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Virtual Reality In Education

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ABSTRACT
Virtual reality (VR) is a technology which permits its users to become immersed in a computer generated virtual world. This paper presents some potential application of VR to education, in particular in two undergraduate courses of Mathematics (Mathematics 1 and Mathematics 5) at the Academy of Architecture of Mendrisio, Switzerland (University of Italian Switzerland). In our courses, we have organized the lectures using multimedia technologies, for example: scientific documentaries, hypermedia, 2D Computer Aided Design (CAD). To introduce the connections between mathematics, nature, and architecture we have also utilised some virtual objects, created using VRML (Virtual Reality Modelling Language). In our case, we have observed that virtual reality is not only an educational tool but it is introductory for a correct students' background.

1 INTRODUCTION
New technologies of communication (hypertext, hypermedia, the Internet) can help to modify our teaching methods [1, 2, 3, 4, 5]. Virtual Reality (VR) is a technology, but can virtual reality aid in education? To answer to this question we have to present some considerations. Recently, the term "Virtual Reality" has been applied more widely to include graphics applications that allow users to walk through a simulated environment and, possibly, to interact with objects in it. In a 1998 study titled Educational Uses of Virtual Reality Technology, Christine Youngblut says of educational curriculum available for use by VR, "The range of educational subjects covered is quite broad, showing a fairly equal split between the arts and sciences." In addition, Youngblut says that VR "applications are fairly equally split between those designed for elementary and middle school levels, those for high school students, and those for college students (undergraduate and graduate)" [6, p. 29]. Virtual Reality is strictly defined in this paper as a specific technology, in agreement with other works [7, 8]. This technology is computer based and gives the illusion of being immersed in a 3-D space with the ability to interact with this 3D space. The interface hardware components consist of a visual display apparatus, some sort of input device, and a position sensor. Typically, the visual display that is used is a helmet that places a television-like screen over each eye, blocking one's view of the physical world. Instead, of the physical world, one sees a 3-dimensional rendition of a place that is created by computer graphics [9, 10]. Input devices can range from a keyboard to a mouse (2D or 3D) to a head-mounted display (HMD) to a motion-sensing data gloves. The purpose of the input device is to allow the human participant to give electrical signals to the computer which can be interpreted as specific commands. Depending on how the software was programmed, one mouse button or hand gesture might represent "fly forward" while another button or gesture means "fly backward." Virtual reality has emerged as a revolutionary human/computer interface, challenging everything to which we are accustomed. Research institutes around the world have demonstrated the potential of VR systems as a visualization tool and, as technology continues to improve, VR systems will become pervasive as tools for research and education [11]. Three primary requirements of a virtual reality system are [12]:

- immersion (that requires physically involving the user, both by capturing exclusive visual attention and by transparently responding to three – dimensional input. For example, through a head – tracker, 3D mouse, wand, data glove, or fully instrumented body suit);
- interaction (through the three – dimensional control device to investigate and control the virtual environment);
- visual realism (that is an accurate representation about the virtual world).

In this paper we describe some applications of the virtual reality in the educational process in two different undergraduate courses of Mathematics at the Academy of Architecture of Mendrisio (Switzerland). The paper is organized as follows: section 2 presents VR in educational process; section 3 describes our educational examples of the virtual reality; and in the section 4 we have our conclusions.

2 VIRTUAL REALITY IN EDUCATION
The potential of VR supporting education is widely recognised. Many researchers believe that Virtual Reality offers strong benefit that can support education. For some, VR's ability to facilitate constructivist learning activities is the key issue. Others focus on the potential to provide alternative forms of learning that can support different types of learners, such as visually oriented learners. Still others see the ability for learners, and educators, to collaborate in a virtual class that transcends geographical boundaries as the major benefit.

