

A Proposed Framework for Modernization of Education using Virtual Reality

A dissertation submitted in partial fulfillment of the requirements for the
award of degree of

**Master of Engineering
In
Electronic Instrumentation and Control**



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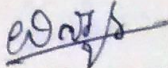
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DECLARATION

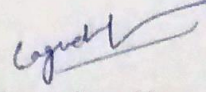
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

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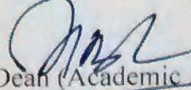
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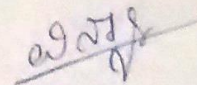

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ABSTRACT

Education is arguably the most important aspect of our lives. Despite it being so important, technology is yet to permeate fully into this field. In such a case, we deprive today's generation of being able to learn more freely and also enjoying it. We can bridge this gap by the use of Virtual Reality. Virtual Reality will be a key ingredient of our forthcoming future. It will not only grow as an industry in itself, but also become a part of our daily life. It is an artificially created environment which provides a way of experiencing things which may not be possible otherwise. The environment may vary from historical places to surreal ones which may be physics defying. In this research work we propose a framework which helps in identifying the concepts which can utilise VR. We also point out the procedure for development of education centric VR applications so that the identified topics can be delivered effectively and in the process creating a learning experience like no other. The feasibility of such a framework is tested at a preliminary stage with the development of projectile motion simulations using various technologies. The created simulations are then shown to a group of people for feedback. It was observed that the feedback was by and large favourable with most being amazed at the power of VR and some being in the state of dilemma. The ones in the state of dilemma were observed to be convinced by the technology but only to be disheartened because of the price. This leads to conclusion that virtual reality can be implemented for education and also be a success if provided at the right cost.

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LIST OF ABBREVIATIONS

3D – 3 Dimensional

2D – 2 Dimensional

CAVE – Cave Automatic Virtual Environment

DK2 – Development Kit 2

FOV – Field of View

GUI – Graphical User Interface

HDMI – High Definition Multimedia Interface

HMD – Head Mounted Display

IPD – Inter-Pupillary Distance

IR – Infra Red

LCD – Liquid Crystal Display

OLED – Organic Light Emitting Diode

POV – Point of View

USB – Universal Serial Bus

VR – Virtual Reality

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1.1 ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is intelligence exhibited by machines and/or software which is human-like. The field of AI is interdisciplinary in nature as it is being implemented in many areas at once like medical, engineering, manufacturing, bio-engineering etc. and even in specialized fields like psychology. It also utilises expertise from fields like maths and biology in order to make new algorithms and techniques for development. Textbooks and researchers in this field describe or define it as "the study and design of intelligent agents"[1], where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success [2]. John McCarthy, who coined the term in 1955, defines it as "the science and engineering of making intelligent machines"[3]. Russell and Norvig quote a few definitions which are classified in two dimensions. The ones on top in Table 1 are related to thought and intellectual abilities, whereas the ones on the bottom address conduct. In the same table the definitions on left measure success in terms of human performance, whereas the ones on the right measure against an ideal concept of intelligence, which we call rationality [2].

Table1 Definitions of artificial intelligence categorized

Thinking Humanly	Thinking Rationally
“The exciting new effort to make computers think ... <i>machines with minds</i> , in the full and literal sense.”[4]	“The study of mental faculties through the use of computational models.”[6]
“The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning” [5]	“The study of the computations that make it possible to perceive, reason, and act.” [7]

Acting Humanly	Acting Rationally
<p>“The art of creating machines that perform functions that require intelligence when performed by people.”[8]</p> <p>“The study of how to make computers do things at which, at the moment, people are better.” [9]</p>	<p>“A field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes” [10]</p> <p>“The branch of computer science that is concerned with the automation of intelligent behaviour" [11]</p>

Through this table we can infer that AI can be pursued with 4 goals in mind. Them being,

- i. make a machine think like human
- ii. make a machine act like a human
- iii. make a machine which can act rationally
- iv. make a machine which can think rationally

AI in today’s time aims at being a human like or human level intelligence. According to most people it involves in making computer programs which can take decisions like humans and solve problems like them. Researchers tend to observe human behaviour and code it into a program so that it may act like humans in those specific situations [12]. However AI can also be developed by watching nature which can help us solve very many daily life problems of our own. AI researchers can also use methods which use computing beyond the power of a human to understand problems posed by real life. It is field which can implement some problems very well e.g. chess but also fail miserably in some e.g. GO. This is all down to the inability of programmers or researchers to understand and implement the mechanisms involved in some real life examples. In some places the problems can be modelled easily using mathematics but in some it requires inter-disciplinary approach, which becomes problematic for programmers alone. Truly said this field requires collaboration between experts of domains such as mathematics, computers, psychologists, linguists and even philosophers. Such an inter-disciplinary team could avoid the cycles of success AI has had since it became a mainstream obsession.

1.1.1 EVOLUTION OF ARTIFICIAL INTELLIGENCE

384BC: Aristotle described the syllogism, a method of formal, mechanical thought.

1st century: Heron of Alexandria created mechanical men and other automaton

- 1600s: Hobbes, who has been described by Haugeland (1985) as the “Grandfather of AI,” believed that thinking was symbolic reasoning like talking out loud or working out an answer with pen and paper.
- 1800s: The first general-purpose computer was the Analytical Engine by Babbage
- 1940-50s: Church-Turing thesis
- 1950s: Samuel built a checkers program and implemented it, which learnt to play checkers. Newell and Simon (1956) built a program, Logic Theorist that discovers proofs in propositional logic.
- 1956: The field of AI research was founded at a conference on the campus of Dartmouth College in the summer of 1956. The attendees, including John McCarthy, Marvin Minsky, Allen Newell and Herbert Simon, became the leaders of AI research for many decades
- 1950s: McCulloch and Pitts showed how a simple thresh-holding "formal neuron" could be the basis for a Turing-complete machine. The first learning for these neural networks was described by Minsky (1952). One of the early significant works was the Perceptron of Rosenblatt (1958).
- 1970–80s: A period when AI reasoning became widespread in languages such as PROLOG.
- 1997: Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov.
- 2011: In Jeopardy! Quiz show exhibition match, IBM's question answering system, Watson, defeated the two greatest Jeopardy champions, Brad Rutter and Ken Jennings, by a significant margin.
- 2011-12: Release of voice based mobile assistants e.g. Siri on iPhone

1.1.2 TURING TEST

The test was initially called the “Imitation game” and not “Turing Test”. It can be described as a test of machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human. Turing proposed that a human would evaluate conversation between computer, intended to generate human like responses, and himself or other human. The human who is evaluating will be aware that one of conversationalist is computer and also knows that both participants are separated from each other. The

conversation is restricted to a text based channel as speech capabilities should not hinder the ability of the computer to produce human like responses [13]. If the evaluator cannot reliably tell the machine from the human (Turing originally suggested that the machine would convince a human 70% of the time after five minutes of conversation), the machine is said to have passed the test. The test does not check the ability to give correct answers to questions, only how closely answers resemble those a human would give.

The test was introduced by Alan Turing in his 1950 paper "Computing Machinery and Intelligence," which opens with the words: "I propose to consider the question, 'Can machines think?'" Because "thinking" is difficult to define, Turing chooses to "replace the question by another, which is closely related to it and is expressed in relatively unambiguous words." Turing's new question is: "Are there imaginable digital computers which would do well in the *imitation game*?[13]" This question, Turing believed, is one that can actually be answered.



Fig1.1 A cartoon depicting Turing test

The paper itself was built on ideas proposed by Kurt Godel that there are statements about computing numbers that are true, but that can't be proven. Alan Turing worked on the problem in an effort to help define a system for identifying which statements could be proven. In the process he proposed the Turing Machine. The paper defines a "computing machine" with the ability to read and write symbols to a tape using those symbols to execute an algorithm [12]. This paper and the Turing machine provided that basis for the theory of computation.

The idea of such a long term, difficult problem was a key to defining the field of AI because it cuts to the heart of the matter – rather than solving a small problem it defines an end goal that can pull research down many paths. Without a vision of what AI could achieve, the field

itself might never have formed or simply remained a branch of math or philosophy. The fact that the Turing test is still discussed and researchers attempt to produce software capable of passing it are indications that Alan Turing and the proposed test provided a strong and useful vision to the field of AI. It's relevance to this day seems to indicate that it will be a goal for the field for many years to come and a necessary marker in tracking the progress of the AI field as a whole.

1.2 VIRTUAL REALITY

Arthur Clarke once said “Any sufficiently advanced technology is indistinguishable from magic”. Virtual Reality (VR) if and when fully implemented has the potential to be such technological magic. The term *Virtual Reality* is an oxymoron for a layman as virtual would be taken for something is not real and reality for something that is real. The actual definition of virtual, however, is “to have the effect of being such without actually being such”. The definition of "reality" is “the property of being real”, and one of the definitions of “real” is "to have concrete existence". Using these definitions “virtual reality” means “to have the effect of concrete existence without actually having concrete existence”, which is exactly the effect achieved in a good virtual reality system [14]. According to the online Oxford Dictionary VR is defined as “... computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.”. We can look at VR at like a jigsaw puzzle and find the pieces it consists of. When we speak of VR the first term, as pointed out earlier, which comes to your mind is computer based technology[15]. Computers form a daily part of our life now and simply can't be done away with. VR requires computer not only to generate or compute the necessary environment but also to differentiate it from technologies like remote controlled robot or telepresence.

In technologies such as these computers may only be required to relay the necessary information while a human acts on it. The next thing that comes to our mind is that VR must be an illusion created with the help of software. It is not an illusion rather an effect as it does not fool or trick the user into believing something a la magic shows. Another aspect which makes VR stand out is that it is not just an animation rather an animation which can interact with the user. Animations are basically movies or clips which are generated by computer or simulated using software to depict a phenomenon.

