INTERPLAY OF DOMAINS

New Dimensions of Design Learning in Mixed Realities

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Abstract. There is a distance between the idea of a design in the imagination and its representation, communication and realisation. Architects use a variety of tools to bridge this gap. Each tool places different demands on the designer and each, through inherent characteristics and affordances, introduces reinterpretations of the design idea, thus imposing a divergence between the idea and the expression of the idea. Design is an activity that is greatly complex, and influenced by numerous factors. Most researchers of Mixed Realities (MRs) have focused on their use as presentation or simulation environments. It has been suggested that MR can empower designers to express, explore and convey their imagination more easily. For these reasons the very different nature of MR with its unique properties may allow architects and learners to create designs that other instruments do not offer. There has been inadequate exploration in the use of these realms for the acts of designing, as well as in educational contexts of design-learning.

Keywords. Learning, Communication, Interplay, Design Generation, Design Exploration.

1. Introduction

Architectural design within Augmented, Mixed and Virtual Realities has been widely used as a method of design simulation and presentation. Educational and professional settings employ these realms successfully to study, communicate and present architectural designs. The rapid development of digital tools over the past decades has had profound impact on architectural education and the ways in which architects create, converse or appreciate three-dimensional spatial environments (Koutamanis, 2000). Numerous publications illustrate the impact that digital media have had on design studios and propose solutions

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for multi-media design studios and ways in which to make use of Mixed Realities (Maver, 2002). Dave (1995) investigated distributed design studios, Wenz and Hirschberg (1997) studied collaborative design within remote collaboration, while Hirschberg *et al.* (1999) analysed patterns of communication within digital design studios. Mixed Reality (MR) often became an instrument to assess design alternatives and final design solutions (Achten, 2001). Yet, none of the authors looked into the comprehension and conception of designing within MR.

A particular form of design studio emerged in the early 1990s that investigated various possibilities that digital media and Virtual Environments (VE) could offer to the learning and exploration of architectural design. These 'Virtual Design Studios' (VDS) defined *virtuality* as acting while physically distant or as acting by employing digital tools (Maher *et al.*, 2000; Schnabel, 2002). It became apparent that the next logical steps to develop these design studios were to combine real and virtual environments in an MR experience. Mitchell (1995) also refers to the need for an ongoing evolution of digital design studios towards a fully integrated studio where the borderlines between realms are dismantled. In the same way, Chen *et al.* (1998) suggest that human-human interactions could take place within and throughout conventional and computer systems of a new type of virtual studios, instead of through or external to them, as it did in some of these digitally supported studios.

2. Virtual Dimensions

MRs have to be studied together with VEs to comprehend the influence that virtual aspects have on a realm where real and virtual elements merge into a new dimension. Similarly to MR, VEs were originally embraced by archi tects for design concept presentations. As computing advances, increasingly sophisticated interaction and design possibilities are needed and supported (Hendrickson and Rehak, 1993). According to Maze (2002) however, VEs are seldom used for creation, development, form-finding and collaboration of architectural design. Likewise Immersive-VE (IVE), which enables active and real-time interactions with design, has not yet been used widely in the design process. Schnabel and Kvan (2003) report that IVE offers new opportunities and solutions to architectural design problems through involvement in a three-dimensional (3D) medium. They argue that, via employment of IVE to create and realise ideas, the architect is challenged to deal with perceptions of solid and void, and navigation and function, without translations to and from two-dimensional (2D) media. Furthermore, they suggest that VE empowers designers to express, explore and convey their imagination with greater ease. For these reasons, the very different nature of IVE allows architects to create

designs that reflect the three-dimensionality of architectural design to a greater precision than in 2D realms. Virtual Reality (VR) is a constructive tool that supports the design and communication process (Davidson and Campbell, 1996). Compared to conventional computer-aided design (CAD), designing within IVE does not present with the typical lack of collaboration and communication as noted by Kvan *et al.* (2000). The exploration of space, volume and location is enhanced and site-specific problems are not only better recognised, but possibilities are also better investigated, both of which a normal design process cannot offer (Campbell and Wells, 1994). Users of IVE can change their viewpoints and escape gravity, all the time remaining 'inside' the model without having to translate scales or dimensionalities. The research found that designers prefer to work three-dimensionally because every creation within IVE is a place experienced directly through movement and interaction parallel to real world familiarity.

The research findings of a design studio held in an IVE show that this realm produces different architectural expressions and exploration of form and gestalt from those explored with 2D tools (Schnabel, 2004). The design proposals illustrated that the 3D space is explored and used extensively in order to create innovative schemes. This proves that designers can successfully use the medium to create and communicate architectural structures within a normal studio setting. Thus, the process of collaboration and design is enhanced and communication between designers is more focused on the subject itself.

In his research, Schnabel demonstrated that employing VE as the medium for the design process enhances the designer's perception and understanding of 3D form, volume and space. This is true not only for purposes of presentation or simulation, but also for different stages of the design process itself. From the results, it was also identified that a direct translation of information from VE into other real media is potentially problematic. However, similar to the conclusions of Yip (2001), it was found that re-representation and translation into other realms contributed to the quality of the overall design process.

