necessarily lead to an overall solution of the whole. As Rittel pointed out, these theories failed because they tried to treat design problems scientifically (Rittel, 1973). Such approaches rely on the assumption that design problems are well-defined and operationalizable. However, as Rittel states, designing involves dealing with wicked problems which cannot be described using a certain set of rules. Their specific properties are, for example, that there is no definitive formulation for these problems. The formulation itself is the problem. Every problem is

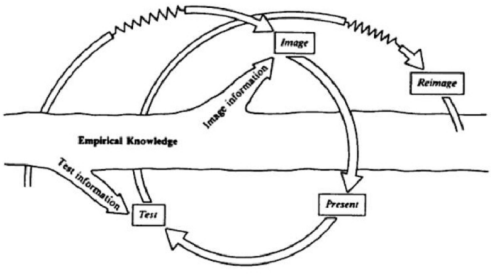


Figure 2 (left)
Design development spiral (from Zeisel, 1984)

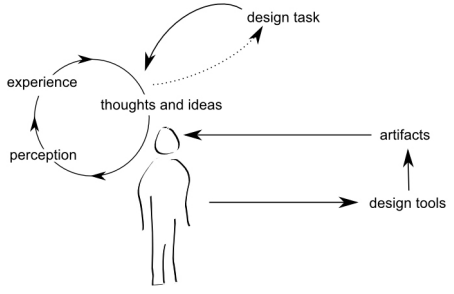


Figure 3 (right)
The design process as a cycle: the tools used are a central aspect of the process

a symptom of another problem and therefore there are no right or wrong answers, and so on. This characterisation of design problems shows clearly that it is impossible to develop algorithms for automating the design process. The computer can only provide support for operational problems. There will always be non-operational criteria that can only be addressed by the designer.

The design process is not straightforward

According to the pioneers of the Design Methods Movement the design process can be structured into three phases: analysis, synthesis and evaluation. The assumption was that after collecting and analysing information, a creative synthesis takes place which can then be evaluated. Influenced in their thinking by the operating principles of the computer, these phases where regarded independently of each other. Rittel (1973) and Lawson (2006), however, argue that these phases are concurrent and inseparable because they are strongly interdependent. Choices are already being made in the analysis phase, which are influenced by the creative mind as well as by the criteria of their evaluation.

Zeisel's postulation of design as a cyclical or spiralling process serves as a useful analogy for the diversity and concurrency of the different design actions. It represents the design process as a spiralling process in which the phases of imaging, presenting and testing recur until a satisfactory result is reached. These phases are informed by the empirical knowledge of the designer and are interconnected through this with each other (Figure 2). That means that there is no clear segregation between imaging, presenting and testing, but a significant relationship in which each depends on the other. The advantage of this model is that it also allows non-predetermined jumps, which can lead to completely new solutions. A sensible integration of computer-based tools must be orientated to this flexibility. The separateness of today's digital tools contradicts this idea of an adaptable, creative process that proceeds as a continuous cyclic movement.

Design tools play a central role

Schön (1983) describes designing as a designer's conversation with the materials of a situation. These materials can, by and large, be regarded as the artefacts crafted using different design tools. Accordingly, the tools used for designing have a great impact on the end result and the process behind it. Gänshirt (2007) describes designing as a loop of indissolubly interweaved thoughts and actions, which are revealed in the single act of design. In this cycle, design tools help designers to externalize their invisible thoughts and to turn them into manageable artefacts (Figure 3). Here the importance of usability – the ease with which tools can be used – as a key criteria for a good design tool becomes obvious: how well and effectively can thoughts and ideas be transformed into adequate representations which in turn can be edited again.

The difficulties and dangers of using computers in designing

In contrast to the enormous potential computers offer, actually working with a computer is still perceived as a handicap to designing (cf. Römer, 2002). To make use of such potential, one is inevitably forced to work within the restrictions of the respective system. A key cause of such difficulties lies in a lack of theoretical consideration of the creative design process, which hinders a wider acceptance of the computer as an integrated design tool. Such barriers in digital systems can be found at three levels. Firstly, at a hardware level, through inappropriate hardware interfaces (display screen, keyboard, mouse). Secondly, at a software level, where excessively complicated software interfaces and functionality hinder the free flow of thought. Thirdly, at a data level, where compatibility between programs is lacking. The problems at each level are therefore closely related to each other.

