Go to contents 16

Design communication in immersive virtual environments:

An initial exploration

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Using Virtual Environment (VE) to visualize ideas from the initial steps of design, the architect is challenged to deal with perception of space, solid and void, without translations to and from a two dimensional media. In this moment, we may expect new forms of design expression.

The goal of our study was to identify how designers use and communicate early design ideas by using immersive three-dimensional VEs. We explored initial intentions of 3D-immersive design schemes, textual descriptions and collaborations within immersive VE. We set-up a series of experiments including navigation- and perception-tasks, designing in immersive VE, transcription of design, remote communication between design partners and controlled observations. The paper describes these experiments.

Finally we summarize observations from this research, for instance the simplicity to interconnect design-ideas cross platforms, conclude with possible future directions of our investigation, initiating a broader research including other disciplines.

Keywords: *Virtual reality, design processes, communication methods, preliminary design, evaluation.*

Introduction

Virtual Environments (VE) have been proposed as a useful tool for architects and designers (Schmitt, 1993). Immersive VEs offer potential for new expressions for designers (Novak, 1996). It is suggested that the exploration of space, volume, solid and void can be aided by direct representation in three-dimensional space without intermediate representation in two dimensional media, such as paper and pen, or scaled models (Brooks, 1993, Dorta and LaLande, 1998)

By locating the influence and the relevance of VE on the perception of space and design of architectural structures, it may be possible for designers to develop new tools and idioms to express themselves in ways not previously explored (Campbell and Wells, 1994).

In this experiment, however, we examined the outcome of design exercises in which we find acts of creation, interpretation and communication in preliminary design stages. To do this, we used immersive design tools together with text-based communication in a series of collaborative design experiments to reveal both products and processes of design in VE (Kvan et al. 1999). We wished to identify how designers use and communicate early design ideas by using immersive VE (Campbell, 1996). Therefore we employed a Virtual Environment Design Studio (VeDS) to investigate how architects use this new media in an initial design phase. (Schnabel et al. 2001). We wanted to identify if an immersive VE would have a positive impact on the development of design, its communication and understanding.

Playground and Helipad

The Virtual Reality Architectural Modeler (VRAM) (Regenbrecht, et al. 2000), developed by the Bauhaus-University Weimar (BUW), was upgraded with a new input-feature based on recognition of gestures in order to create and modify three-dimensional primitives within VE. With the help of a typical immersive VR setup, such as a Head Mounted Display (HMD), a tracking device and stylus, users are able to translate simple gestures into 3D shapes (Schnabel et al. 2001). In order to avoid an overload of the designers' capacity of cognitive processing, the visual translation of the space (3D model) and the possibilities of the software (gesture library, walk-through, zoom, etc.) have deliberately been limited.

In order to capture the thinking- and communication process, we teamed up students in pairs to act as an enlarged brain thinking aloud: while one team-partner is using the HMD and designs within the VE, the other is following the action on a monitor and communicating their common ideas and creation with a remote partner by using a chat-channel (Wong & Kvan, 1999). To be able to facilitate the constrains and opportunities of VR, we developed two tasks, which allows the designer to create freely with in VE.

The first task, building up upon a study by Kvan et al. (1999), was to design a playground for a toddler's school, which is located on a rooftop of a high-rise building (Figure 2). This is a common scenario for the Hong Kong urban environment, in which due to land shortage, multipurpose building have to be designed. This first design challenge was also used to make students familiar with the equipment as well as the different representation of design. It was our intention that students free their minds of traditional design-proceedings and explore the medium plus their ideas. A playground as the design challenge supported that purpose (figs 2 & 3).

The second task was to design a landing ground for helicopters in Central, Hong Kong. This particular task reflects the perspective and movements possible within VE. (Schnabel et al. 2001). A model of the central part of Hong Kong was given to the students (Figure 3). These design studios were set up following well-known Virtual Design Studio (VDS) manners, with two exceptions. The whole design studio had to be finished within 4 hours of concentrated and continuous working and participants could only use immersive VR to create their design. Text-based descriptions via online chat-channel allowed additional information of the design, its intensions and presentation to be communicated.