In traditional instructional environments, students learn by assimilation, for example, by listening to an instructor lecture about a subject. Current educational thinking is that students are able to master, retain, and generalize new knowledge in a learning-by-doing situation. This philosophy of pedagogy is called constructivism and its supporters vary, ranging from those who see it as a useful complement to teaching – by – telling to those who argue that whole curriculum should be reinvented by students through gently guided discovery learning [6]. The major distinction between traditional instructional design and constructivism is that the former focuses on design instruction that has predictable outcomes and intervenes during instruction to map predetermined conception of reality onto the student's knowledge, while the latter focuses on instruction that fosters the learning process instead of controlling it [13]. Educational theory and cognitive science support the exploration of VR as an educational tool. In the field of educational theory, the concept of constructivism powerfully articulates an effective strategy for teaching children. Its proponents advocate that students should be fully involved in their education instead of playing the role of passive sponges waiting to be told the correct answers. The actual methods that constructivist teachers may use vary greatly. At one extreme, teachers may propose that there are no correct answers and that individual students must discover their own truths [14]. At the Human Interface Technology Lab (HITLab), a part of the Washington Technology Center at the University of Washington in Seattle, several pilot studies had been performed to examine VR's potential in the field of education. The Pacific Science Center studies used 10 to 15 year old students who were attending a week-long summer day camp. Some of these students had extensive computer knowledge, while others were novice computer users. As part of their camp, they learned about VR. In groups of 10 or so students, they brainstormed virtual world creations. In sub-groups of 2 to 3 students, they created objects for their world along with specifications as to how the objects should be placed and move in the virtual world. An example of constructivist teaching method is "The Adventures of Jasper Woodbury," a videodisk program for teaching math that was developed by The Cognition and Technology Group at Vanderbilt (CTGV). "Jasper" consists of 4 adventure stories designed to provide students with real-world, open-ended problems that do have correct mathematical solutions. CTGV believes "that the realistic nature of our Jasper problems (including their complexity) helps students construct important sets of ideas and beliefs and refrain from constructing misconceptions" [15]. Using constructivist theory, Byrne (1996) has created a virtual chemistry world to encourage students to learn by exploring and interacting with the information. Instead of sitting in a classroom and passively viewing images of atomic orbitals, students can place electrons into a atom and see the atomic orbital appear as the electron buzzes [16]. Cognitive science is another field of knowledge that guided the use of VR and multimedia technologies as educational tool [17]. Since cognitive scientists study how the human mind works, their theories can address how VR can help students learn. According to cognitive theories, VR can help humans process information and therefore learn, by making abstract concepts more concrete. According to many cognitive scientists humans think symbolically [18, 19]. VR can present abstract information in concrete forms that humans have been processing by immersing people in a visual computer-generated world.

3 VIRTUAL REALITY OUR EXAMPLES

In our case, we have used VR inside two different courses of Mathematics (first and fifth year). In this paper the term "virtual reality" is used broadly to cover both immersive and non-immersive VR. For example, in the course of Mathematical Thought (first year) VR is a good medium for making abstract concepts concrete [20]. To illustrate our idea, we needed a subject area to examine. The topic dedicated to the polyhedra and their interconnections between nature and architecture is an excellent example of an abstract topic that is difficult to learn [4]. The difficulty of understanding scientific concepts is well researched [21]. "Students' misunderstandings and misconceptions in school sciences at all levels constitute a major problem of concern to science educators, scientist-researchers, teachers, and, of course, students" [22, p. 1054]. This difficulty is attributed to the abstractness of the scientific topics [11, 23, 24].

Virtual reality has been used by our students in different way [25]:

- to observe and to rotate the platonic solids and the polyhedra from the different points of view (outside and inside the virtual objects),
- to create some virtual object using VRML (Virtual Reality Modeling Language),
- to observe and to manipulate the fullerreni molecules (C_{60}),
- to observe and to manipulate the geodesic domes,
- to study the symmetry presents in the crystals.

In the course of Mathematics 5, the VR has been analysed as a medium to create the virtual towns, and to virtual world. VR is also connected with the Internet and the cyberspace [9]. There are some interesting topics on the virtual communities and the virtual cities with their sociology implications [26]. During our course we have emphasized the connection between virtual reality a fractal geometry, to realize the virtual worlds, for example to create trees using fractal algorithms, mountains, special effects. Figures 1 and 2 show an example of VR application to generate virtual landscape using fractal procedures.

