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# Educating the Virtual Architect

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*This paper elaborates and illustrates an educational experiment in which students were asked to develop their design in the virtual environment and at the same time evaluate the process and the product. Starting from a general overview on the VRML 97 technology the workshop offered an opportunity to students to enhance their curricula with new tools through experimenting and interacting with their design spaces. Students' designs were tested and critically discussed in a fully immersive VR environment offering them new stimuli for both designing and enriching their learning experience. Students were finally asked to present their projects in a fully interactive VR environment.*
*The outcomes of the experiment, and the challenging question it raises about the nature of reality and virtuality – technical, pedagogical and even ethical – offer a contribution to the debate on the concept of an "Ideal Digital Design Curriculum".*
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## Architecture through the looking glass

An intricate process of fragmentation of our built environment, which originally started with the introduction of circulation patterns suitable for vehicular traffic, has in the late twentieth century been facilitated by non-material, but very powerful, networked communication and information technologies.

The 20th century phenomenon of urban sprawl can be exemplified by the development of shopping centres and towns which cluster around motorways. This emerging pattern could no longer offer visual perception of urban spaces characterised by buildings, streets, public squares and landmarks, in a well-defined relationship of solid to void, but more confused urban spaces which primarily follow vehicular circulation patterns. Further de-materialisation of architecture in the information age happens through fragmentation of the built environment by its reduction to series of images. Proliferation of neon signage, billboards and liquid crystal displays on many anonymous buildings of modern cities, trades the solidity of contemporary architecture for the message it conveys through signage or advertising (with Japanese cities being the prime examples). This is the architecture which presents itself as the medium of information.

An emerging vocabulary of architecture built for the information age expresses the presence of electronic space in the built environment. The relationship between built architectural form and the immaterial world of information technologies could be supported by the choice of materials, such as glass walls acting as transparent physical support to electronic billboards integrated in the façade, or similar projection screens incorporated into the interiors which could be used as windows into virtual worlds.

In the paradigm shift from real to virtual the permanency of "real" architecture is challenged by the fluidity of virtual architecture which becomes a function of time. In cyberspace the information content is delivered in the form of images and dynamic representations. The new visual elements which

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spring from the immaterial life of cyberspace are capable of both integrating with and revolutionising our built environment.

Revolution in practice and in the teaching of architecture is not going to happen through the confinement of innovative formal explorations to the realm of virtual. With this century's acute environmental problems the challenge is no longer on the competing individual and international styles in design, but on the production of better quality (sustainable) architecture. It is the virtual environment which opens up the possibilities for the production of better built environment by:

- addressing sustainability through environmental simulations and appraisal;
- engaging design creativity through immersive design;
- enabling user-participation in immersive design environment through collaboration between designers and users of real buildings and cities.

## Architectural design in the virtual environment

There is a new paradigm for teaching students of Architecture: it is the virtual one, which is web-based and distributed. This paradigm integrates time with space by adding the fourth dimension to 3D modelling worlds. It adds interactivity in the form of event management, browsing multiple environments, spatialised sound - to name but a few of its powerful features. Without having to rely on high-end technologies, designers can traverse an exciting journey from static 3D space exploration (or pre-planned animation) into interactive virtuality by making use of VRML.

Visual appraisal by means of virtual walk-throughs can reveal aesthetic and functional problems present in the design, which would not be readable from non-interactive architectural representations. In a walk-through with real-time responsiveness, the participant engages as creator and perceiver at the same time. In static VR worlds, commonly used for simulations of architectural environments, navigation is the primary means of exploration. To this static world the time dimension can be added in the form of pre-programmed behaviours. In a typical example of a dynamic behaviour, movable objects within a building such as doors can swing or slide open; in addition the action of a door opening could instigate the uploading of data-file representing the interior of a building.

The act of dynamically observing while walking through a virtual world can be enhanced by yet another level of interactivity through immersive design. In this scenario the creator of the design is “inside” the product of his/her design and can create or modify any element of that design while fully immersed in it. This can be seen as a step forward from passive exploration of a design proposal in the virtual environment to active design experience. In this immersive environment , and with real time response, the designer can “sketch” in 3D and then refine the idea within a traditional desktop modeller. This possibility to establish a real-time link between CAAD program and a fully immersive virtual environment opens up whole new scenario for collaboration among design professionals. Related to this is an avenue for user-participation in the virtual environment. Suffice to say that virtual reality offers to lay people a whole new prospect to understand and actively participate in design decision making.

To properly evaluate a work of architecture one has to gain experience beyond spatial perception alone. The formal characteristics of both the exterior and the interior of a building are influenced by a complex set of requirements for provision of environmental comfort for its users. The understanding of interaction of design variables such as the quality of daylight, the strategy for artificial lighting, thermal comfort, airflow and acoustics can be gained through simulations. It is true that, for example, computer simulations for optimising the energy efficiency in buildings are often difficult to interpret if they are not properly visualised. Although these are the early days of VR it is possible to anticipate that in the interactive virtual environment

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the simulations of the effect of light, airflow and temperature can be intuitively interpreted and modified.