Results

The intention was to use immersive VE as a tool to create and communicate design as part of a whole design-process. The studios served as base for further exploration and development of the design-task. The results are therefore only slices of more extensive development and not wholly elaborated and finished

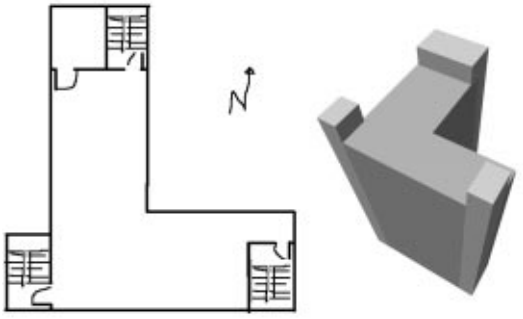


Figure 2: Plan and Model of Playground (plan was not given to students)

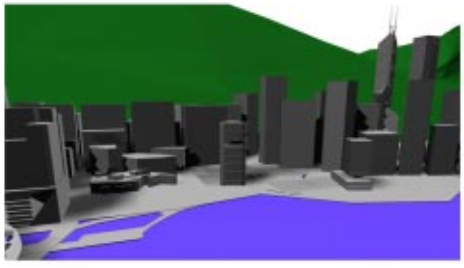
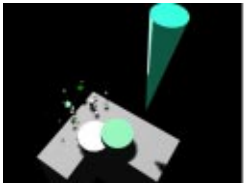
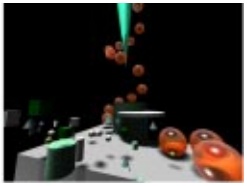


Figure 3: Screenshot of Hong Kong-Model with the site of the Helipad (middle of picture at waterfront)

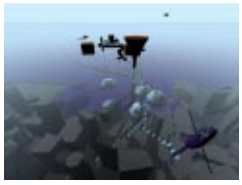


Figure 4 (left): Users are involved (in terms of scale, viewpoint and navigation): design that uses the flexibility of VE, offers to explore structure and its spatial impacts on the creations (Playground, VeDS104)

Figure 5 (right): Primitives representing functions or forms, independently of their actual 3D shape (HeliPad, VeDS'10, Phase 3 - 4)

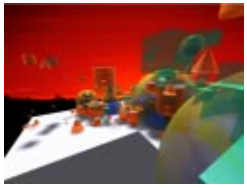



Figure 6 (left): Primitives can symbolize both positive and negative representations of design-elements, remaining interpretable by viewers of the model (HeliPad, VeDS108, Phase 2; Playground, VeDS112)

Figure 7 (right): Lack of experiences or complexity of the VE, created errors, which are transformed into 'meaningful' architecture (Playground, VeDS103)

schemes. The results are initial exploration of the participants' ideas and act as visual communication tool of its meaning.

Initial reviews of the graphic results suggest that the students used the three-dimensional design space actively. Volumes were created to represent design elements at all cases within the 3D design space available. Typically, a design created in a 2D space would have located elements in plan with some raised in section/elevation to create three-dimensional spaces. In this experiment, however, the students started 'drawing' the design elements at all points above the ground plane. Observation during the creation of the design show that participants did not use a 'bottom-to-top' (floor by floor), an 'inside-out' (function defines form) or 'outside-in' (form defines function) approach to their design. Students mostly used an integrated design-method. Being virtually inside the model, they sculpted their proposals, employing the flexibility of viewpoints offered in VE. They explored the spatial impact of their design proposals in relation to existing forms and activities from outside and within the model (Figure 4). Although the input systems were crude and clumsy, users rapidly learned to represent their design intent by using representational volumes: cubes and spheres (Figure 5). These primitives symbolized both positive and negative representations of space. Viewers of the model, however, were able to understand this ambiguity (Figure 6). In some cases, because of lack of experience or the complexity of the VE, errors or coincidences were transformed into meaningful architecture (Figure 7), a design behavior observed in more traditional 2D design environments as well (Schön and Wiggins, 1992). Other instances

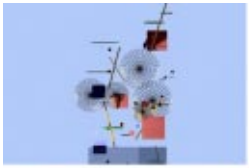


Figure 8 (left): Plan and perspective of design with an image by Kandinsky as mental inspiration - image added later by student (Playground, VeDS106).

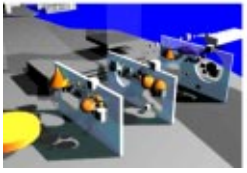


Figure 9 (right): Differences in design- and operation-skills as well as architectural language can also be observed (HeliPad, VeDS'06, Phase 2 - 4)

demonstrate that students were inspired by their three-dimensional model and translated their design back to a (mental) two-dimensional image (Figure 8). Differences in design- and operation-skills as well as architectural language can also be detected (Figure 9).

We expected a high number of navigation-/ orientation discussions as well as explanations of meaning of elements placed in the scheme. Surprisingly, the chat texts show only a few lines of such conversations (Table 1). This suggests that participants could not only orientate themselves easily within the VE but also were able to abstract and extract the design-intent of the remote partner without much difficulty (table 1).

