Virtual Reality Used in a Collaborative Architectural Design Process

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Abstract

This paper presents a project and where the possibilities to use Virtual Reality in architectural design processes are examined. The main goal of the project is to develop a process for collaborative design of laboratory layouts using VR (Cave-technology) as a tool integrated into the concepts of Process Architecture. The project has been carried through in co-operation with the Chemical Department at Lund Institute of Technology/Lund University. It is a "real" project integrated in the University's programming process. A workshop initiated the design process and was followed by a series of different design events, which were arranged with the participants from one research and one education laboratory. At these events the participants made several visits to their future labs in a VR-Cave. The visits were alternated with more traditional design sessions with paper and pencils. The results show that the collaborative design process including VR helped the users by providing a method with which their ideas could be better formulated, analyzed, tested and finally realized. The results from the project have been incorporated into the building program for the new Chemical laboratory building.

1. VR in Architectural Design Processes

The possibilities of using Virtual Reality (VR) as a way of visualization in architectural design have earlier been explored in several different projects [3]. Many of these projects have mainly been concerned with VR as a tool for the architect to better view and understand the design. In this project our focus is on how new technology, used in a context together with other design tools, can be brought into the architectural design process as tools for collaborative design. We therefore try to integrate 3D and VR as a tool in the concept of Process Architecture.

Figure 1. The VR Cave at MediaLab at Chalmers University of Technology

1.1. Process Architecture

The methodology we are using is based on the concepts of Process Architecture developed at the Space Planning and Organization Research Group (SPORG) at MIT [8]. The approach of Process Architecture is characterized by a collaborative engagement of all stakeholders that integrates professional tasks and architecture. It is concerned with design as collaborative activities, and with action research as a means of intervention. The collaborative design process is an individually designed process for each project and is based on a series of structured design-events, which develop the design through collaborative interaction. The

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structured events consists of different design tools and design events, as walkthroughs and design games, which have been developed with the purpose to promote creativity and facilitate common understanding of the design tasks [1]. The concepts of Process Architecture also aims at incorporating the informal and spontaneous activities that take place outside the formalized traditional process

In the traditional architectural planning process strict hierarchy between different stakeholders in the process is maintained in information and design-decisions. The architect gathers information from the users/future occupants in order to form a ground for design proposals and decisions taken by the management. Also the participatory design process is in practice often seen upon only as a method, which makes it possible to better find out and fulfil the users requirements about their work environment. The users are engaged and asked to give information and demands about their needs. From this information, the architect still alone makes design proposals

Contrary, a collaborative design process means that all stakeholders, including users, architect, project leader, facility management, work environment specialists, interior designer and others are engaged together in chosen parts of the design. The role of the architect is in that way double. She/he both has to design the process, be a Process Architect, and design the actual building. In this field of powers, especially in cases when the different roles are played by different players, the roles has to be carefully developed and made clear.

In this project, we have tried to integrate advanced visualization (VR) as a tool, and develop it as a structured design event into the Process Architecture method. In all architectural design processes, it is difficult to communicate with clients and users only with architectural drawings. Some of the participants in the process are not used to these sorts of representations. This inequality in the possibilities to grasp and understand the design proposals which are to be interpreted, creates a situation where an inequality also are established concerning the influence different persons has possibility to achieve on the design process. Other kinds of presentation-tools such as perspectives, axonometries and scale models are therefore often used to facilitate understanding and communication. We think that VR can be an even more powerful tool in founding a common ground for all participants in the design process [11].

2. Collaborative Design of Chemical Laboratories

2.1. Introduction

A case study has been carried through in co-operation with the Chemical Department at Lund Institute of Technology/Lund University, Sweden [6]. It is an actual project integrated in the University's programming process. The building will be executed during 2000-2001. We entered the programming process at a very adequate moment, when all the design tasks and problems still had to be identified and solutions for the new laboratories had to be worked out. Consequently, the participants were very committed and focused on their task. Participants came from two different institutions at the Chemical Department; from one research laboratory at Organic Chemistry and from an educational laboratory at Inorganic Chemistry. Our process started with a spread out workshop March and April 1999, aiming at analyzing the future needs and making actual proposals of how to design new laboratory work areas. They participated in our project together with people from the University's facility management and administrative staff, architects, researchers and others. The proposals from the workshop where then modeled in 3D, simulated with VR software, and at two different design events, May and June 1999, brought into a VR Cave at MediaLab at Chalmers University of Technology, Sweden. The visits in VR were alternated with more traditional design sessions with paper and pencils. The proposals from the project have been incorporated into the building program for the new Chemical laboratory building.

(The story told in the following about the educational laboratory is only one among several design stories, which took place during the workshop and design-events. We have chosen to focus on this one, because it is a very evident example of what happened during the process. Conclusions in the paper are based on this case and what happened in the common events).