Schnabel and Kvan (2003) also point out that despite the advantages of VEs, a re-representation within other media – or a mixing of realms – will lead to a deeper understanding of spatial design. Hence, an MR will contain intersections of properties of the real and virtual realms, and allow designers to interact within this MR to create, explore and communicate their designs.

An MR offers designers an instrument that allows conceptualisation of design ideas in a finer way, whereby digital 3D models are generated with immediacy similar to physical reality, constructed to improve the perception of designs developed by drawings. Through its involving qualities, MR provides immediate feedback to its users, which is not possible within CAD or traditional design media. Subsequently, architects can negotiate their own design despite the technology used and the abstractness of MR. This process of design

promotes the convergence of the idea and the design intention in a manner that is closer to a normal interaction with 3D media. In that sense it relates to a 'human' interaction.

3. Mixed Domains

In their study, Underkoffler and Ishii (1999) report that MR is a practical medium to aid the design and communication process, and to establish collocated presence for a joint experience in design reviews. This leads to the significance of a shared learning experience, which is an essential part of the curriculum in architectural design. Students need to learn the common vocabulary of designing, its syntax and grammar of communication. Current digital design tools do not make sharing particularly easy. Perceived usability does not originate from a design-related background; rather, it has been adapted from other domains such as engineering. Interfaces in desktop design tools were originally designed to accommodate a single user only and have recently been extended to facilitate the need for 'shareability.' This becomes crucial in the context of architectural design, where peripheral data are used extensively and described through spatial abstraction. Through this, the needs and aspirations of a variety of stakeholders are negotiated and represented. This provides an opportunity to gather data on the necessity of design communication and collaboration between the participants through the means of an interactive medium like MR.

As Schnabel and Kvan (2003) have reported that designers within a VE gain an enhanced understanding of spatial relationships, the designers' *sense of presence* has an important role to play, allowing a finer interaction with the design. Since MR permits a blending of virtual entities with a real environment, it can as a result increase the comprehension of the design proposal. MR creates the ability to move around in space, merging real with virtual models and designs, as well as to change scale. Thus the understanding of the design and its relationship within the architectural context is enhanced, site-specific contexts are better recognised and a variety of options can easily be investigated.

Imagination is part of the process but it is limited by some constraints of communication media and representation. Designers therefore need to apply a variety of tools to overcome these limitations and to allow them to express and communicate their ideas. Schnabel (2002) found that designing within all dimensions of space leads to a richer exploration of the design. Within the different properties of MR designers are also empowered to express, explore and convey their design three dimensionally thereby consequently reducing the divergence between idea and creation. That will ultimately lead to an improvement of the overall design process and its communication. Due to the novelty of the instruments and realm however, there might be some factors that

influence the design outcome that are caused by the use of the new medium. With time and ease of use this will be overcome without doubt and will not influence the act of designing.

4. Innovative Learning

MR as a teaching tool for architectural design offers fascinating new possibilities. Students and teachers can explore a variety of theoretical and practical frameworks in order to understand dynamically and spatially complex relationships. Earlier limitations within either physical or virtual realms are reduced and advantages of both can be merged into one environment. An architectural design studio that employs MR as a tool, allows novices and experts to communicate and collaborate instantaneously. Hence the participants explore, communicate and understand spatial issues in a new way. Designers are able to work interactively as every object within the simulated environment is experienced through movement, interaction and immediate feedback. These possibilities offer a different 'conversation' with the design that otherwise is not obvious or possible. Spatial and architectural issues can be addressed in a manner akin to the real world in which MR enhances the translation of the designers' intention. A certain credit has to go to the experiences that were encountered by the use of the technology and the abstractness of any given model.

Today's common computer hardware and software enable architectural design studios to employ an MR-system and its components easily. There are no longer major technical overheads that have to be dealt with. This enables collaboration between remote partners and a translation of theoretical and practical architectural design issues to remote locations.

Following the arguments proposed by Bosselmann (1998) and (Hack and Canto, 1984), it is important for architects, in the early design stages to use a medium that reflects the complexity and interactivity of the site and the proposed design. Using conventional media to translate architectural ideas limits the exploration and communication of spatial issues. Designing within and understanding a three-dimensional space, MR offers new opportunities to designers. This relates to similar findings of design studios carried out within IVE (Schnabel, 2002).

Seichter and Schnabel (2005) used the ready available MR-technologies to conduct a design studio as base of their research. They studied how designers create and communicate early design ideas by employing MR as a medium for their interactions. Subsequently the study assessed the perception and understanding of the design process within a collaborative design studio that employed MR as a design medium. They examined the relative effectiveness of the MR instruments in enabling the communication between real and virtual representations.

MR offers a platform for teamwork in remote settings. Architects can collaborate with colleagues using an interactive media that supports the design and communication process in a more immediate way than simply the exchange of files. Communication is enhanced through media that relate to the process of thinking, creating and understanding. The MR-studio demonstrates the ability to establish a unique combination of collaboration and communication of an interactive design process that is transparent and immediate. Users of an MR system are more highly supported to investigate spatial relationships and characteristics of the design can be experienced dynamically within the real and virtual environment.