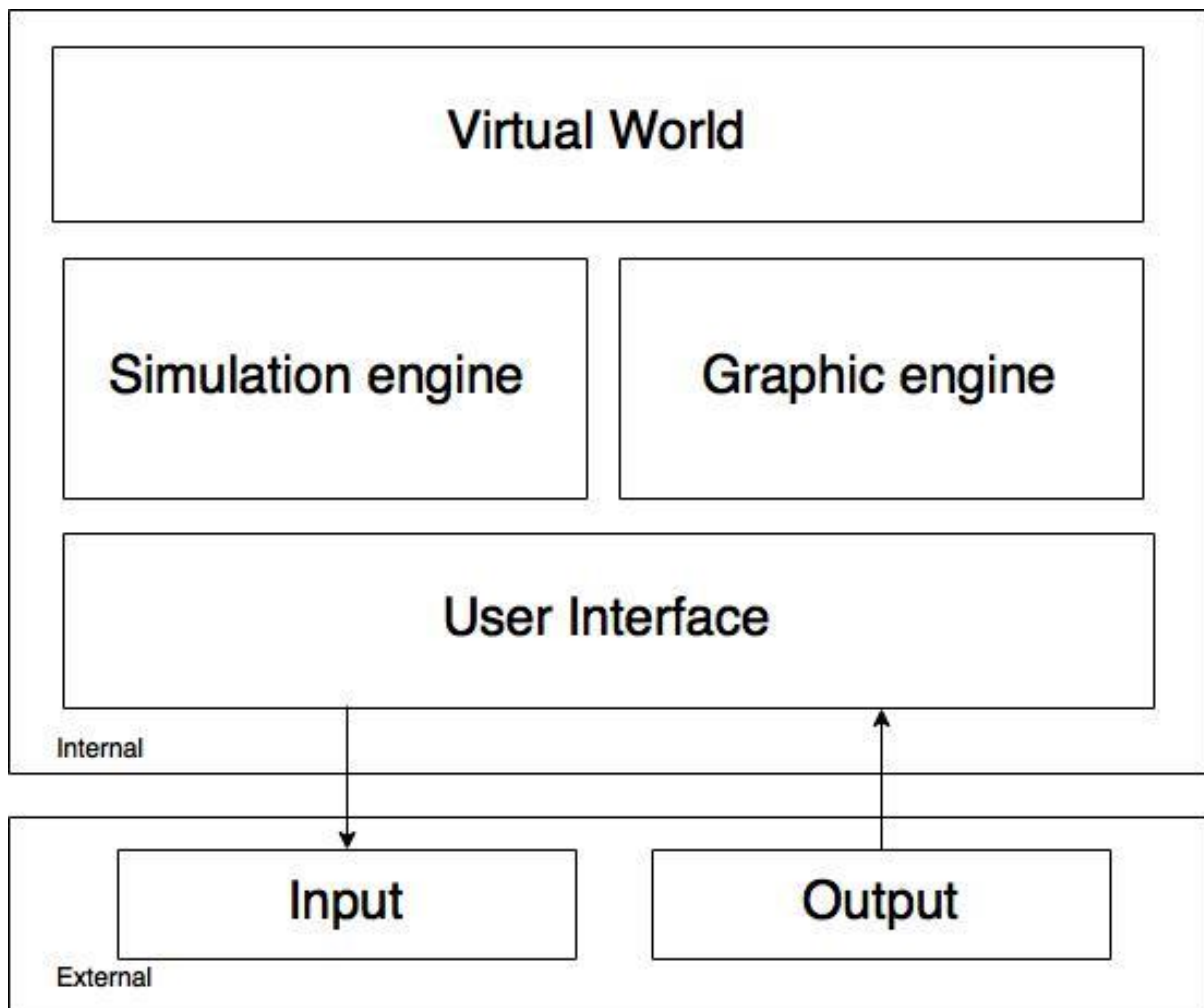


Fig. 1.2: Block Diagram for understanding VR

VR makes use of a user interface which helps interaction between user and the software. This interaction is the most essential part of any VR and can be a make or break aspect if not implemented properly. An important piece which helps increase the degree of interaction is the environment. This environment when in two dimensions can be limiting whereas with a three dimensional one, the possibilities are endless. The degree of interaction and immersion will increase manifold when in a three dimensional environment. A three dimensional space allows the user to be free and also help him/her ease into the environment. Two dimensional spaces with computer generated graphics have been around us for some time but they only look real but not feel real. The feedback or more specifically sensory feedback is another aspect of VR. It is absolutely necessary in order to provide the realism and be able to stand out from the two dimensional computer graphics. Sensory feedback can be either forced feedback i.e. haptic or auditory in nature. Haptic feedback requires special sensors which can sense the reaction in virtual world via software and relay it to the user. This proves useful in places where feedback is paramount like in telepresence and artistic endeavours. Auditory

senses can be tickled with the right spatial audio from software. Spatial audio combined with the three dimensional world can make the user/wearer believe he is in a different world altogether.

When we speak of VR people think of it as *computer-simulated environments* instantly. These environments may mimic places in real world or in fantasy world like in games. Such experiences are the trend in fun parks all around the world[16]. The environment can either be projected with the help of monitor or a stereoscopic display. The display can be accompanied by a set of sensory information as well which augment the experience of the user[17]. The military has been using such a setup, typically known as a simulator, for training pilots. The computer generated environment can be similar to the real world in order to create a lifelike experience—for example, in simulations for pilot or combat training. It can also take the form of developers' imagination like in games. In recent times VR has reinvigorated the passion among the general masses. It is no longer a fad which was embedded in our minds by movies like Star Wars and Minority Report. With the recent advancements in computing we are nearly able to create such surreal experiences, nearly being the keyword. The hardware which is the utmost essential part of great VR experience has also become cheaper in recent times making it affordable to take the technology to masses. Software also has come a long way since the early stages of VR; we have been able to create games which look life-like. It has also been able to model humans and physics into it for better effects.

2.1 WHAT IS VR?

Computer generated graphics are a part of our daily life right from the mobile to our computer screens. In this day and age every professional from engineer to interior designer harnesses the power of computer graphics. This allows us to explore and experience the surroundings which may not be accessible or not created yet at all. This possibility creates a fascination among the users which are evident due to the thriving gaming industry. But this fascination does not stop there, people want to go a bit further in that computer generated environment and feel it as well. Therein comes, *Virtual Reality*. VR can be defined in simple terms as a computer generated environment which has the ability to interact with the user via special equipment. Or it can alternatively be defined as, *Virtual reality* is composed of an interactive computer simulation, which senses the user's state and operation and replaces or augments sensory feedback information to one or more senses in a way that the user gets a sense of being immersed in the simulation (virtual environment)[18]. VR has the potential to be used in a vast variety of fields ranging from education to manufacturing. In this chapter we explore VR as technology, the history behind it, applications, components and the various technologies that are available now.

2.2 HISTORY

Virtual Reality was always a dream for film-makers, artists and people alike. Everyone wanted to something out of the world to create, to imagine, to live through which would help them in their daily lives in one way or another. The path towards has been a treacherous one, at one point everyone thought creating such surreal experiences would not be possible at all. Today we are ever closer towards that goal of immersive reality experiences and the people who contributed towards it should not be forgotten. We take a look at how the technology has evolved with the various milestones.

The fascination with virtual reality started way back, when people started to look for ways and means to improve the movie viewing experience. People wanted to take that next step by feeling the movie and not watching it [19]. The viewers wanted to be in the movie and be a part of it, not just watch it on a big screen. Experimentation with viewing experiences can be traced back to the 1950s. Morton Heilig, credited by many as the father of virtual reality, developed and patented *Sensorama* which is a multimodal experience display system. The user sat in the machine with a three-dimensional city display, heard the sounds of the city, felt

the wind and the vibrations of the seat, and could even smell certain scents [20]. A few years later Ivan Sutherland said “Display as a window into a virtual world improves image generation until the picture looks real. Computer maintains world model in real time. The user directly manipulates virtual objects. Manipulated objects move realistically. Immersion in the virtual world via head-mounted display. Virtual world also sounds real, feels real” [21]. This is considered to be one of the fundamental ways to define a virtual reality system. Even after such advancements in technology, we are still a quite a way from his vision. He then proceeded to develop a head mounted display, which was nicknamed ‘*The Sword of Damocles*,’ due to its size. In the mid-1970s Myron Krueger created *Videoplace* “a conceptual environment with no existence”. In this system the silhouettes of the users, grabbed by the cameras were projected on a large screen. The participants were able to interact one with the other thanks to the image processing techniques that determined their positions in 2D screen’s space [22]. Myron Krueger was also responsible for coining the term *Artificial Reality*, which describes the identification of the user’s activities with subsequent generation of feedback which reinforces the illusion of the activities taking place in a virtual environment. Later in the 1980s Jaron Lanier along with his company VPL was responsible for creating *Sayre Glove* and *Dataglove*. They used built-in sensors to detect finger motions which were then reported to the computer. The company was also responsible in making *EyePhones* which used a pair of LCD displays to make a HMD. This, along with *Dataglove*, was the first commercially available VR systems. In 1987 Jim Humphries, a lead engineer with NASA VIEW Project designed *BOOM*. It contained 2 CRT monitors which could be viewed through eye holes where you keep it by the eyes and move through the virtual world. The position and orientation were tracked by a mechanical arm. It was later commercialized by *FakeSpace Labs*. In the 90s the most famous advancement came in the name of CAVE (*Cave Automatic Virtual Environment*) a room where the walls were made up of screens displaying the virtual environment. The user wore LCD shutter glasses to visualize the projected stereoscopic images. Thus, it allowed the user to have an illusion of depth along with superior quality images compared to the HMDs. The experience was augmented by the use of surround sound. In recent times, companies like *Oculus VR™* have developed HMDs which are affordable and highly responsive to the movement of the user. They not only provide accurate tracking, but also better image resolutions compared to earlier HMDs. But we are still quite a way from the perfect immersive virtual reality experience. Various companies have also started making their own HMDs which will rival *Oculus VR™* and help explore the various possibilities.