2.2. The Lab Walk-Through

An inquiry and documentation of some lab occupant's work-experience initiated the process. The project-team visited two different laboratories where the work-environment was photo- and video-documented. The project team was immediately confronted with the design issues at stake. In the educational lab, the users already had ideas about how to organize their lab for teaching. As it was an ongoing project, the responsible programming architect had already made a sketch, which appeared as a try to adapt the users ideas to what he thought was the spatial and technical demands of the building.

2.3. Workbooks

From the lab walk through the research project-team produced a photo-documentation, which were presented to the users as workbooks. These were sent out to the participants a week before the workshop. At the workshop, the participants made an evaluation of their work environment as they worked together with the workbooks. The participants worked in-groups of two or three. They made notations in their workbooks of what they found important, either positively or negatively. One of the major problems identified was that there gathered too many students in front of the fume hood during the lessons. That means that besides that it gets uncomfortable and crowded it is also difficult for the students to se what is going on. The safety can also be in danger if the students by accident push each other while they are dealing with dangerous chemicals.

Figure 2. Participants in a "design-game"

2.4. Design-game

A "design-game" was carried through with the purpose to identify different possible organization-structures and communication -processes in a modern lab [10].The participants were equipped with a set of cartoon pieces in different colors and sizes. These could represent different objects and functions and be arranged freely in different relations with each other. With these cartoon-pieces different layouts of the future labs were "played" and designed. It was obvious that the existing sketch from the architect did not fulfill the users own ideas of a good functioning educational laboratory. The architect had proposed a traditional laboratory layout with the benches and fume hoods arranged in rows parallel with the walls [7]. It did not solve the problems with place and access to the fume hoods. When the group were given the possibility to design their own layout, the result was an island of fume hoods in the center of the laboratory. Here the students could better see from all sides what was going on inside.

2.5. Conclusions/Consensus

In the end of the workshop all the participants agreed upon which of the ideas and proposals that had been developed in collaboration during the workshop should be kept during rest of the process and modeled in 3D and VR. The conclusion was that the idea with a fume hood island in the middle of the laboratory survived the evaluation of the participants, but they still observed problems with the measures and modules of the building. The architect's idea was therefore still a realistic alternative, and the decision from the group was that both alternatives should be modeled in 3D and VR.

3. 3D model/VR simulation

3.1. Specifications

When the proposals from the workshop where brought into VR cave the 3D-models were built with a standard PC with ArchiCad Version 6.0 from GraphiSoft. The software VR-simulation program was dVISE from Division. Two levels of detail were tested [4]. At the first visit the interior walls, glass walls, doors and ceilings were represented as single colored surfaces. No details like textures, joinery, fences etc. were represented. Nor installation equipment, electric fittings, plants or people. There were directed light but no shadows or reflections. The building was situated nowhere without surroundings. The model could therefore be characterized as sketch model made of cardboard but represented digital. Level- and collision detection did not function. On the second visit two weeks later there were some changes added to the model. Characteristic surfaces had mapped on textures and pictures like carpets, details of cupboards and blackboards. Through the windows you could see the actual view outside the building. Level collision detection functioned this time.

3.2. Cave design-event 1

Two different design events with two weeks in between were arranged with the participants from the workshop. At these events the group made several visits to their future labs in VR. The visits were alternated with more traditional design sessions outside the Cave with drawings, paper and pencils. The design-event therefore consisted of two parts, inside and outside the Cave.

At this first design-event, the users found out that their proposal with the fume hood island only could fit into the modules of the building if they turned the whole lab 90 degrees. The idea emerged while they were inside the VR Cave and was developed around the table over the drawings. The decision by the group was to turn their island proposal 90 degrees and totally abandon the alternative derived from the architect's sketch.

Figure 3. An image from inside the VR Cave.

3.3. Cave design-event 2

At the second visit to the Cave, the changes decided in design-event 1 had been executed and revised in 3D. That means that the laboratories had been rebuilt with the island solution turned 90 degrees. The participants used a great deal of the time to evaluate this model. They were much focused on spatial questions as measures and sight lines. The users idea was confirmed as being the most effective to fulfill the demands of the education laboratory.

4. Conclusions

4.1. "A success story"

The case study convinced us that it worked very well to bring advanced visualization tools into an architectural design process using the methods of Process Architecture. The users of the laboratory were successful in convincing the participants in the collaborative design process, including the management and architect. They could show that it would be possible to build a laboratory for learning where a major design factor was the students possibility to actually see what was happening in the fume hoods during the labs. The architect's proposal aimed at accommodating the users ideas to the building and its technical systems. This would probably have been the winning alternative, if this project not had taken place. The collaborative design process, including VR, thus helped the users by providing a method with which their ideas could be better formulated, analyzed, tested and finally realized. The University management and the architect were where also very pleased with the result.