Using an MR system, designers gain a more complex understanding of relationships of their design and engage in a richer communication with their partners about their design proposals. MR contributes to architectural design through an innovative approach thus enabling new forms of design expression.

These findings support Kvan's (2004) postulation that new opportunities arise for architectural design as we move apart by utilising digital tools to reconnect. The sharing of ideas is related to the perceivable and tangible existence of design items as well as the sensation of applying them.

5. New Dimensions

The above discussed MR and IVE Design Studios (Seichter and Schnabel, 2005; Schnabel, 2002), addressed concepts of architectural design creation influencing recent developments in architectural design education. These partly experimental, partly realistic studios explored innovative methods of architectural expression, form finding and communication and developed unconventional solutions. They coupled the studio-learning environment with an in-depth digital media exploration in order to close the gap between skill training and the application of that knowledge to explore new ways to integrate compound design issues. The use of MR and VR as design instruments allowed the participants to create an innovative architectural design language, based on 3D experiences of space with real and virtual descriptions.

MR-design studios rely on the skills and knowledge of the participants. Often however, these skills have to be built up first. For this reason, the training has to be part of the studio and be directly related to the design intentions of the studio. In the above mentioned studios the students acquired most of their software skills and experience of MR design methods within the first half of the semester. Empowered by their new gained skills the students connected their knowledge with their ambition to express their design proposals using a new design language. This amplified their design experience and learning outcomes.

The studio also merged the individual projects into one larger unit and students shared knowledge and skills. This removed them from an individual ownership of their design but allowed them to reflect on their own as well their colleagues' design as a whole cluster of contributions. This relates to earlier research of design studios that were based on the same principle where media were applied outside their normal pre-described purpose, and innovative design methods were deployed through an interplay of media and design explorations (Kvan, 2000; Schnabel *et al.*, 2004).

6. Interplay in Learning

Architectural design studios are an essential learning experience for students. Their traditions and proceedings are well established. These studios are, additionally, informed and supplemented by courses and seminars, which can feed into their learning outcomes. Studios go beyond pure skill training and require reflection upon, and the creation of, knowledge. There can be, however, a gap between skills training and the application of knowledge within the studio context. At the final presentation of their work, students may not be able to identify how they arrived at their solution and to what extent individual contributors informed their design.

This tension is also apparent in design studios that relay on digital media. These studios present the underlying concepts of architectural design using digital communication tools, but also have to provide training in software skills and other technical subjects (Kvan, 2004). The integration of digital media courses into design studio curricula often fails, because the compound acquisition of skills prevents a deep exploration of design and the theoretical aspects involved. Participants can employ digital media tools within a studio context only long after they have mastered the subject matter and acquired proficiency in techniques. By then, however, the studio may consider these skills no longer valid.

A dilemma of semester-based teaching is that students reach their highest level of skill and experience at the end of a term, after which they leave for their break. Students are therefore unable to apply their knowledge immediately. At the beginning of the following term, however, the knowledge and skills they had gained earlier are likely to be either inactive or not employed, and learning foci may have shifted to other aims.

The architectural design studios presented here addressed these issues by integrating the learning experience from the beginning by focusing on interplays of instruments, media and realms that create or inform about the design. The objective of this 'interplay-designing' was to allow participants to understand the impact that each step and variable has on the design and to follow the impact it has on the project. Participants developed and

communicated their understanding of architectural design by utilising their training within the various MRs of the design-studio environment. Because of this, students began to think about design problems in different ways.

The employment of MR allowed students to experience aspects of the design process spatially (in three dimensions), and in detail. Additionally, the overall scale of the design could be communicated using tangible interfaces, digitally controlled devices, physical and digital models, text and sketches. Subsequently the generated design could be linked in a variety of ways to extract or generate new or novel architectural design or understandings of space and form. Additionally, the digital components of the MR could be used in the manufacture of objects for example by means of digitally controlled devices (Seichter and Schnabel, 2005).

Each of the elements created or used in the MR were an essential part of the overall process of design creation. It addresses and expresses certain aspects of the process and its re-presentation. This method enabled a holistic discussion about design, form, function and development, which is significant not only within architectural education, but also in all other dialogues involving spatial representations.

MR-design studios have demonstrated that the problems of MRs are not insurmountable, because technical solutions are constantly evolving, difficulties are resolved and equipment is becoming more sophisticated and easier to use. This is despite the challenges of visual perception, mental workload, errors, comprehension of design and its communication and the different frequency of creation-feedback-modification loops. Since MRs increasingly play a role in the design and form finding of architectural creations, virtuality becomes, in that sense, reality. Following the findings of Gibson and Kvan (2002), this suggests that techniques that produce physical representations on demand, such as rapid prototyping (RP) may have a significant contribution to make to a design process that involves MRs. In educational contexts, whereby the training and learning of spatial aspects and the transfer of knowledge to new situations is crucial, MR allows for a deep learning experience that is authentic and enriched by the experience of direct ‘cause and effect’ on design decisions. Despite the dependencies on technologies, students are embracing new ways of designing and its communication, thereby bringing forward the development of design.

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