2.3 COMPONENTS OF VR

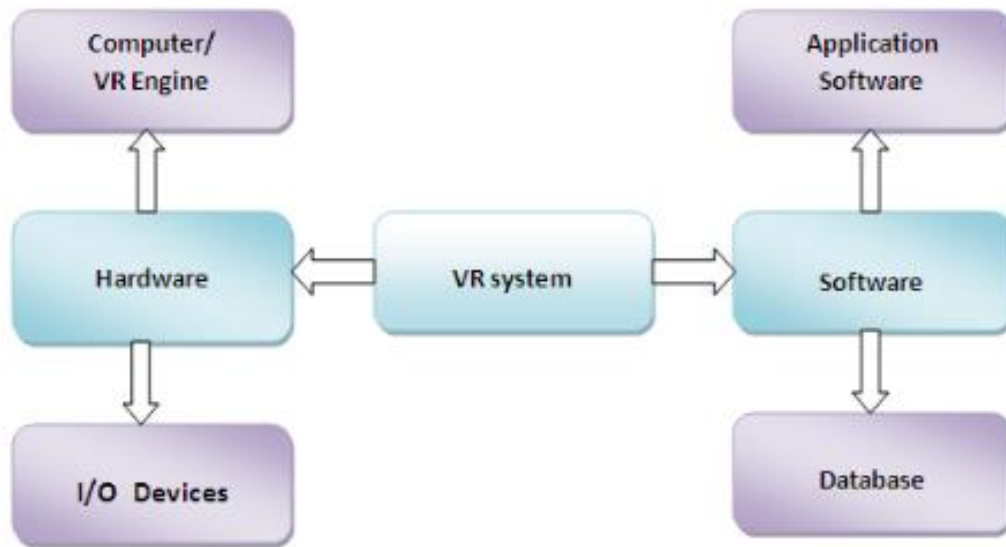


Fig 2.1: Components of VR system

VR systems can be understood easily by breaking down into its components. The components not only tell us how this works, but also give us an idea as to how this can be further improved. The various modules are

a) A head mounted display, which can either have two screens, one for each eye, or a single screen divided virtually by software into two. This kind of arrangement helps in projection of stereoscopic images easily on to the viewer's eyes.

b) An effective tracking system which can track user's movement in real time and report it to the software for rendering. Ideally, it should be able to not only track the position and orientation of the head, but also track hands, which can be used for better immersive capabilities.

c) An audio output, which can easily make the user feel at ease in the new virtual environment. The audio should be spatial and not normal stereo as the immersion depends solely on how the user hears and reacts to sounds from the VR system.

d) A virtual environment created through software packages. The virtual environment can vary according to the use or intent or purpose of it. It should be lifelike and follow the general physics rules of the real world so as to trick the user into believing it is the reality. It can also defy physics if the intent is to create surreal experiences which give enables the user to enjoy and imagine new worlds. The software is very important as it not only acts as a medium between the input and output, but also has to do processing in real time and be efficient at it.

e) A sensory output system which gives feedback from the VR environment via the system. The virtual objects in the VR system react to the stimuli or actions of the user and create a feedback of their own. This feedback can be of audio visual type or of haptic type. This sensory output is very important as it generates the feedback loop which is a necessary part of VR system.



Fig 2.2: Flow of data in a VR system

VR systems are reliant on feedback. The better the feedback the better will be the system itself. Feedback is not only in terms of how the virtual objects react in the VE but also how those reactions are felt by the user. The stimuli or action from a user will have an effect on the virtual objects which in turn will react back or feel the action carried[15]. This reaction from the virtual objects needs to be conveyed back to the user in the appropriate form. This reaction may be visual, which can be projected on the screen, or it can be of haptic type which should be conveyed via the correct equipment like a glove or vibrator. Now another major part of the VE is the audio. It may not seem like an important aspect of such an environment, but the lack of it or improper usage of it will lessen the immersion level of user. Proper spatial audio which is in sync with the video or simulated environment is very necessary as it adds realism to it [22]. The sounds can easily trick the user into thinking that the world which he/she is in is real. Software which handles all the interaction between the input and output interfaces is also processing the graphical side to the VE. Hence, proper and efficient software for rendering such an environment is critical. The user interface that we create as part of the VR system acts as a gateway between the user and the virtual world. The user interface defines the fundamental way in which communication between these two entities take place and helps the user easily into the VE.

2.4 APPLICATIONS

VR in current scenario is being touted as the next big thing in the gaming industry. But the applications of VR are not only limited to gaming, but are far and wide. We take a look at the applications of VR including gaming.

2.4.1 GAMING AND ENTERTAINMENT

This is the most talked about application of VR as it is easy to market in an already enthusiastic crowd. Gaming is being focused upon as the primary target right now because of various things. It involves a lot of software rendering of the virtual worlds which makes the interface part of a VE stronger. Next as gaming involves a lot of movement along with action and reaction from the gamer, it needs to be very accurate in tracking the movements. A proper gaming experience will induce or immerse the gamer into a new world. The development of high precision tracking and low latency displays via software will help in other areas and applications of VR.

2.4.2 ARCHITECTURE AND HOUSING

VR can help visualize the creations of architects in a different manner. Today they are done via videos which render the created models in a visually pleasing and appealing manner coupled with animations or videos of the real world. This is not only limiting in nature but also doesn't show the design or creations in full glory. VR helps in projecting the models or creations in a 3D environment, which is life like, to the investors or consumers. This idea can be extended to housing sector where the buyer gets a walkthrough of the house before buying it actually. The buyer may also be situated in a completely different city as to the apartment. A visual walkthrough will enhance the experience of buying properties but also give them an idea as to how it may actually look like when it is completed or is built already. This is in stark comparison to how things are done in today's market i.e. via photos or videos of the house.

2.4.3 MODELING AND DESIGNING

Designers and artists can make use of VR in many ways. Today they have tools which help them make 3D models easily but they visualization is missing. This can help bridge the gap tremendously [23]. VR coupled with tools specifically designed for these purposes can be used to create and visualize simultaneously. This will allow the creators to not only fine tune but also give them complete freedom. They could visualize their creation super-imposed on the field where they intend to use or install it. They can get feedback from others by sharing the creation virtually before actually implementing it hence saving resources.

2.4.4 TRAINING AND EDUCATION

This field can make the most use of such a technology. Utilization of VR in the sphere of training can save costs and keep people from harms. Training can be provided on virtual tools

and in virtual places instead of dedicating a specific place for it [24]. It can prevent injuries in case of training in hazardous conditions which is the case in manufacturing industry. It can also help the trainee learn at ease, better and faster as mistakes will be more tolerable [16] [25]. Education sector can put this use in myriad ways. It can be used to create virtual labs and save resources and be used elsewhere. It can also be used to teach concepts which are hard to grasp via traditional teaching methods [26] [27]. AS VR provides a 3D environment, students from school to colleges can easily visualize complex topics in a much easier way.

2.4.5 DATA VISUALIZATION

This is an upcoming thought or area of implementation for VR. Industry professionals and data enthusiasts want to VR to be capable of helping them visualize data in much better way. Data visualization can help unearth a lot of potential in this technology and also help things make easier for the professionals. Intuitive data visualization will be possible which can revitalize the way we look at data and also help in accelerating the learning and give better insights.

2.4.6 MEDICAL

Uses of VR in this field can be varied. It can be utilized to teach students as it easily helps them envision and understand better. It can also be used by doctors to understand the patients data in a better and easier way [28]. VR can be utilized to treat patients as well [29]. In cases of PTSD it can help the patient get relieved from the trauma. VR can help psychiatrist deal with his/her patients efficiently by employing pleasing virtual world to therapeutic uses [30]. Virtual world can also be used to motivate patients undergoing motor rehabilitation process. Apart from this VR can be tailored to be used as a surgical tool by the use of high accuracy robots at one end and feedback enabled equipment at the other [31]. Doctors could be potentially doing lifesaving surgery via these methods while they are miles away from the patients [29] [32]. The use of VR in this field has to be careful as well because dealing with human body is no small task and it require precision coupled with a fast responsive system.

2.5 VARIOUS VR TECHNOLOGIES

As history suggests lot experimentation has been going on to produce the perfect experience or the perfect immersion. These experiments have over the years been successful and unsuccessful with varying degrees. But the efforts have led to something tangible today unlike before where VR was considered to be a pipe dream. In initial stages VR was the

hype, everyone believed that it would be something extraordinary and implementable. They were partially true as VR has proven to be extraordinary and enticing but has also been very hard to achieve. This was due to the fact that hardware was incapable of crunching numbers required for computing such large amounts of data. And it was compounded by the lack of software as well. The software design was the bottleneck at times and was incapable of being the interface required for VR. Times have changed and new technologies have emerged. Here we take a look at some of the new and old VR technologies which have become popular or were popular.

2.5.1 HMDs

Head mounted displays or HMDs are not a recent invention or thought but have come to the forefront of VR race in the last few years. HMDs were thought of back in the 1950s as pointed out earlier. Earlier it was very cumbersome and ill-conceived due to a lot of factors like size and resolution of display among many others. Today technology has advanced so much in the field of displays, sensors and trackers that making a head mounted display has become just a challenge of integration and design. Here we have shown a few of the popular HMDs these days from fig 2.3 to fig 2.5. These HMDs have tackled the problem of resolution by including a high resolution display which is also now commonly found in mobiles. These also have a method of tracking the motion of user or wearer with the help of sensors like accelerometer and gyroscope. Now these sensors are coupled with IR also in some cases which help to track the head movement easily. The industry is still exploring the various tracking technologies available and experimenting to find the best suited method. HMDs are also accompanied by software created by the parent company which helps utilise the device in a proper manner. These HMDs are primarily designed for gaming experience as the market is easily influenced and in most cases is already enthusiastic in adopting this. HMDs face a lot of issues like latency and display distortion which are partly due to software. The other problems being faced in this technology is that of design and weight issues. People will not want to wear something that is uncomfortable and ugly at the same time. Weight is a major concern again as it relates to the comfort level of the user/wearer.



Fig 2.3: Oculus Rift DK2 [33]



Fig 2.4: HTC ViVe [34]



Fig 2.5: Sony Morpheus [35]

2.5.2 CAVE

CAVE stands for Cave Automatic Virtual Environment, a recursive acronym, is shown in fig 2.6. It was first conceived at University of Illinois Chicago. It involves the use of projectors to project the virtual environment onto the surface of the room, typically shaped like a cube. It is connected with a computer which relays the necessary graphics and is also utilised to track the user's movement. The room's floor can also be a display with the help of an overhead projector and/or a panel fitted at the bottom like other faces of the room. The display on the floor has to be fitted with toughened glass so as to be able to bear the weight of the user. The tracking is usually done via sensors mounted on the head of the user and also through sensors mounted on walls of the room. The user wears a LCD shutter glass which helps in decoding the stereoscopic projection from the projectors. The resolution of display used here is very high and have to be so to avoid pixilation of the video/photo and destroy the experience. It has many uses and applications but is limited by the high cost of inventory right from the displays to the computer. Prototypes of parts can be created and tested, interfaces can be developed, and factory layouts can be simulated, all before spending any money on physical parts.