## The educational experiment

This part of the paper elaborates and illustrates an educational experiment in which a small group of students volunteered to develop their design ideas within a virtual environment and at the same time to evaluate the process and the product. A series of workshops run by the authors introduced the students to VRML97 and to the range of tools for modelling, event management and reality enhancement. Students' designs, as they evolved, were tested and critically discussed in a fully immersive VR environment offering them new stimuli for both designing and enriching their learning experience. Students were finally asked to present their projects in the fully interactive VR environment.

Some of the important criteria when considering appropriate tools for students' design experiment in the virtual environment were platform independence and the ability to add interactivity in viewing 3D virtual worlds. It was important to enable students to explore design ideas virtually, both on their home PC-s and in the Virtual Environment Lab at the high end of the hardware spectrum. With VRML as a common platform the "scalability" of the environment offered the possibility to combine, collaboratively, a number of simple models into a large-scale virtual environment suitable for high-end machines and wholly immersive virtual worlds. Moreover, with the use of VRML97, it was possible to add behaviours with time dimension through integration of three-dimensional computer generated environments with event management techniques.

The brief for the design project associated with the workshop was quite demanding: A Sailing Club for the Disabled located on a canal site in Glasgow City Centre. A real client community agreed to be involved in the project and in the assessment of its outcomes.

## The technical tool kit

When modelling for virtual environments students were instructed to define the geometry with the minimum number of polygons and to add detail by appropriate use of texture mapping. Standard CAAD packages, such as 3D Studio and formZ, were used as input modules, with the intention that VRML format would be used throughout the design process.

Event Management in VRML was done through the use of "sensors" (i.e. visually programmed behaviours), and connectivity. These include:

**touch sensor***:* triggers the pre-set animation sequence at the point when the object defined as a touch sensor is selected in the VRML browser.

**proximity sensor***:* creates a proximity sensor node by setting up a rectangular region in space, so that entering the region in a VRML browser starts a set of objects animating.

**time sensor***:* adds the time-based animation controls, such as the start and the end frames for a particular object's animation, and looping. This helper can be used to split up an object's animation keys over several triggers, or to make animation endlessly loop.

**anchor***:* allows for adding links to other HTML pages, VRML worlds, or can alternate cameras in the VRML world.

An additional range of tools provide the capability of enhancing the realism or the interactivity of the virtual worlds. These include:

***level of detail:*** Objects in the virtual world can be represented at different degrees of realism by varying the level of detail which in turn depends on the distance from the observer. The same object can be represented by different models with different levels of detail. The replacement of models is triggered by the change of distance between the observer and the object.

**turbidity***:* fog provides a cue of depth, and can be used to simulate atmospheric effects. Type (linear or exponential), colour and visibility range can be specified. Fog can also be used in conjunction with level of detail to cover for the diminishing level of detail with distance.

**billboards**: help create geometry that is camera aligned. Any geometry related to a billboard will rotate about the z-axis of the object to face the viewer. Billboards are well suited for texture-mapped trees or people, which populate the virtual world.

**in Line**: allows for reference to another VRML file, which is included in the virtual world, when the file is loaded into VRML. The in-line objects have the appearance of an instance object, but they function at the browser level. A typical example would be an in-line reference to the model of the interior, which appears upon opening of front door of building (modelled as exterior shell only).

**sound:** allows for introduction of 3D (spatial), or ambient sound in the scene. A spatial sound has a particular source location in the scene. The sound source may be located at a point and emit sound in a spherical or ellipsoidal pattern. The sound node may also be used to describe an ambient sound that tapers off at a specified distance from the sound node.

## The design outcomes

The outcome of the experiment – although not statistically measurable – was nonetheless considered to be remarkable by both the tutors and the client community. One second year student in particular made the most effective use of the full range of functionality of the system.

In relation to the site and exterior of the building these were:

- Good balance between modelling of 3D geometry and texture mapping to provide a thoroughly convincing, large scale model of the site, which includes existing buildings of importance to the intervention as well as the wider urban issues such as the adjacent motorway.
- Ability to approach the site, as would a user, by sailing along the canal or, as a wheel chair user, to open gates and wheel along foot-paths to the building entrance.
- Understanding of the urban site by “flying” nearer or further from the adjacent motorway (along which cars are speeding) to check the attenuation of noise pollution.

In relation to the building itself, the contribution of the student’s ability to “visit” his design, during the evolution, as would a wheelchair user, was clearly evident in the quality of the design solution and was manifested in a number of subtle but important ways, for example:

- The approach from the canal footpath and the carpark to the front door was carefully considered in terms of slopes and angles.
- The door access and view lines of wheel chair users, on entering the facility (including signage) were completely thought through.
- The elegance of articulation of the building into two zones - wet and dry - was the evident result of:
  - the Boolean operations performed by the student on the volumes;
  - the immediate testing of these in the virtual environment.
- The unparalleled level of detail presented by the student in response to user requirements, was exemplified by :
  - the transparency of the balustrades on the ramps and the sophisticated louvre system on the external glazing - a direct result of the designer’s perception, from the user viewpoint - of what is important to someone in a wheelchair. Through every window in the building the student was able to show the appropriate view from the building.
  - concern and commitment to the real experience for a wheelchair user. The sliding door towards the canal could be opened and the user wheeled out into a mesh deck in order to get a first-hand experience of being “on” the water before perhaps, two ramps down, actually getting into a canoe, the mechanism illustrated by an elegant animation.