Hardware level

Bolte (1998) states that in contrast to the natural character of using analogue tools, people often lament a loss of immediacy when using a computer. Virtual objects are manipulated not directly by hand, but rather via complex hand-eye coordination mechanisms conditioned by inappropriate hardware and software interfaces. Computerised operations are often seen as detours, obstructing directly linked actions.

In contrast to the actual presence of physical artefacts, digital ones disappear in the virtual realm. Although available as files, they are intangible and at worst can get lost in diverse virtual folders. It becomes hard to maintain orientation in the sheer volume of different information. In addition, one can only ever see a small part of the theoretically unlimited digital working space. It is often more difficult to recognise relationships to the whole in the space of a small "window" compared with a large sheet of paper.

Another interesting aspect, which can be observed among students and practitioners alike, is that once they have started designing using a computer, it is difficult for them to switch back from the digital environment to use more suitable analogue tools to work on their designs. This reluctance to depart from the digital chain is due to a large degree to the need to change media. Because one has to consciously decide to change, which generally entails several steps, it is often not undertaken.

Software level

The loss of directness is, of course, also a factor of the design of the software interface. Software input often entails operations that do not correspond to the logic and sequence of design steps. Instead of concentrating on a chain of design thoughts one focuses on the functions and operations of the programs. Virtual building models are an important basis for many design tools, but to create them necessitates intensive work up front. To justify this effort the results are often too hastily accepted as good enough. An awareness of the amount of work a decision may necessitate hinders the thinking process and creates resistance to making changes. Connected with this, the computer's ability to work very precisely makes one liable to believe its perfection. Work produced using a computer follows a digital logic which plays no role in reality. The perfection of these virtual artefacts is a result of this logic and gives them the appearance of final products. It becomes difficult to doubt the authority of a perfect visualization, and it is accordingly harder to regard it as maybe just an interim solution. It is also worth noting that when sketching freehand, the movement of the hand is embodied in the emerging visual product. For this reason handwritten notes are easier to remember than typed text. The same is true of virtual design artefacts that do not directly originate from hand movements – one develops a personal relationship to these only slowly, making it harder to identify with them.

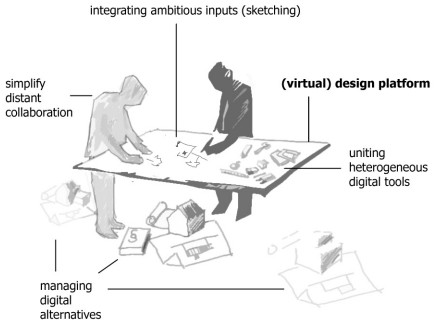
Data level

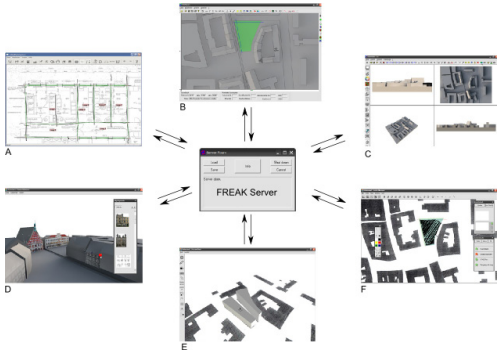
In real life, things and tools are effortlessly combinable. The isolation of digital tools, on the other hand, propagates a certain authority. Switching between different tools becomes difficult because of the circumstance of importing and exporting. Every tool, although located in the same medium, produces a finished end product of its own that is not directly visible in other tools. Thus, changes to a three dimensional model have no impact on a photomontage in which the building is depicted in its surroundings to check how it fits into its context. This lack of fluent compatibility between the different heterogeneous tools leads designers to stick with one single all-purpose software. This software may have restrictions that have an enormous influence on the result.

Overall, in each of the three levels, working with computers requires one to pay greater attention and binds mental capacities. The designer's chain of thoughts is obstructed and there is a risk of losing sight of the larger context.