Fig 2.6: CAVE [36]

2.5.3 VIRTUSPHERE

VirtuSphere is a virtual reality device as shown in fig 2.7. It is, as the name suggests, spherical. It consists of a 10-foot hollow sphere, which is placed on a special stand that allows the sphere to rotate freely in any way according to the user's steps. It works with computer based recreations and virtual worlds, and rotates as the user walks, allowing for an limitless plane upon which the user can walk. A wireless head-mounted display with gyroscopes is used to both track the user's head movement as well as display the surroundings of the virtual world. It can serve many purposes, including exercise, video gaming, military training, and simulated museum tours. It is a creation of Ray and Nurulla Latypov, whose company, VirtuSphere Inc, is based in Binghamton, New York.

2.5.4 GOOGLE™ CARDBOARD

Cardboard is an initiative by Google to bring VR to masses. It makes use of a daily life item like cardboard to make a head mount for a display. The display in this case is the phone you own. As the fig 2.8 suggests the phone goes in the front of the mount. The mount created with cardboard houses a set of lenses which help re-create the stereoscopic image relayed from the phone. The display is made to relay stereoscopic images via software which divides

the phone into two parts virtually. Left part of the divided screen is for left eye while the other half is for right eye. This setup is coupled with a magnet, to make use of the magnetometer in our phones, which acts like a mouse click.



Fig 2.7: Virtusphere [37]

2.5.5 TELESURGERY

This technology has immense uses if implemented properly. As the fig 2.9 shows the robot operating on the patient is being operated a surgeon, typically far away from the scene of surgery. This setup is highly complex in nature and has no room for error. The surgeon operating has to feel the patient hence his gloves are fitted with forced feedback mechanism. The haptic feedback helps him/her to differentiate or know the tissue feel minutely. The robot also has to be high precision and equipped with various tools. Internet connecting the two

should be lag free and consistent else the consequences can be very bad. The surgery room can have helpers or nurses who relay the information via video feed to the surgeon. The audio feedback from the nurses/helpers also is very crucial. The bottlenecks in implementation are from the software side and subject to the availability of fast internet connection.



Fig 2.8: Google cardboard [38]

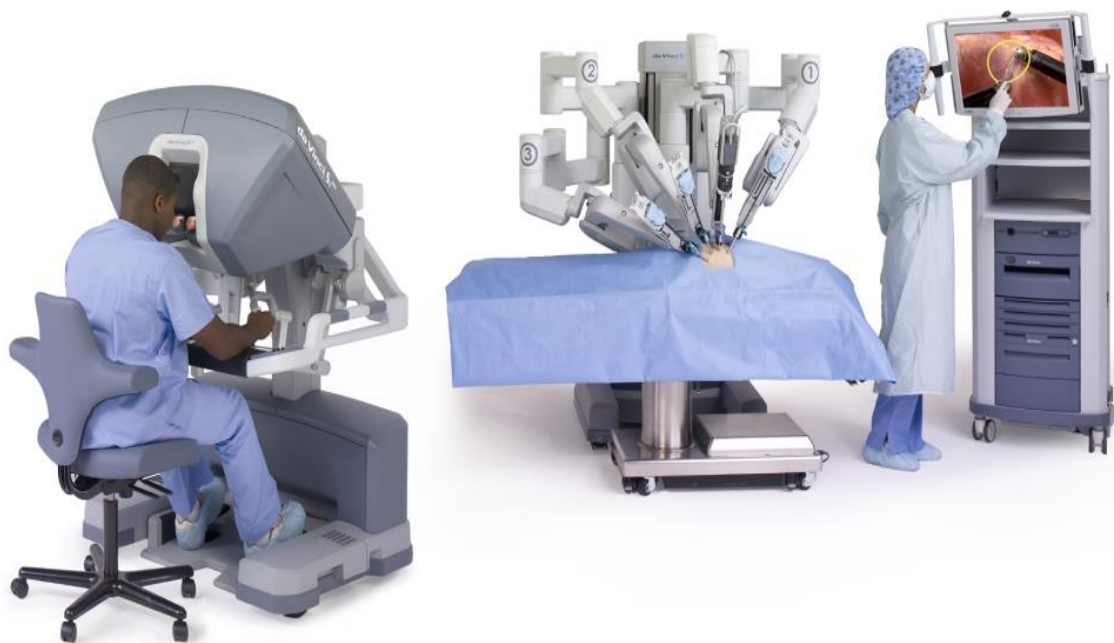


Fig 2.9: Telesurgery [39]

2.6 HOW HMDs WORK

HMD working can be understood better when we take in to consideration how our eye perceives images. The fig 2.10 depicts how the eye perceives an image. The regions are divided into two, monoscopic and stereoscopic. The normal FOV of one eye has an approximately oval shape. It extends about 90° horizontally to both sides along the line of sight and about 120 ° vertically, precisely, 50° upwards and 70° downwards. With both eyes together, the horizontal FOV is a bit larger than a semi-circle. The central visual field is viewed by both eyes. Only within this binocular overlapping zone of about 100° to 120° can we perceive depth through stereopsis. Our visual field is further extended by the fact that we can rotate our eyes in their orbits [40]. With the head fixed, the eyes can maximally cover an area of approximately 290° horizontally and 190° vertically.

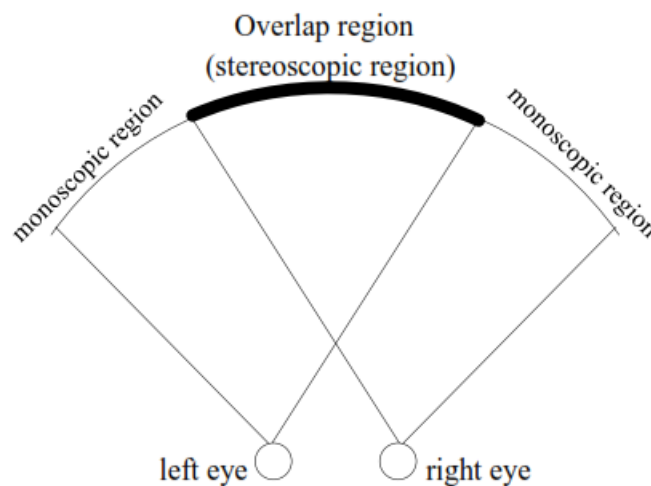


Fig 2.10: FOV

HMDs usually have a fixed or dedicated display which makes use of his FOV efficiently or aims to. Some HMDs like cardboard may not have a dedicated display in which cases the FOV is a lot smaller than the HMDs with dedicated displays. Resolution of the display is also an integral part as a display with low resolution will greatly diminish the experience. High resolution helps in better reproduction of images and maintaining the surreal feeling. Another problem with low resolution is that the pixels become visible to the naked as the display is very close to the eye. Display is just the interface or the visual element of the VR experience. The display has to be combined with the necessary instruments to reproduce the image. Lenses are utilised for this purpose. The choosing of lenses has to be carefully done as the vision should not be hampered and also the image should not get distorted. Optical infinity is taken to be 9mtrs by visual experts. This and IPD are two important factors to be considered while designing any HMD. Optical infinity is the distance at which, given the average human

eye rangefinder "baseline" (distance between the eyes or IPD) of between 2.5 and 3 inches (6 and 8 cm), the angle of an object at that distance becomes fundamentally the same from each eye. The HMDs make use of IRs for tracking. The IRs can be tracked by two methods, one utilising IRs on the HMD and other with IRs on a separate device coupled with IR emitter. All this has to be synced to the computer hence wires are used to relay the data and also get the visual content from it. The computer is connected via HDMI or USB cables. The cables also take power from the computer for usage. The next step in coming future will be to include eye tracking as well.



Fig 2.11 IR sensors on HMD

2.7 COMPARISON OF HMDs

Table 2.1: Comparison Chart 1

Description	Name of the Supplier and Product		
	Oculus VR™	SAMSUNG™ GEAR VR	Google™ cardboard
HMD Type	HMD	HMD for Phone	HMD for Phone
Display Type	OLED	OLED	Phone specific
Resolution and Size of display	5.6” 1920 x 1080	5.5” 2560 x 1440	Phone specific usually 5” or more
Refresh Rate	75Hz	60Hz	60Hz
Field Of View	100°	96°	96°
Connectors	USB and HDMI	None	None
Sensors	Gyroscope, Accelerometer, Magnetometer	Accelerator, Gyro meter, Geomagnetic, Proximity	Accelerometer, Gyro meter, Proximity or other phone specific sensors
Wireless motion sensors	Oculus Touch planned for 2016 release	None	None
Software supported	Unity 3/4, Unreal Engine 4/5	Android apps	Android apps
Weight	440gm	250gm	20gm
Cost	\$325	\$200+Phone	\$25+Phone

Table 2.2 Comparison chart 2

Description	Name of the Supplier and Product	
	Sony™ Morpheus	Valve™ VR
HMD Type	HMD for PS™	HMD
Display Type	LCD	OLED
Resolution and Size of display	5” 1920 x 1080	Min 5” 1080 x 1200 for each eye
Refresh Rate	120Hz	95Hz

Field Of View	100°	100°
Connectors	HDMI, USB	HDMI, USB
Sensors	Accelerometer, Gyroscope	Accelerometer, Gyroscope (may change before release)
Wireless motion sensors	PS™ Move bundled	Targeted
Software supported	Proprietary	Proprietary
Weight	Unspecified	Unspecified
Cost	Unspecified	Unspecified

Students of late have been exposed to a lot of gadgets in their social life whereas in their school life it's not the same. This creates a huge gap in the aspiration of students and reality of things. Students use gadgets like mobile and tablets at home from an early age, as early as 1 year, where they are able to see and feel the power of technology. Whereas, when they grow older and start their school, we are still stuck on the same chalk and board. This soon starts feeling out-dated and mundane for them. To get rid of this and make things interesting we need to bring together the state of the art technology to excite students. Today's students lose focus very easily in class as the pace of teaching may not match with the speed and ability of their understanding or might seem plain boring. Apart from concentration issues, students also face comprehension issues. Hence, need of the hour is to make things more personal with a supervisor to guide them onto the right path.