Figure 1 Virtual landscape generated using fractal procedures (grid phase)

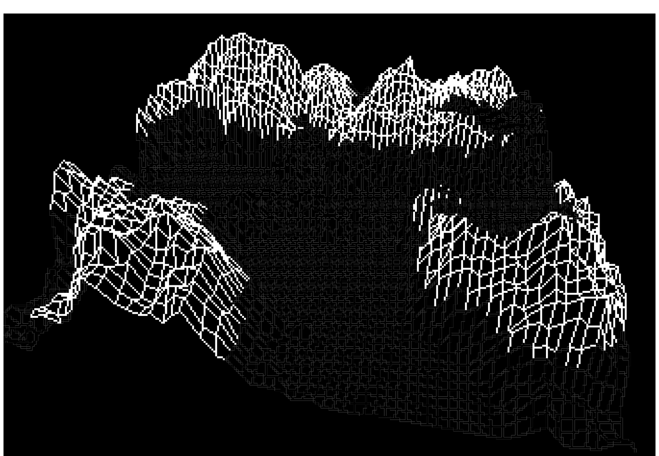
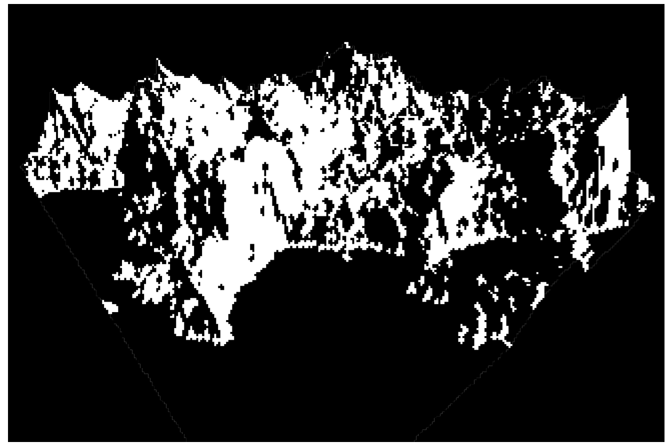


Figure 2 Virtual landscape generated using fractal procedures (texture phase)



Virtual Reality in our teaching process is a good tool to train our students to use this technology inside an architectural project (e.g., to realise a virtual building in 3D or a virtual set designing). VR is also integrated with the Web and the cyberspace, for example to realise a Geographic Information System (GIS) [25].

Already there are several browsers on the web that can be used for non immersive viewing of virtual worlds, although these browsers only support very minimal interaction with virtual worlds. Virtual worlds can be designed for single inhabitants, such as a solo flight trainee, or for many, simultaneous participants. When a virtual world supports multiple users, it can give rise to a virtual community. Inhabitants of a virtual community have a heightened sense of presence in this artificial world, since they can communicate with each other in the context of the simulated world. Virtual communities can provide the settings for effective teleconferencing, and for productive, remote cooperative work. We have also analysed VR as a medium to create virtual cities. For this reason, our students have researched virtual worlds on the Web (e.g., Alphaworld). AlphaWorld is an urbanised virtual world where each piece of land is owned by individually registered users (citizens of the virtual world), and where people, represented as avatars, can meet and interact. The world is rendered in fully three-dimensional graphics. As time goes by, this world has been further developed. In the future we will use an immersive virtual reality to create virtual visit in the buildings in agreement with other researchers [27, 28].

4 CONCLUSIONS

Virtual reality technology may offer strong benefits in education not only by facilitation of constructivist learning activities but also by the potential to provide alternative forms of learning that can support different types of learners such as visually oriented learners. VR promotes the best and probably only strategy that allows students to learn from non-symbolic first-person experience, and it permits to the students to see the effect of changing physical laws, observe events at an atomic or planetary scale, visualize abstract concepts, and visit environments and interact with events that distance, time, or safety factor normal preclude [16, 29, 30, 31, 32]. Most educational applications for VR are designed to make use of some characteristics which include:

- Allowing students to gain a greater understanding of abstract concepts through the creation of visual metaphors,
- Allowing students to directly manipulate and scale virtual objects or environments for clearer understandings,
- Allowing students to visit places and interact with events that distance, time, or safety concerns would normally prohibit [6, 33]

These characteristics allow virtual worlds to support a wide range of types of experiential learning that is otherwise unavailable [6]. Based on data collected from thousands of students of different ages, using different applications with different interfaces, there is overwhelming evidence that students enjoy both experiencing pre-developed applications and developing their own virtual worlds [34].

Virtual Reality has a definite role to play in education, if merely from a motivational viewpoint. However, this should not be extrapolated to the idea that VR should be used for every aspect of education. While VR may offer something for every subject, the cost of the system, especially at current prices means VR is a heavy resource sink.

We have observed that the use of virtual reality for teaching offers a series of advantages learning, for example the efficacy, and a high level of interactivity, in agreement with other researches [32, 35]. We are sure that VR will be an important tool to organize learning environments in the 21st century.

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