Design and Development of Virtual Reality in Education: Comparative Analysis

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***Abstract*— This paper is a concise review of virtual reality, its outline, VR in the education world, as well as possible designs of virtual reality implementation in lab setup, which are essential components of virtual reality systems. This paper addresses current efforts and designs that are developing, evaluating or using VR technology in education and industries. It builds a picture of the states of the art and practice and reviews some of the research in the education field. Also some critical questions that are being addressed which will be helpful in establishment of virtual reality implementation designs.**

***Keywords*— Education; VR; Immersive;Non-Immersive; Semi-Immersive; HMD;**

I. INTRODUCTION

Educating current and future generations of Indian children to live an information society is a critical issue. It is compounded by the recognized need to provide life-long education for all citizens and to support a flexible workforce. Virtual Reality technology has been widely proposed as a major technological advance that can offer significant support for such education. There are numerous ways in which VR knowledge is probable to facilitate learning. One of its unique feature is the ability to allow students to visualize nonrepresentational concepts, to observe events at atomic or environmental scales, and to visit environments and interact with events that distance, time or safety factors make unavailable. The types of activities supported by VR facilitate current educational thinking that students are better able to master, hold on to and simplify new facts when they are actively involved in constructing that knowledge in training situation.

The prospective of VR technology for supporting education is widely recognized. There are many programs designed to introduce large numbers of students and teachers to the technology have been settled, a number of academic institutions have developed research programs to investigate key issues in virtual reality. Virtual reality will be ideal in situations where:

1. Access to the real world object or surroundings is inflexible or difficult.
2. Using the actual real world objects is unsafe or positions a health hazard for the user.
3. Procurement and testing with the real world object is too expensive.

A. Definition:

"Virtual Reality is a high-end user interface that involves real time simulations and interactions through multiple sensorial channels. These sensorial modalities are visual, auditory, tactile, smell, taste" [1] Burdea, 1993

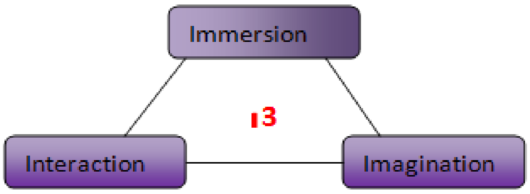

Fig 1: Virtual Reality Trio I^3

Virtual Reality, VR, is a newly up-and-coming computer interface characterized by high degrees of immersion, interaction and imagination with the objective of building the user believe, as much as possible, that s/he is in reality within the realistic looking world, as opposed to being an outside viewer looking in. In an ideal virtual world, a user would be absolutely incapable to determine whether they were experiencing a computer simulation or "the real thing". Figure 1 shows the Virtual reality troika, immersion, interaction, imagination. Virtual reality implementations typically use high quality three dimensional graphics, 3- D audio, high speed and specialized hardware such as head-mounted displays and wired clothing to achieve high degrees of practicality and suitability. A variety of solutions are available, with higher quality implementations providing a greater degree of practicality, immersion, and suitability at a likewise higher cost. High-quality solutions are not yet reasonable and reasonable solutions are not yet high-quality; However we feel it practical to initiate developing virtual reality based educational applications today, so that we will be ready for the advances in tools and software which will become available tomorrow, as the growing popularity of this technology pushes prices down and quality up.

II. OUTLINE OF VIRTUAL REALITY:

Virtual reality has a long and very rich history [2][3][4][5]. It is supposed that the initial try at virtual reality came in the 1860's as artists began to create 3-D, panoramic murals. Today's VR is more high-tech and is possibly most excellent known for its use in the gaming world. Virtual reality is also used for military training and as a form of therapy. Here are a few of the more interesting highlights of virtual reality...

Table 1: Outline of Virtual Reality [2][3][4][5]