Education can be seen as a discovery, investigation and observation process, besides the gain of knowledge. Technology can take education in new ways; make it much more attractive to the students, making possible the use of new tools, also evolving the process of teaching. Virtual Reality takes an important place in this evolution. In general technology has changed the way people perceive things and consume data. This entire shift from being a glorified calculator to something that is always in your palms, has taken place rapidly. VR represents the next wave of technology where communication systems and computing will merge in a virtual world. Many generations were denied the use of technology to bridge the gap between life outside and inside school but no more should it happen. This should be the motivation to provide cutting edge technology at a place which hones their minds and character. There are several definitions about virtual reality, but in general, they refer to an immersive and interactive experience based on graphic images in 3D generated in real time by computer, in other words, it is a simulation generated by a computer, about a real or just an imaginary world. More specifically, virtual reality is a computer interface that permits the user to interact in real time, in a tri-dimensional space generated by a computer, using their feelings, through special devices. The user can notice the virtual world, through a window built by the monitor screen or by projection screen or it can be inserted in the real world through a helmet (HMD) or multi projections rooms (caves) and interaction devices. VR represents virtual scenarios, in which trainees can gain experience and familiarization with the real working

environment. VR allows students to practice training skills, reproducing processes, activating simulations, manipulating virtual objects with behaviours similar to those expected for them in real life, and receiving instant feedback on the consequences of their actions. The technology also allows several students in different locations to take part into collaborative training activities, learning how to coordinate themselves with the rest of participants. It is also very suitable when the real scenario is not available for training (e.g. in space missions) or to prevent possible risks for the trainees (e.g. in nuclear power station operations). All this also raises a few questions.

- i. Does learning in virtual learning environment offer advantages over more traditional methodologies?
- ii. What implications for learning do immersive virtual world offer?
- iii. Which learning rationale is the most suitable for VR environments?
- iv. How student effectiveness of virtual world does compare with other instructional practices?
- v. What is the impact of learner characteristics (e.g. age, gender, race, or previous experience) on learning in VR? What types of learners benefit from VR?

We take a look at a few of these questions and propose as framework to determine the effectiveness of VR. But one thing is for sure using VR we can shape minds for the future and also help hone better humans.

4.1 WHY USE VR IN EDUCATION?

In today's world we are surrounded by technology right from the moment we start our day to the point where we go to sleep. Technology is amiss from the most important aspect of our lives i.e. Schools and Colleges. To bridge the gap between their general life and study life we must and should introduce advanced technology, which not only serves the purpose of tutoring but also acts as tool of inspiration.

Study in India can be understood through this block diagram

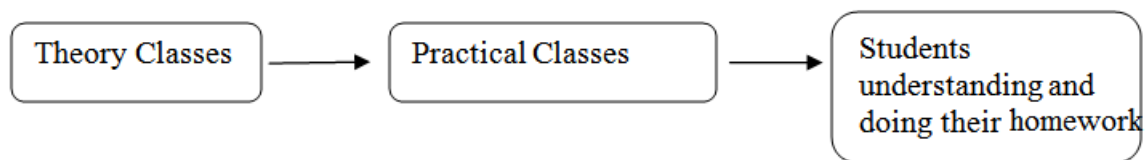


Fig 4.1: Block diagram representing the flow of teaching

This is a very crude representation of the procedure of delivery of knowledge from a teacher to the student. The education system is closely knit in terms of involvement and delivery of the classes and then exams to evaluate the understanding prowess of students. This process of knowledge delivery can be enhanced via the introduction of Virtual Reality. Today's curriculum involves a lot of concepts which can be better delivered and/or understood in a 3D dimensional environment rather than the conventional 2D setting of a blackboard. Nowadays some schools have begun to use electronic media for delivering these tougher concepts. But even these electronic media for e.g. projector and screen are 2D based while the media itself maybe 3Dimensional [41]. This creates a gap between the technology and the students. It may seem to bridge the divide of technological life outside and in class but in turn it does not eliminate the need for better understanding or better experience of class. The introduction of VR can help in bridging that gap by equipping the students with a 3D environment which can easily present and help them visualize the tough concepts of various subjects in their curriculum. Subjects like Chemistry and Biology have inherently more content which can be visualized in such an environment [42].

Now the process can be understood with help of an augmented block diagram of the basic system shown above.

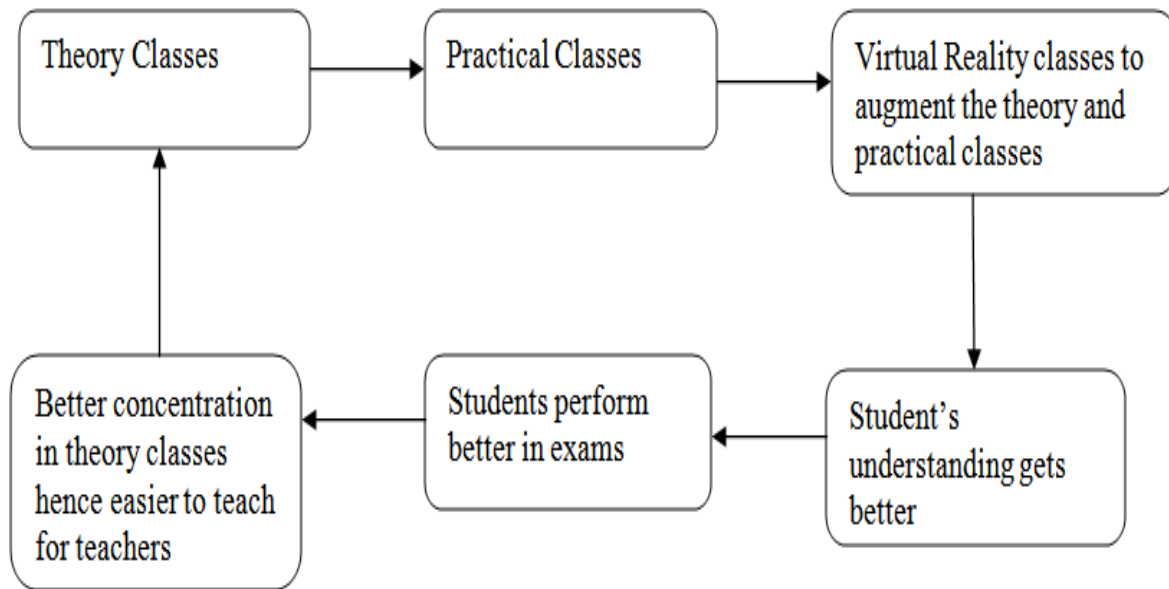


Fig. 4.2: Block diagram showing education via VR

Reduction in load and stress of teachers as result of VR augmentation and better performance of students in turn perform better as they are able to understand the concepts in a much better fashion. This closely knit bond between student and teacher is further improved by the introduction of VR system [43]. VR provides new methods of visualization which are visually intensive. Sometimes VR can provide information which are not possible through other means as it provides a way to examine things close up, far away, and also of areas and events which are inaccessible via other means. VR helps illustrate features and processes easily and more accurately than other technologies. It also helps in motivating students who are otherwise burdened easily. VR helps transcend language barriers as well. It helps in communication between different cultures as text translation will be easily accessible [44][17]. Time period taken for learning is a crucial point in education, in traditional methods time for teaching can be large but VR helps reduce this [45]. Apart from this VR also helps students by giving them time to explore the teaching environment. It also provides a platform for the disable to be engaged in learning spaces where they would normally miss out.

4.1.1 WHEN TO USE VR FOR EDUCATION?

The decision to use VR in education can be eased by asking a few questions. These questions help us solve the dilemma up to some extent or can serve as a preliminary cursor for the decision. The questions are as follows.

When to use VR

- i. training environment requires familiarization
- ii. teaching environment involves hazardous materials and requires proper safety training
- iii. training involves high precision equipment which is costly and hence requires prior preparation to avoid costly damages.
- iv. training is not cost effective
- v. simulation is more productive than the real thing and less cumbersome.
- vi. training helps motivate people
- vii. classes need to be shared with someone at a distant place
- viii. shared social space is a necessary part of the experiment or training
- ix. visualization of data and its manipulation so it can be understood and is a necessity
- x. simulation has to be carried out or development of environments is to be done and it can be done so only using computers
- xi. teaching needs to be more involved and fun
- xii. concepts are more visually demanding and/or need imagination power rather than grasping skills
- xiii. use of real training environment can avoid certain displeasure e.g. medical field
- xiv. disabled can be given an opportunity to perform experiments and activities which they cannot in real life

VR has a lot of advantages when being applied to certain scenarios. It can help ease the burden of teacher while also generating enthusiasm in a student.

4.1.2 WHEN NOT TO USE VR FOR EDUCATION?

The flip side to the use of VR in the education sector can be questioned as well. Usage of VR may or may not be useful in many cases. Hence some questions can help avoiding wastage of resources. The following questions can also be generalised for more scenarios involving daily life and be applied there to the same effect.

When not to use VR

- i. Traditional teaching method is more effective

- ii. Interaction with human is necessary
- iii. Using VR can pose problems for health e.g. motion sickness or headache
- iv. Too costly in comparison to normal teaching approaches
- v. Concepts are not visually demanding
- vi. Simulation becomes very real and enticing
- vii. Imagination power of students starts decreasing after too much exposure in VR

4.1.3 A MODEL FOR DETERMINING USE OF VR IN EDUCATION

Today education makes use of many computer based technologies like projectors and animation to good effect in most cases. But the use of these technologies falls short in more visually demanding concepts where students are not easily convinced or even get confused in trying to grasp what is being taught. The model being proposed will help with regards to deciding when to use VR in education. This model can also lay the foundations of the framework being proposed for development of applications in VR. The model is as follows.

- i. Subjects and their syllabi in the curriculum are considered
- ii. Specific subject(s) are identified which may require assistance of VR
- iii. Reasons to use VR and their advantages are considered
- iv. Specific concepts in the syllabus of identified subject(s) are earmarked
- v. A refined list of concepts/topics is made keeping in mind that 3D simulation will be more beneficial in all aspects

After identification of topics/concepts the process of development can begin. The following steps or framework is proposed for development.

- a) The level of realism required is identified for the concepts that are earmarked
- b) The level of immersion required for teaching those subjects along with the degree of presence required is also found out.
- c) Interaction between the virtual world and student is the next factor in consideration. It also involves the identification of feedback measures for input and output if necessary.
- d) According to the results in these steps software and hardware combination is chosen. The combination may involve normal 2D projection coupled with sensory input/output or fully immersive virtual environment with no sensory inputs and outputs, among many others.