While the text records do not, on initial examination, identify how or why the students were using the three-dimensional space in these ways, we do find records of intense discussion about design, functions and concepts (Table 2). Students engaged in design discussion and development of the scheme referring to what they saw in the model provided by their distant collaborators. The time-limitation of the different phases lead sometimes to shortening of the textural description or simplifying of the model, depending on the skills (table 2).

Discussion

Designing within immersive VE offers new expressions to designers. VR is a constructive tool to support the design and communication process (Davidson and Campbell, 1997). Other VDS reported a lack of collaboration and communication (Kvan et al., 2000), however, our experiments showed the opposite. Chat-protocols show participants remarking to each other that the collaborative experience was satisfying. The exploration of space, volume and location is enhanced and site-specific problems are not only better recognized, but also possibilities are investigated, which a normal design process cannot offer (Campbell and Wells, 1994). Users of immersive VE can change their viewpoints and escape gravity,

Table 1: Excerpt from Chat line of Phase 2: VeDS107 (hoiman) and VeDS110 (pakling)

pakling@hk	*we are creating the steps leading to the sky helipads....(using cubes)*
23/2/2001 3:21 PM	
pakling@hk	*maybe think cylinders would be appropriate.....*
23/2/2001 3:26 PM	
hoiman	*good! hum u can see...there is a cylinder beside the pland platform...*
23/2/2001 3:26 PM	*we think they are the back office for the helipad..*
pakling@hk	*we may create cubes and spheres.....*
23/2/2001 3:27 PM	

Table 2: Excerpt from Chat line of Phase 3: VeDS107 (hoiman) and VeDS110 (pakling)

hoiman	*may be you can make the modification for us...*
23/2/2001 15:34	*but we think the helipad should a little bit higher than the buildings surround…*
pakling@hk	*we would modify our objects... so as to connect to your helipads*
23/2/2001 15:35	
hoiman	*hey....i have an idea...can we have some connection to the surrounding buildings*
23/2/2001 15:35	*...since it is much more meaningful that the helipads can serve the other commercial buildings.*
pakling@hk	*ok...we would see if we can achieve that...*
23/2/2001 15:36	
hoiman	*i think a few connections to the adjacent buildings such as the Central Plaza and the Attic*
23/2/2001 15:39	*building and the Academy for Performing Arts building would be nice..*

but remaining all the time 'inside' the model without having to translate scales or dimensionalities. Designer work more three-dimensionally because every creation within VE is a place experienced directly through movement and interaction. This possibility forces a different dispute with their own design that otherwise is not obvious or possible. Spatial issues are addressed, similar to experiences of physical real buildings. Despite the technology used and the abstractness of VE, the process of design becomes 'human' that enhances the translation of the designers' and users' mental intention.

VE offers designers a tool (such as VRAM) that allows conceptualization of design ideas in a finer way: Digital three-dimensional models are generated with immediacy similar to physical models, constructed to improve the perception of designs developed by drawings. VE provides through its involvement an immediate feedback to its users, which is not possible within CAD or traditional design media. Thus it is possible that VE can replace "modeling" as CAD has replaced "drafting".

Our experiment has shown that immersive VE can support an instantaneous, direct, scaleless and intuitive control over a (three-dimensional) design. However, VRAM capabilities do not match the sophistication of today's CAD software; it can supplement, but not replace, other design media. An immersive and easy-manageable environment is needed before immersive VR can change effectively the design process outside our research conditions. This can then be used on a broad base in normal architectural and related applications.

Problems with the working environment clearly limited what the designers could do. In particular, clumsiness of gesturing and limited field of vision constrained use. The HMD hindered users; particular problems encountered were the wiring entangling arms or legs; interference of and sensitivity of the tracker; lack of precision in gesture recognition and insert-points of elements; polygon size of models; frame rate of display, rendering and calculation time of models; cost of equipment; inability to support multi-

user, multi-viewpoints and networking of VEs are all issues that deserve attention.

Conclusions

Immersive VEs play increasingly a role in the design and form finding of architectural creation. Virtuality becomes in that sense reality. Possibilities, which have only been imagination of creators, can now be visualized and communicated to both professionals and laymen. Our experiments prove that visual perception, mental images/workload, errors, comprehension of design and its communication, frequency of creation/feedback/modification-loops as well as impact on the design-creation, can create alternative solutions to conventional design methods. Technical solutions are constantly improved and equipment is becoming more sophisticated, affordable and easy to use. Immersive VE combined with other technologies, such as rapid prototyping and automated construction methods, give designers a set of tools, with which they can express different ideas in a for most users straightforward manner. VE is becoming an easy to use tool for everyone, which creates, visualizes and communicates ideas.

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Go to contents 16

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