We are convinced that VR has to be placed in a meaningful context if it shall work as an efficient design tool. You can not just throw the technology in without having a natural relation to the phases and tasks of the design process. That is why we have examined VR as one of the tools in the concept of collaborative design and Process Architecture. Otherwise VR runs the risk of being just an expensive mean of presenting building projects.

4.2. VR helps founding a common ground

The untrained participants see and understand things they would not have done with traditional presentation tools. Examples of this are actual volume of spaces, sight lines, heights of windows and furniture, elements overlapping each other etc. The immersive scale 1:1 VR environment also appears to give a good sense of distances. (But the participants didn't always trust what they saw. They were asking the technicians whether they could relay on the measures as they appeared in the virtual space. When they wanted to be absolutely sure they preferred to relay on traditional tools and used the drawings and a ruler. Maybe this could be replaced by a possibility to get measures in figures by pointing inside the Cave). The VR model therefore strongly contributes to the important step in the design process of forming a "common ground" for the participants.

4.3. It is fun to discover and learn in VR

The conversation inside the Cave is free and creative. The participants have the possibility to direct the promenades themselves. That means that instead of being showed a building project prepared from certain viewpoints by for example an architect, here the participants are free to watch what they want, go were they like in the model. That makes you more active, more feels like a discoverer. It is fun, stimulating and fascinating to meet immersive VR-Cave. You are constantly learning something [2].

4.4. From engaged presence to reflective distance

Inside the Cave the environment immerses you. You get absorbed of what you see and talks about everything that shows up. The conversation moves between careful investigations and questions like "is that distance enough?" "Can you see the blackboard from here?" to rather easy-going, exhilarated conversation, which are both creative and constructive. Outside the Cave, around a common worktable, the discussion turns to more traditional work-mood. You analyze, sketch, measure, and solve problems. The interaction between these two different situations constitutes the design-event [9].

4.5. Low detailed VR models works well in early design phases

One of the sub goals of the project was to find methods for developing time efficient 3D and VR-models, which have a level of detail coordinated with the phases of the design process. The applications of VR in the building sector has until now mainly been focused on the use of VR as a method of presenting projects with commercial purposes. The development of VR as a design tool raises quite different demands. In the design phase there is no time or resources to build every proposal, idea or step in the design process as a fully developed VR-model. When you still are working with the overall structure and volume of the building, you need a simplified design model, which is capable of handling details in a different way. The design decisions have not yet reached the level of technical details, coatings, colors, furniture and so on [5].

The participants in the case study did not pay much attention to the two different levels of detail presented in Cave visit one and two. They were very focused on their own design task, they wanted to know exactly how their laboratories was going to be, and were less observant on the VR tools as such. You can conclude that in this case, the simple and low detail performance of the sketch-like VR models promoted creativity. No bias discussion about irrelevant information in the models emerged. The participants felt that it is possible to change the model, that not everything is finished. These models were not presentation models.

5. Future Work

The project and case study presented here is an ongoing project, which is planned to continue for the next two years. The cooperation between SPORG and Interactive Institute will continue in developing the concepts of Process Architecture in several "real life cases" together with industry. We will go on developing both methods and tools for the integration of advanced new technology into the field of early stages of architectural design, mainly focused on collaborative design of workplaces and learning environments.

That endeavor contains a project where we will develop an interactive "digital design game" and integrate the tools of workbooks and design games with 3D and VR visualization. Our specification includes possibilities to be able to display images from the existing workplace environment together with scenarios and prototypes of the new work environment. You should be able to call a database for different building types, tried solutions and good examples, and to store comments and notations in a memory. We will work with a LCV (low cost visualization) display system where we can project stereoscopic VR environments on a single flat wall in scale 1:1.

The "digital design game" will be built on a modern Computer Game platform, in order to facilitate some of the advanced features available in modern Computer Games:

- Cheap and easy accessible. Can be used on standard PC:s or Game consoles like Playstation etc.
- Advanced 3D/VR representation. Fast interaction with virtual space.
- Simple tools for modeling accessible.
- Technology develops and improves very fast.
- A variety of interfaces available, different input devices, some with physical features as force feedback and level recognition.
- Bandwidth effective means limited demand for network performance so it could easily be distributed via Internet.
- Can present spaces which are inhabited and where you can interact with other players.
- Also possibility to interact with the environment inside the virtual space/world. That means to interact with doors, furniture, displays etc, in built or present technology as screens.
- It is easy to learn.
- Fun to use, that means stimulates creativity and learning.

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