- e) The virtual world is built according to the specific concepts and needs. In some cases it maybe from a teacher’s perspective, where the control lies with the teacher. In others it may be from a student’s angle, where he/she may be free to explore the environment.
- f) While development is being done a pilot study may be done to get necessary feedback from the concerned people.
- g) The feedback obtained will help improve the experience in the end. And can help developer identify problems and/or unnecessary features.

The development can be done on these guidelines but the implementation part will require more cycles of evaluation and feedback between concerned people and developers. Another case is possible where the teachers themselves act as the developers and introduce the cycle of feedback in their daily curriculum. Main feedback can be taken by a survey. In further sections we take a look at the finer details of this framework.

4.2 OBJECTIVES

Table 4.1 Objectives and their constituents

S No.	Objective	Step 1	Step 2	Step 3
1.	To study the field of VR	Part 1: Identifying of aims pertinent to Indian society Part 2: Virtual Reality is a wide field hence aim will be to narrow the field down to specific aims	To continue the study as it can help the development process	To monitor the developments of various products i.e. both software and hardware which can help make the system better and affordable
2.	To study and analyse various aspects of VR	To study various papers and research work and setting up of parameters and objectives to		

		work upon		
3.	To identify which instruments can be used	Narrowing down of the instruments available acc. to the parameters set		
4.	To start the development of a VR	Development of a basic VR will commence	Continual of the VR system acc. to the already set objectives and parameters	Additional functionality to be added upon by the use of more instruments
5.	To set the parameters and evaluation of system	Conducting a survey of students and teachers which will help set the parameters of work	Survey of students and teachers to evaluate the preliminary performance of system	
6.	To analyse the effectiveness		Analyse the data from survey and improve the system depending on feedback	Final assessment of the fully developed system

4.2.1 EXPLANATION OF OBJECTIVES

- i. This phase lays the foundation of the process to be undertaken for development of a Virtual Reality system. Since the field of VR is very vast as the applications can vary according to need and/or imagination of the developer. First step will be to read about the VR and its various uses. Then we can explore the various uses according to our society and its needs. The application has to be useful for Indian diaspora as a whole. After identifying the best possible point to implement a VR system on, a further study will be conducted so that it helps in knowing the problems or challenges that can be

faced during the course of development. Along with this we will also look to single out the devices which can be used for developing the system.

- ii. The development of system will begin after procurement of the instruments identified in earlier steps. Procured instruments will be put to development using the provided SDK and the above identified topics suggested by the group of teachers and students. The development step is broken down according to the points mentioned in table which will ensure the system is acceptable and according to the needs of the identified user.
- iii. This is a crucial step as it defines the motives of the project as a whole. Main aim of this objective is to interact with the teachers and students on a regular basis to know about their needs and feedback on the system being developed. The first meeting with them will help in laying out the parameters and identifying of the topics to be developed for usage. The feedback and suggestions from both parties will help in ironing out the problem areas.
- iv. The development procedure will go hand in hand with surveys conducted from time to time on the group of teacher and students. These surveys will keep the development procedure in check and on schedule. Surveys will contain questionnaire and feedback from both the teacher as well as the students. The points from teacher will help us in knowing the areas in which the VR system can be implemented and improved. The students' side will tell us about the experience of the system itself and whether it is satisfactory or not.

4.3 METHODOLOGY

Methodology can be easily understood by breaking it down into phases.

- i. Preliminary Phase

This phase can also be named the preliminary investigation stage. In this we firstly identify the schools that are equipped with smart classes. Then we do a survey to find out the thoughts of teacher and also pointing out the concepts which they would want to teach in 3D. This survey will also include students which will ask them about the concepts which could be taught better using the 3D environment. This survey will form the basis for development and also help in charting out a path for the project. This phase will initiate the procurement of required equipment.

- ii. Pre-development Phase

The concepts pointed out by teachers and students alike will be studied and checked for feasibility. Then depending on the number of concepts and subjects involved the student groups will be formed i.e. control and experiment group. The control group would be going through the usual classes, whereas the experiment group will study the same concepts in 3D environment. This will help in later stages. This phase will conclude the procurement of required equipment. An outline or chart will be formulated on the timeline to be followed for completion of the project.

iii. Development Phase

The charted out path will followed which will include the development of concepts and verification of the same by the developer itself. Development and testing will be done in-house.

This phase will include an assessment.

Mid-project Assessment: To get feedback on the work that has been done already. It would provide course correction if needed and will also help in familiarisation of the equipment to teachers. A class of 3hrs spread across a week would help in this cause and if needed students will also be brought in the loop. Development will continue after this.

iv. Final Phase

Once the development is over, we can begin the final assessment. This would include classes for students to tune of 30hrs spread over a month for subjects pointed out. It could include 3hrs a week for one subject or one subject at a time depending upon the dynamics of the school.

A combination of regular classes and this will be used to assess the difference in the two. As stated earlier the control and experiment groups will help the cause. The performance of the students can be measured by two methods

- a. The feedback from the tutor
- b. The regular exams

Teacher's and student's feedback will help in pointing out further refinement if needed. All this will help in knowing about the feasibility of such a technology in an important aspect of life. If found feasible, it would pave the path for greater market and research.

4.4 INITIAL FEASIBILITY STUDY

The proposed methodology needs a feasibility study as well. The following sections help prove that VR can be a tool to modernize education [46]. The tools being used for this

feasibility study are the same tools which will be used to develop the environment/software for study. Apart from them we use MATLAB™ to demonstrate the same scenario in an environment which is familiar to us. This helps us in comparing the traditional methods which involve simulations and/or animations created by computer. The GUI developed with the help of MATLAB™ resembles closely the simulations we use in current teaching methods. Unity and Unreal Engine are the choices of development environment for creators because they have their own physics engine and higher graphics capabilities than other platforms.

4.4.1 IMPLEMENTATION OF PROJECTILE MOTION IN MATLAB

MATLAB is very powerful software with wide uses. Since it is a familiar tool we utilise it to create a GUI which helps simulate projectile motion. We choose projectile motion as it is something very common yet complex. Many students are not able to grasp the concept of this motion easily and also fail to understand the effect of gravity on objects. This simple GUI as shown in fig 4.4 will help illustrate the motion. These kinds of simulations are nowadays commonplace in our learning space. Fig 4.3 shows the GUI creator of MATLAB which is used to create the GUI as shown in fig 4.4. As seen in the GUI we can enter values for initial position in the horizontal and vertical plane. Then we can set the speed and angle at which the object is thrown. We assume that the user will utilise this to further his study and not study from scratch hence the avoidance of equations.