Figure 4 (left)
Conceptual sketch of the virtual design platform

Figure 5 (right)
The client–server concept facilitates a seamless link between different heterogeneous design tools





An ideal digital design environment

Building on the aforementioned theoretical considerations, this paper presents a concept and prototypical implementation of a "barrier-free" digital design environment (Figure 4). The aim of this approach is to minimize the obstacles and the resulting dangers when using computers for designing to in turn maximise the potential of the design medium (design support and collaboration).

The prototype builds on a pre-existing software-framework called FREAK, which has been developed previously at the chair of computer science in architecture at the Bauhaus-University Weimar. This framework already supports several single software solutions for building surveying, designing and design support (Petzold et al., 2007), but they have never been brought together to form a consistent design environment. As a result, an experimental "design platform" has been developed according to an understanding of design as an open and flexible process, as discussed earlier in the paper. In the following the four main aspects of this platform are outlined briefly.

Coupling heterogeneous tools

The central concept of this "barrier-free" design environment is the independency and seamless integration of different heterogeneous design tools (Figure 5). This is intended primarily to enable the designer to use digital tools as flexibly as possible, bringing together different content in one single model. The ability to unite all the information that arises in the course of a design process facilitates fluent interaction between the clients, so that no barriers originate at a data level. This seamless transition between the tools corresponds to the notion of a cross-linked cyclic design process, because the different clients, which each serve different purposes, can be used in any order or combination but remain in the context of the entire digital model. Changes to the digital model immediately affect the model representation in all the other clients. This flexibility is made possible because information created with the respective clients is automatically managed by a top-level hierarchy in a special data structure. This project database serves as an open container for every possible data structure. It is easier to design creatively using this system, because the designer doesn't have to think about the organization of different kinds of data (models, drawings, images, sketches, simulations, etc.) and can concentrate more on thoughts and ideas concerning the design itself. To maintain an overview over the huge quantity of heterogeneous information in one single model, the content of the individual clients can be displayed as layers in the design environment. The content of each individual layer can be selected and their visibility changed. This allows the designer to work selectively in the digital working space.

Sketching in a virtual environment

Sketching is one of the most important and most used tools for designing but it is rarely integrated into digital systems. Graphical tablets or tablet-pc computers make it possible to sketch freehand in the digital design environment. By seamlessly integrating sketching (as one the different heterogeneous tools) into the design platform, ideas can be transferred easily to the screen. These sketches assume the role of mediators, serving as intermediary stages for the further editing of the model, and make it easier to actively identify with the abstract geometry displayed on the screen. Sketches can be added immediately to any view of the building and are stored in a digital sketchbook in the central project database. This ambiguous level, which overlays the virtual model, allows ideas and intentions to be quickly transported to the virtual environment. These approximate, graphic statements may be followed up by transforming them into models "by hand". The digital model is used as a sketchpad, and the sketch in turn provides a source of changes to the virtual model. The analogue and digital are intermingled in a single data structure. Sketching "above" the virtual artefacts stimulates visual thinking, whereby the designer can identify with virtual representations. It also facilitates communication in a spatially decentralised design process. The most essential aspect is, that ideas which arise while viewing or editing the virtual building design, can be noted down as and when they arise and are stored so that they correspond to the relevant item or view (Figure 6).

Managing the design path

A final design always represents a single option out of a theoretically infinite solution space. The process leading to this result has been described as a cross-linked cyclic process. On account of its near-unlimited storage capacity, the computer has the potential to record this process with all its intermediate steps. The difficulty in recording the design process today lies in the fact that different options, or alternatives, are ordinarily saved in separate files. The subsequent comparison of alternatives takes place in separate program windows or different programs. The result is often an almost inscrutable number of files, often with a cryptic nomenclature. The elementary process of generating variants, reduction and selection (Rittel, 1973) is hindered instead of being supported.