Timeline	Highlights
1890:	Thomas Edison and his assistant William Dickson pioneer the Kinetograph (a camera for recording pictures) and Kinetoscope (a projector for playing them back)—in effect, the first one person can undergo movie experience
1895:	French brothers Auguste and Louis Lumière opened the first movie theater in Paris, France. Legend has it that one of their movie shorts, Arrival of a Train at La Ciotat, is such a convincing depiction of reality that people in the audience scream and run to the back of the room.
1929:	Edwin Link develops the Link Trainer (also called the Pilot Maker), a mechanical airplane simulator. His work pioneers the field of flight simulation.
1950:	US Air Force psychologist James J. Gibson publishes an influential book, The Perception of the Visual World, describing how people see and experience things as an "optic flow" as they move through the world. These ideas, and those of contemporaries such as Adelbert Ames, help to form the foundations of the 20th century psychology of visual perception,which feeds into academic studies of computer vision and virtual reality.
1957 :	Morton Heilig invents the Sensorama- a simulator with 3D images along with smells ,wind and sound – to create the illusion of reality that takes you into another world.
1961:	Philco Corp develops project Headsight, a helmet incorporating a video screen with a head-tracking system. This technology has been used in military training operations
1965:	Ivan Sutherland comes up with the concept called Ultimate Display. Using a head-mounted display(HMD) connected to a computer, users could see a virtual world.
1982:	VR goes to Hollywood as the movie “Tron” was the first to depict the virtual reality.
1987:	Jaron Lanier, founder of VPL Research and creator of the DataGlove and the EyePhone, is creadinted with coining the term virtual reality. Also that year, the Holodeck makes its first appearance in “Star Trek: The next Generation.”
1991:	Virtuality Group adds VR to arcade video games. Users step into a Virtuality cabinet and use goggles to enter a three – dimentsional gaming world. Eventually, some of the more popular arcade games-like” Pac-Man”- have virtual reality versions
1993:	Sega introduced its wrap-around VR glasses at the consumer Electronics Show
1997:	Geortia Tech researchers use VR to create war zone scenarios as PTSD therapy for veterans.
1999:	The film “ The Matrix” hits theraters, featuring a computer – generated world where citizens of the future are imprisoned from birth
2011	Palmer Luckey develops the Oculus Rift, an inexpensive homemade HMD, in his parent’s garage.
2012:	Oculus turns to fundraising platform Kickstarter to finance the Oculus developer kit, which was meant to get the Oculus Rift to developers who could then integrate the VR device into their games.
2014:	Independent developer Createsmith was able to recreate the hoverborad scene from “ Back to the Future Part 2” by using a Nintendo Wii Balance Board and a VR headset.
March: 2014:	Sony introduces the Project Morpheus VR headset for PlayStation
April 2014:	The Federal Trade Commission approves Facebook’s purchase of Oculus for nearly $2 billion.
April 2014:	Virtuix announces it has raised $3 million in funding to develop a VR treadmill that will allow games
September 2014	The Des Moines Register launches “Harvest of Change,” a virtual reality experience showing the life of an Iowa farming family. Samsung announces the Samsung Gear VR, a headset that uses a Samsung Galaxy smartphone as a viewer
August 2015	Discovery releases nine 360-degree videos, which include skateboarding in San Francisco and surfing
November 2015	The New York Times distributes 1.3 million cardboard VR viewers and releases a short spherical video piece called “The Displaced.”

III. VR IN THE EDUCATION WORLD:

VR allows user to think about and manipulate things that you cannot see in the real world. It allows the user to look in to special perspectives, Interact in real time, visualize 3D concepts, discover dangerous situations, abstract scenarios or present realistic and promote different learning styles and training methods.

Now days, an education has adopted virtual reality for teaching and learning situations. This enables students to work together with each other as well as to work within a three dimensional environment. VR allows us to present complex data in an accessible way to students which is both fun and easy to learn. In addition with this, students can interact with the objects in that environment in order to discover more about them. For example, Mechanical students can learn about the vehicle system and how it works by physical engagement with the objects within. They can move parts, see around parts. This enables them to see how abstract concepts work in a three dimensional environment which makes them easier to understand and retain. This is useful for students who have a particular learning style, e.g. those who find it easier to learn using colors, symbols and textures or creative. As research has shown, students remember 20% of what they hear, 30% of what they see and up to 90% of what they do or simulate. One of the best benefits of using virtual reality as an educational medium is the immersive experience it brings it into reality. Bland and vague subjects like history and engineering drawing, mechanics along with experiment-oriented subjects like chemistry, physics will be greatly impacted by virtual reality. This will be so because the students will be uncovered to senatorial stimuli; may it be testing the concepts first hand or reliving the events that lead to them.

According to Kirkos Nicoletta sala,[6] the evolution of multimedia and Virtual Reality (VR) technologies can open new learning opportunities in engineering and in an architecture education and many more. Multimedia assists the teaching process, the lectures are now more interactive where students can operate some virtual objects or they can navigate in hypermedia; A vital issue for amalgamation VR into architecture and engineering curriculum is safety: some users, after the navigation in virtual world using the typical VR’s devices, had ocular problems (e.g., blurred vision, eyestrain, and fatigue), disorientation and nausea. The next generation of VR tools will be studied to avoid these effects

Kami Hanson, Brett E. Shelton[7] addresses the issues regarding identifying the appropriate techniques for integrating VR into conventional instructional design, and the considerations for development for non-technical educators.