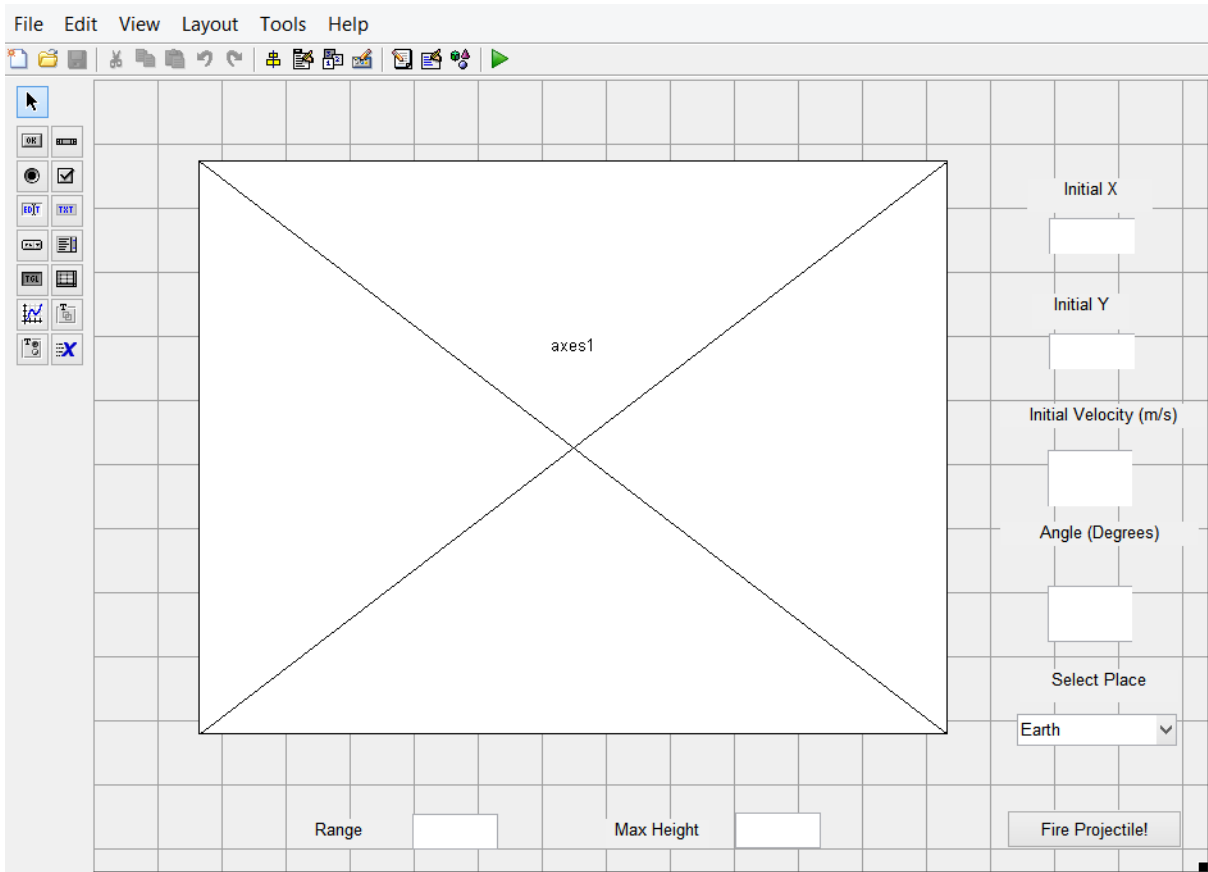


Fig 4.3: GUI creator

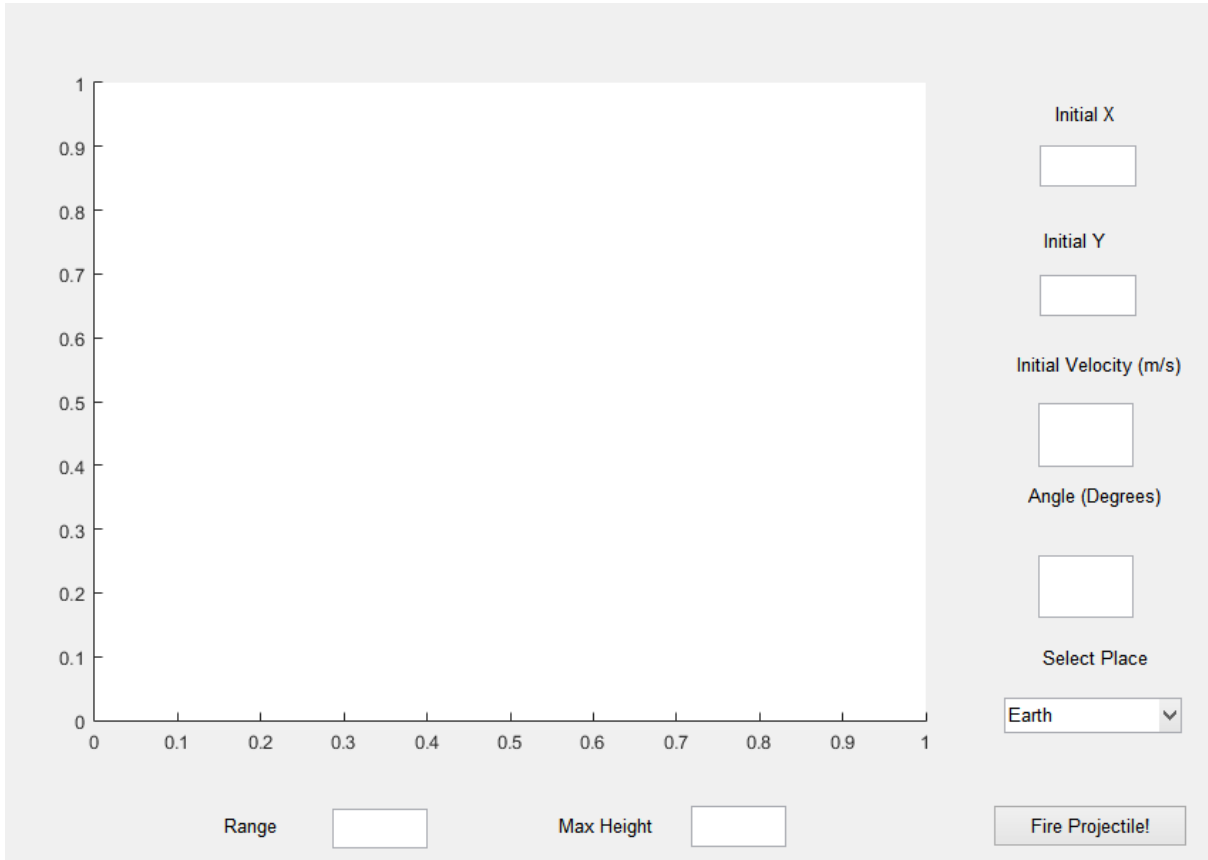


Fig 4.4: GUI for projectile motion

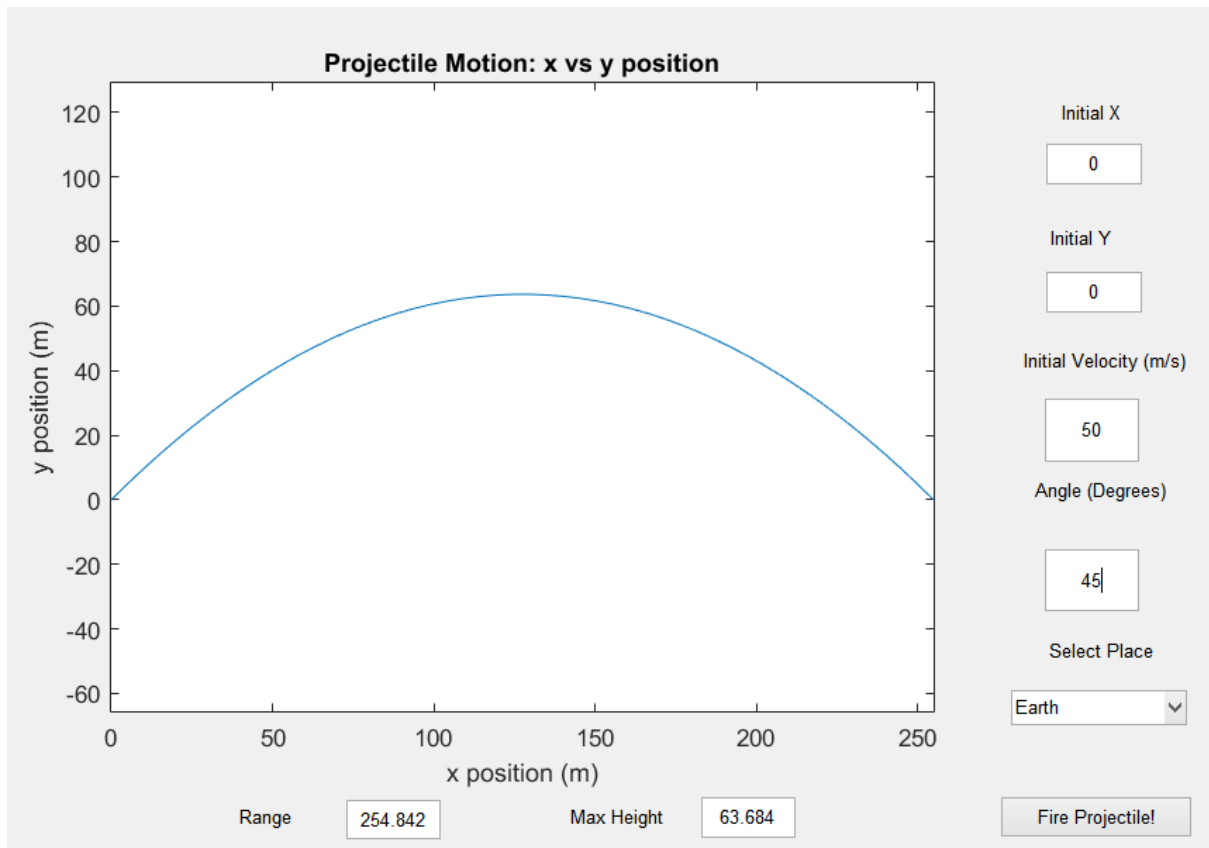


Fig 4.5: Output corresponding to Earth

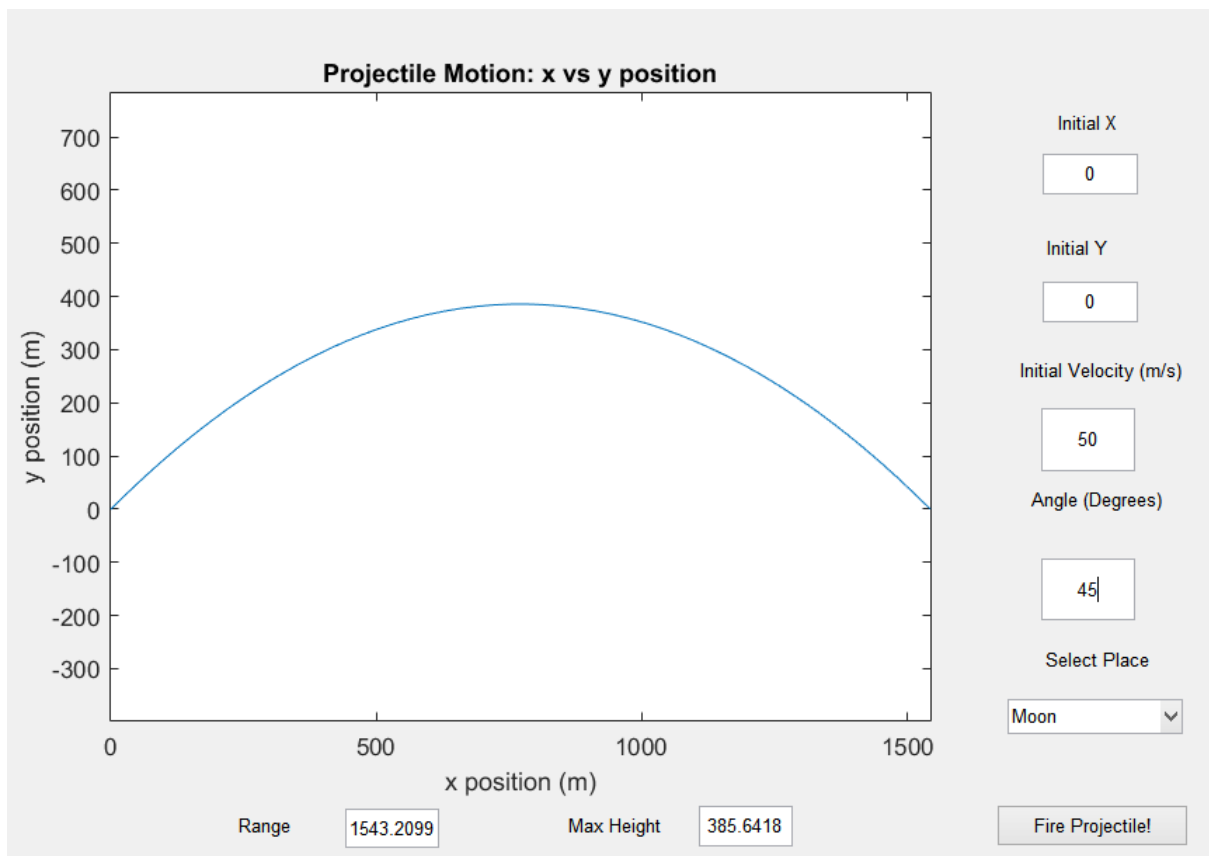


Fig 4.6: Output corresponding to Moon

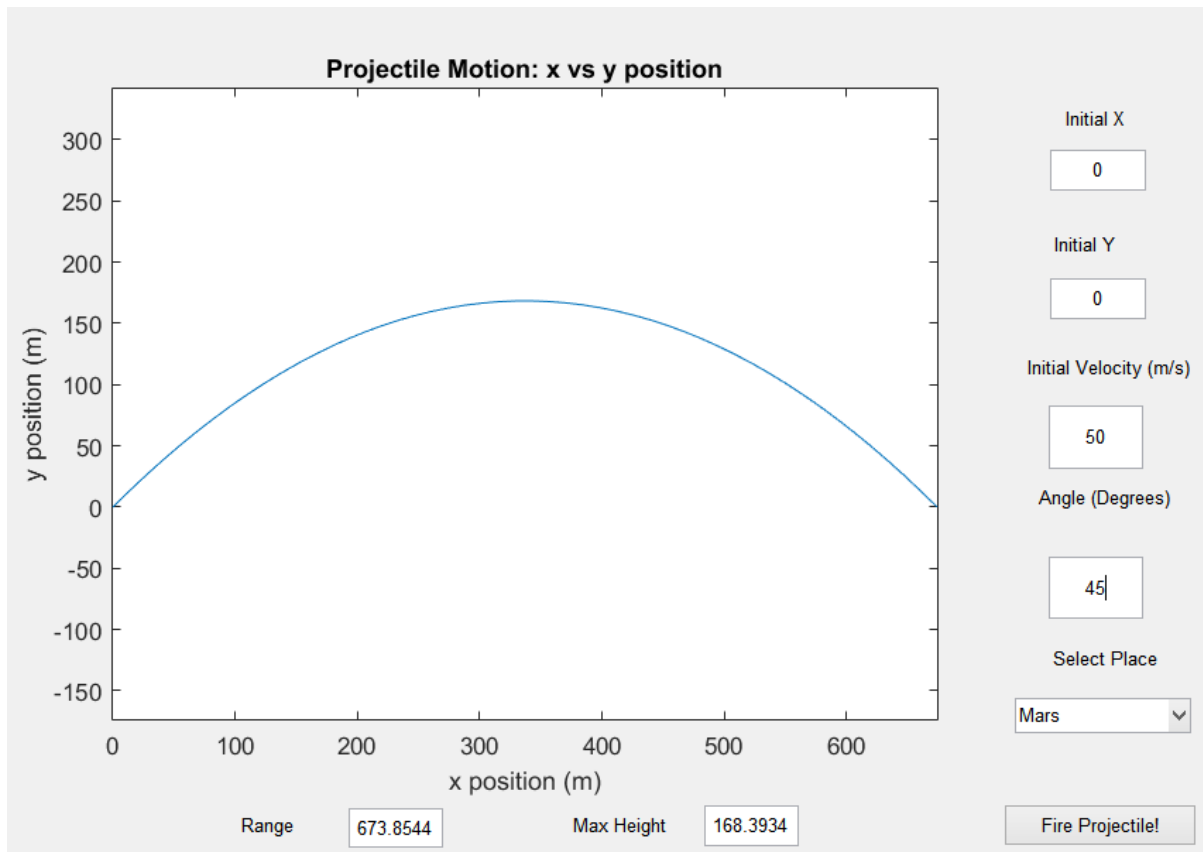


Fig 4.7 Output corresponding to Mars

As evident from the GUI, the user can also select the environment in which the object is being projected or thrown. Simply stated the gravity factor can be selected. The three options are Earth, Moon and Mars. Motions in these environments are shown in fig 4.5 to fig 4.7 respectively.

4.4.2 IMPLEMENTATION OF PROJECTILE MOTION THROUGH UNITY3D

Unity is a software package which is generally utilised to create games and graphical effects. Nowadays it also being utilised in the field of VR for creating immersive games. These games are not just third person games but also first person where the gamer gets to live the game. Unity is great as it can be used to create cross-platform games. Oculus VR has announced that it will support all games made through it and also released a plugin which helps put stereoscopic camera in the game easily. The graphic capabilities of Unity are only rivalled by Unreal Engine, which is discussed later. Fig 4.8 shows the setup, a shooter in the form of a cube and a target. The projectile is fired at the click of a mouse and travels from the cube to the intended target. The motion can be seen in fig 4.9. The reason for choosing this method is that, this way the interaction part of VR can be shown from a third person's perspective. This helps to differentiate it from traditional simulation while providing the basic