The concept for managing design variants in the proposed prototypical design platform simplifies the creation, comparison and combination of design variants and allows one to jump back and forth through the entire design process. It takes into consideration all the connected tools and allows one to explore one's own design path. To facilitate this, an easy to use navigation method for switching between alternatives and perusing the design path has been implemented. Forgotten or discarded approaches can be reviewed, taken up again or combined. The designer should be able to work in parallel on different alternatives without having to think about the file organization. The emerging selection of different design alternatives can later on be analyzed through performance simulation and compared directly with each other. Soon it should be possible to combine alternatives or individual elements thereof with other alternatives to create new design variants. The goal is the emergence of an organized structure without the need to define a structure oneself. This in turn facilitates a self-evident, almost natural way of working with the emerging digital variety (Figure 7).

Connecting to others

Digital technologies enable one to bring together different views and contents of a design project, which can be edited by different participants in different locations. This has enormous potential, particularly given today's changing working conditions. An important aspect is that all participants have access to a consistent data-basis and are able to communicate via this effectively. The proposed system therefore facilitates fluent cooperation in heterogeneous working spheres. Because all partners access the same database via TCP/IP, an effective

Figure 6 (left)
Freehand sketching integrated seamlessly within the digital design environment

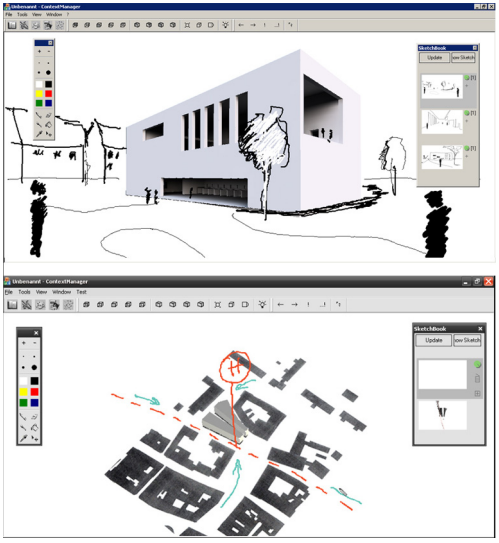
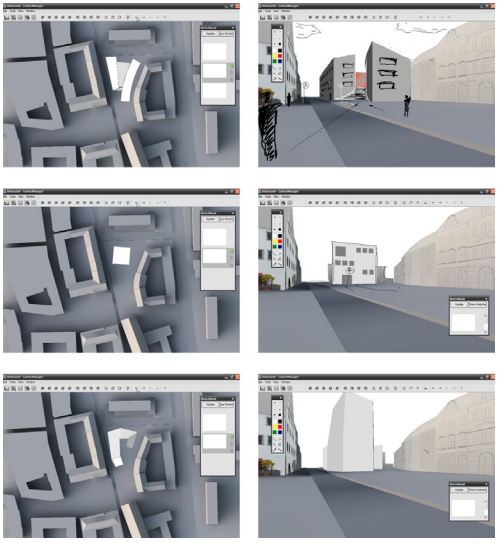


Figure 7 (right)
Different design alternatives remain in the central database and are directly accessible in one homogenous design environment



communication platform emerges. The model, resided on a central server, can, therefore, be edited by every design partner with their own appropriate specific tools. Access to the model is not only possible separately and in succession, but also simultaneously. Everybody can see what all the others see. By using a communication platform of this kind, the various trades are not restricted to separate views in distinct specialist programs on dislocated computers, but work together directly on the same integrated digital building model. Together with the three aforementioned points – sketching, uniting heterogeneous contents and managing alternatives – the virtual building model, and its development process become clearer and can be discussed more easily within the overall context. Individual perceptions are not maintained separately on distributed computers in specific programs, but become "public domain" in the virtual building model.s Everybody sees what the other concerned parties see, helping to prevent conflicts that can arise through remote communication.

Conclusion

Due to the fact that digital media has been adopted widely in the architectural design process and the enormous potential this development can offer, this paper reiterates how important it is to consider the particularities of designing in digital systems. With this in mind, we have presented a concept and prototypical implementation of a "barrier-free" design environment within the scope of an existing research software framework, which continually gets extended. Although at present it is difficult to achieve the aim of such a "barrier-free" design environment using commercially available systems, we regard this approach as a role model for the further development of CAAD. Digital design support in a consistent digital chain can only benefit architectural design when the natural process of designing is not hindered by its tools.

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