Han Xiaoying, Chen Feng, Chen Wei[8] have developed a visualization cluster suitable for developing solutions to problems in the domain of virtual reality education. The

cluster is constructed from commodity components. The monitor wall is reconfigured into a cave-like structure.
Lei Wei, Hailing Zhou, Aung K.Soe, Saeid Nahavandi [9] proposed a novel platform for STEM education using Kinect, haptics and virtual reality simulation software. They demonstrated the general pipeline and the core components with respect to their configurative potentials, functionalities and implementation details. The result clearly shows the interactivity and reliability of the proposed system.

Nico Hempe, Jürgen Roßmann.[10], presented the novel eRobotics approach, which aim is to provide a comprehensive software environment to address robotics related issues. While the render component was mostly neglected in scientific contexts in the past, author showed that a powerful render framework is essential to bring together complex eRobotics applications and edutainment aspects in order to understand complex technical systems and their correlations.

Jiangfan Feng [11] observed, in the current evolution from an manufacturing society to an information society, conventional instructional approaches based on the use of textbooks in classrooms are less memorable. Instead of memorizing facts, more emphasis is being placed on the high-level thinking skills needed to construct and apply knowledge. Additionally, education is no longer seen as something limited to a classroom or to a certain period in a person's life.

Jannat Falah, Salsabeel F. M. Alfalah, Soheeb Khan, Warren Chan, Tasneem Alfalah David K. Harrison[12], proposed the design and development for the proposed learning support which addresses daily issues for medical students in learning anatomy. The developed system was based on user's requirements in depth medical doctor's consultations. The system was developed to enhance medical education by utilizing VR technology

IV. POSSIBLE DESIGNS OF VIRTUAL REALITY LABS [13]

We had visited to some selected companies & try to find out which possible design is best to create VR experiment in education field. Questionnaires had prepared during the visit and discussed with the expert. A closely related issue concerns where VR technology should and equally important, should not be used. Here questionnaires address both educational content and student individuality:
Questionnaires

1) Can Virtual Reality Address Educational Objectives and Learning Styles?
2) Does learning in virtual worlds provide something valuable that is not otherwise available?
3) How does the effectiveness of student use of pre-developed virtual worlds compare with traditional instructional practices?
4) How does the effectiveness of student development of virtual worlds compare with other instructional practices?
5) How does the effectiveness of student use of pre-developed virtual worlds compare with that of student development of virtual worlds?
6) How does the effectiveness of immersive and non-immersive virtual worlds compare?
7) How well does VR technology support collaborative learning between students?
8) Is this collaboration educationally effective?
9) Is VR-supported learning cost effective?
10) For what type of educational objectives or material is VR technology best suited?
11) Where is it not suited?
12) Are there specific student characteristics that indicate whether VR-based education is appropriate? Does the technology benefit only certain categories of students?

Student prospective and teacher acceptance of VR learning environments will depend on many factors, including ease of interface use, and ease of integration into the classroom.

13) Do students find VR interfaces easy to work with?
14) Does the effective use of VR technology change the teacher's role in the classroom?
15) What are student and teacher reactions to the use of this technology?

Practical questions that need to be considered are:

16) Are the hardware platforms and minimum set of interface devices required affordable to most schools, colleges, organizations?
17) Are the needed software development tools commonly available?
18) Is the technology currently mature enough for practical use?
19) What is the added value of a VR system?
20) What affordances (specially designed reification) in the virtual world will enable the expected learning?
21) How will the user see, feel and/or hear?
22) Where is the data coming from?
23) How will data be analyzed and integrated?
24) How will the data be rendered?
25) What software's and databases will be needed for Virtual Reality?
26) What hardware equipment's will be needed for Virtual Reality?
27) What is the influence of the physical presence of a HMD on the user while walking around and exploring an environment?
28) What would be the most promising combination of subsystem for a multiuser interaction?
29) What makes an immersive VR experience believable?
30) How the development of VR application can be facilitated to novice users?

These questions will be examined and try to find out the best design solution. While the information presented in the paper is insufficient to provide definitive answers, it is does provide some useful indicators of current designs. The studied designs are discussed below.

A. Non-Immersive (Desktop) Systems or Windows on World (WoW)

Non-immersive systems, as the name pointed, are the slightest immersive implementation of VR practices. This uses a conventional computer monitor to display the 3D virtual world. Non –immersive system also called using the desktop VR system or windows on world, the virtual environment is viewed through a porch or window by using a regular high resolution monitor. Interaction with the virtual environment can occur by using straight means such as mice, keyboards and trackballs or may be enhanced by using 3D interaction devices such as a data glove, space ball, wands, and stair steppers.