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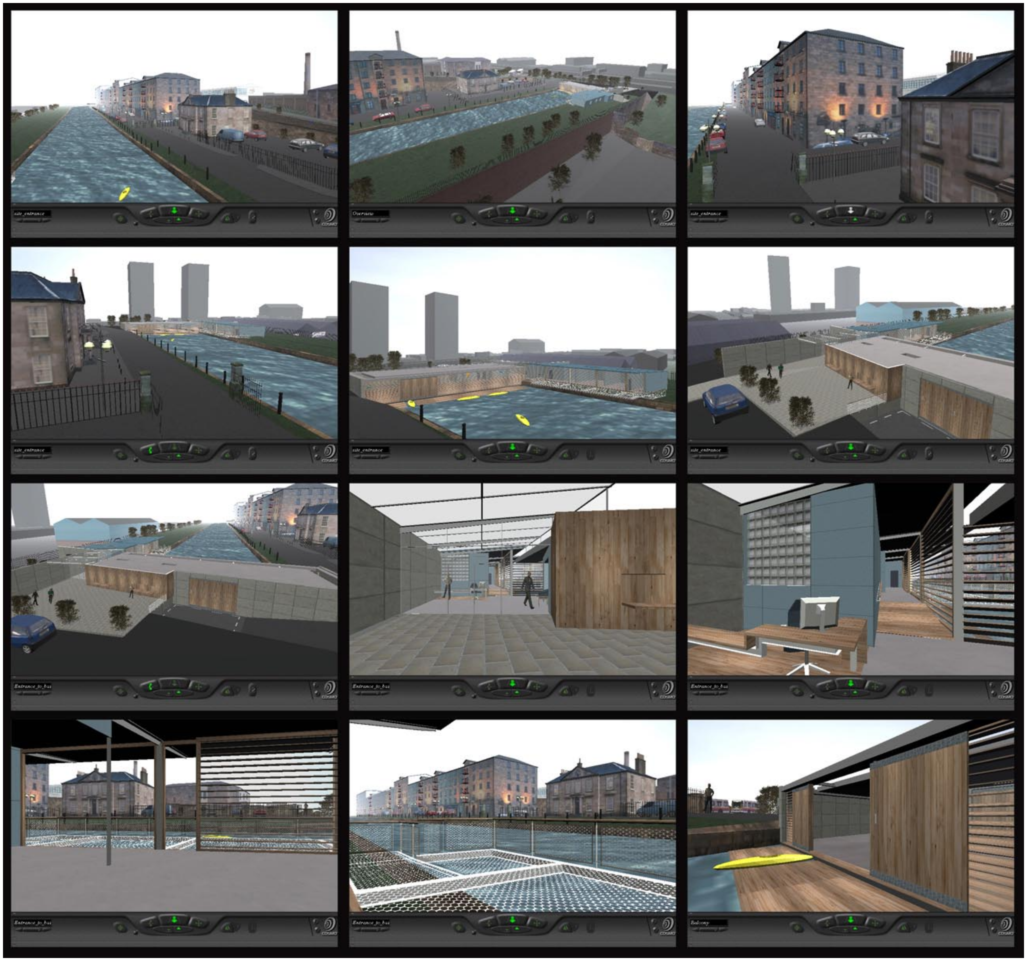

*Figure 1. Sailing Club for the Disabled at Spier's Wharf, Glasgow.*

The client community group were presented with the work of the students, and were impressed by the sensitivity with which the brief was addressed. They are featuring the outcome on their website (http://www.fcccp.org.uk).

## Conclusions and future aspirations

As in the earliest days of the introduction of computers into architectural design, the quantum jump is made by students. The work reported here, and which will be shown during the conference is, we believe, the epitome - in the current state of the art - of excellent practice. It makes a breakthrough, we believe, in the evolution of good design ideas, modelled offline but appraised interactively.

There is some way to go, of course, to design interactively in a virtual environment. The next step which we envisage is to link to the 3D model the emerging and sophisticated software for the thermal,

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lighting and acoustics properties of the building. This would allow the user to visualise, dynamically, airflow, temperature gradients, lighting levels and to experience the actual acoustic characteristics of the space as she/he moves through it.

The other exciting development is for representatives of the client/user group to "join" the designer within the virtual environment and to participate directly in the evolution of the design concept. The recent development of a wheel-chair motion platform for immersive virtual environments (Maver, 2001) will allow the future users of buildings like the Sailing Club for the Disabled to navigate themselves, in their own wheelchair, through the virtual building.

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