Advantages of Non-immersive System:

- Do not require highest level of graphics performance
- No special hardware
- Lowest cost VR solution
- The non-immersive structure has benefits that they do not necessitate the highest level of graphics performance, no special hardware tools required and can be applied on high specification PC clones

Limitations of Non-immersive System:

- Limited to a certain extent by current 2D interaction devices
- More sophisticated implementations
- No sense of immersion
- Virtual Reality Modeling Reality Language (VRML)

Fig.2 : Non-Immersive (Desktop) Systems or Windows on World (WoW)

B. Semi-Immersive Projection Systems

A semi-immersive system will contain of a comparatively high performance graphics computing system which can be combined with either:

- A large screen display
- A large screen projector system projection system is similar to the IMAX theatres. The resolutions of projection systems range from 1000 - 3000 lines
- Multiple television projection systems
-

Advantages of using semi-immersive system:

- Provide a greater sense of presence that non-immersive
- Greater appreciation of scale
- Greater resolution that HMDs
- Supports Multiuser Interaction

Limitations of semi-immersive system:

- Setting up a projection screen system is far more difficult than a desktop system and is considerably more expensive
- Use multiple projection systems are more expensive
- There are problems with current interaction devices for these systems
- The transfer of control between users is one of the major issues that must be deliberated in the future.

This may have a considerable benefit in educational applications as it allows real-time experience of the Virtual environment which is not available with head-mounted immersive systems. Additionally, stereographic imaging can be achieved, using some type of shuttered glasses in synchronization with the graphics system.

Fig.3 : Semi-Immersive projection system

C. Fully Immersive (Head-Mounted Display Systems or cave)

The most direct experience of virtual experience is delivered by fully immersive VR systems. This type of implementation are possibly the most widely known VR implementation where the user either wears an HMD or uses some form of head-coupled display such as a Binocular Omni-Orientation Monitor or BOOM (Bolas, 1994)[13].

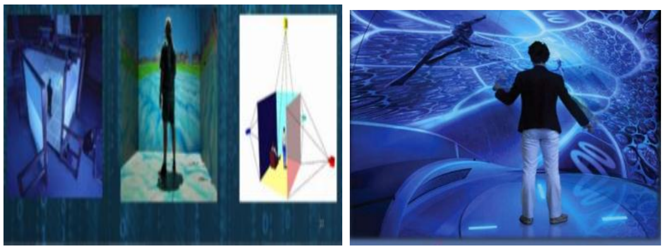

Fig.4 : Full-Immersive system

Advantages of using full-immersive system

- Easy, user-friendly and ideal for project review or team collaboration
- Give sense of presence which depends on parameters like view of the HMD, the resolution, the update rate and contrast and illumination of the display
- The advantage of this method is that the user is provided with a 360^0; field of regard meaning that the user will receive a visual image if they turn their head to look in any direction.

V. COMPARISON BETWEEN VR IMPLEMENTATIONS DESIGNS

TABLE 2: COMPARATIVE ANALYSIS OF VR DESIGNS[13][14]

Main Features	*Non- Immersive VR (Desktop)*	*Semi-Immersive VR (Projection)*	*Full Immersive VR(Head-coupled)*
Resolution	High	High	Low - Medium
Scale (perception)	Low	Medium - High	High
sense of situational awareness(navigation skills)	Low	Medium	High
Field of regard	Low	Medium	High
Lag	Low	Low	Medium - High
Sense on immersion (sight, sound, touch, smell, taste)	None - low	Medium - High	Medium - High
Input Devices	Mice, keyboards and trackballs Data Glove, Space Ball ,Joystick	Data Glove, Space Ball ,Joystick	Data Gloves, Voice Commands
Cost	Lowest	Expensive	Very Expensive
Output Devices	Standard Monitor	Liquid Crystal Shutter (LCS) glasses, Large Screen Monitor or projector System	Head Mounted Display, BOOM, CAVE
Interaction	Low	Medium	High

VI. CONCLUSION AND FUTURE WORK :

Educational practices of the knowledge are broadly great as where learners work together with pre-developed VR applications and where learners progress their own virtual worlds in the course of researching, understanding and demonstrating their knowledge of some focus matter.

The focus of this work is the use of virtual learning environment in the education field with some possible designs and comparative analysis of the designs based on some main features. Fully immersive VR systems lean towards the most challenging in terms of the figuring power and level of technology and consequently cost required to achieve a acceptable level of practicality and advancement is constantly ongoing to progress the technologies. Major extents of query and development include arena of resolution vs. view trade-offs, reducing the weight and size of HMDs and reducing system lag times. Virtual Reality is on the most capable methods of bringing safe, cost effective, convenient and elastic knowledge to the enhancement of traditional teaching. A review of present virtual technologies in the education field has been highlighted.

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