knowledge of how the projectile moves. The speed can be set in the settings on the right which are avoided as they show parts of the code. Next fig 4.10 shows a different angle of the motion with different value of gravity. All this can be visualized with the help of Oculus Rift DK2. The plugin provided helps in exporting the files and to be reproduced for a stereoscopic HMD.

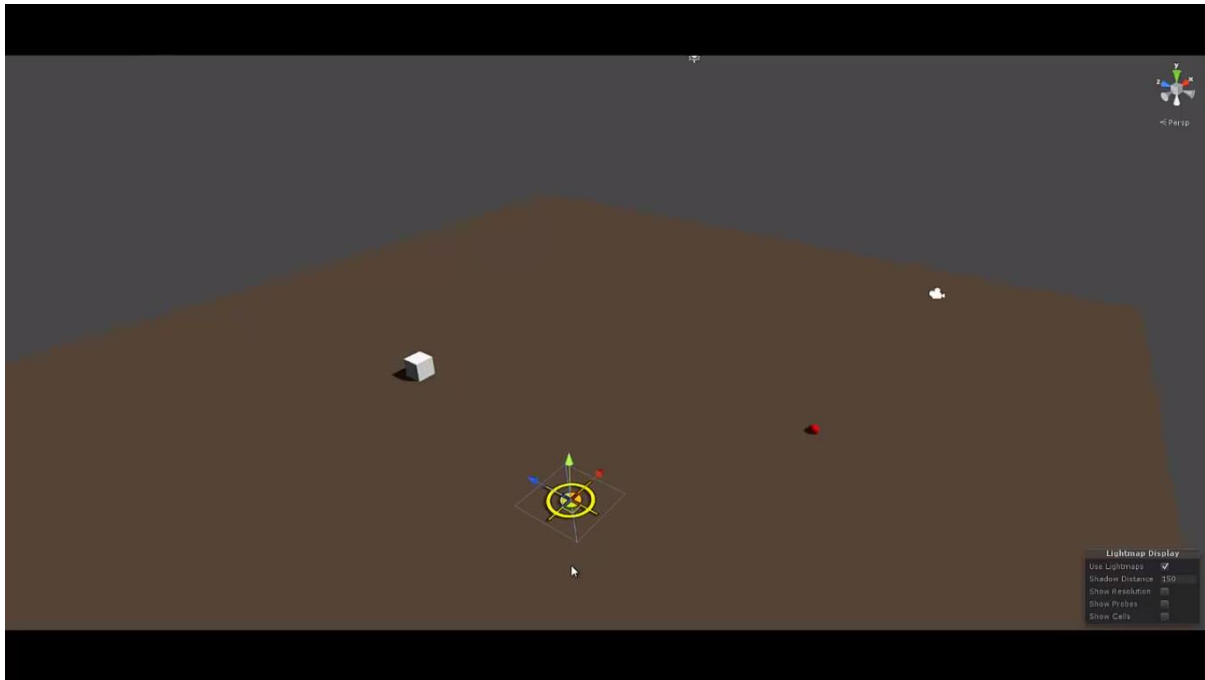


Fig 4.8: The setup in Unity

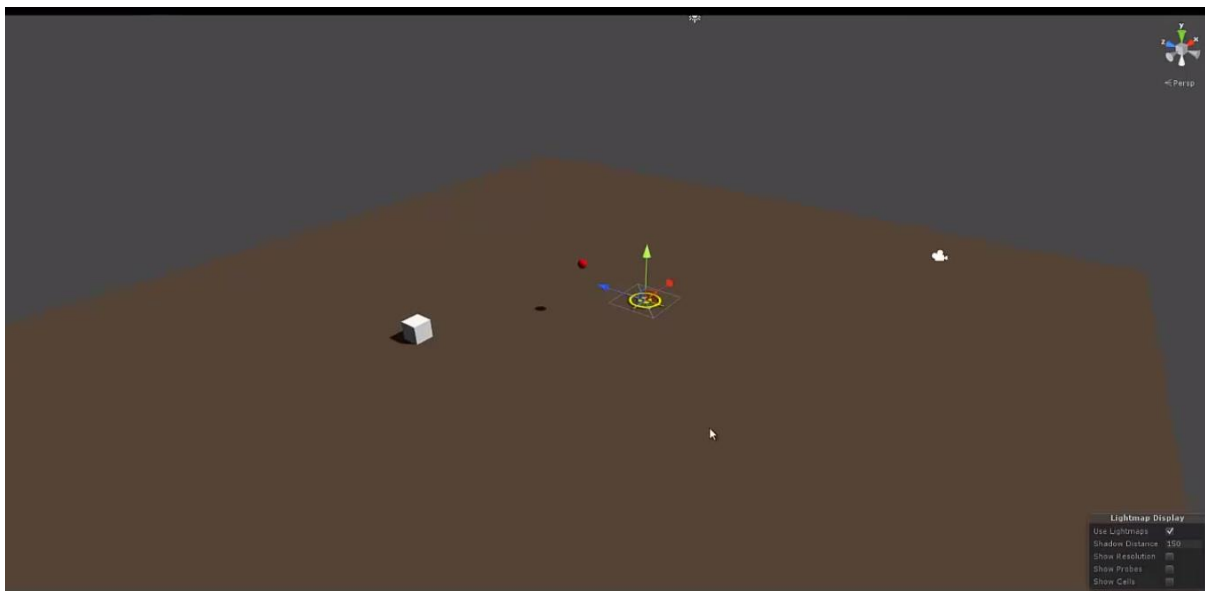


Fig 4.9: Motion of the projectile in Unity



Fig 4.10: Motion of projectile for different value of gravity

4.4.3 IMPLEMENTATION OF PROJECTILE MOTION THROUGH UNREAL ENGINE 4

Unreal Engine as stated in the earlier section has the graphics capabilities to rival that of Unity and in many cases also trumps it. Opinion is divided in the gaming community as to which is better and where. One thing that everyone agrees is that both are good for development as they support many platforms. Here in this simulation, we provide a different perspective from others as shown earlier. Fig 4.11 shows the motion from a first person's viewpoint. The blue rings denote the path of projectile. This is also utilised in games for many purposes. The fig 4.12 illustrates the impact point of the projectile. The limitation in this simulation is of speed and gravity. The angle of projectile can be easily set using the pointer as seen in figures. The last figure i.e. fig 4.13 shows the motion of projectile from a different POV, which helps in visualization further. These simulations help in providing different standpoints for the same motion and demonstrating the power of VR.

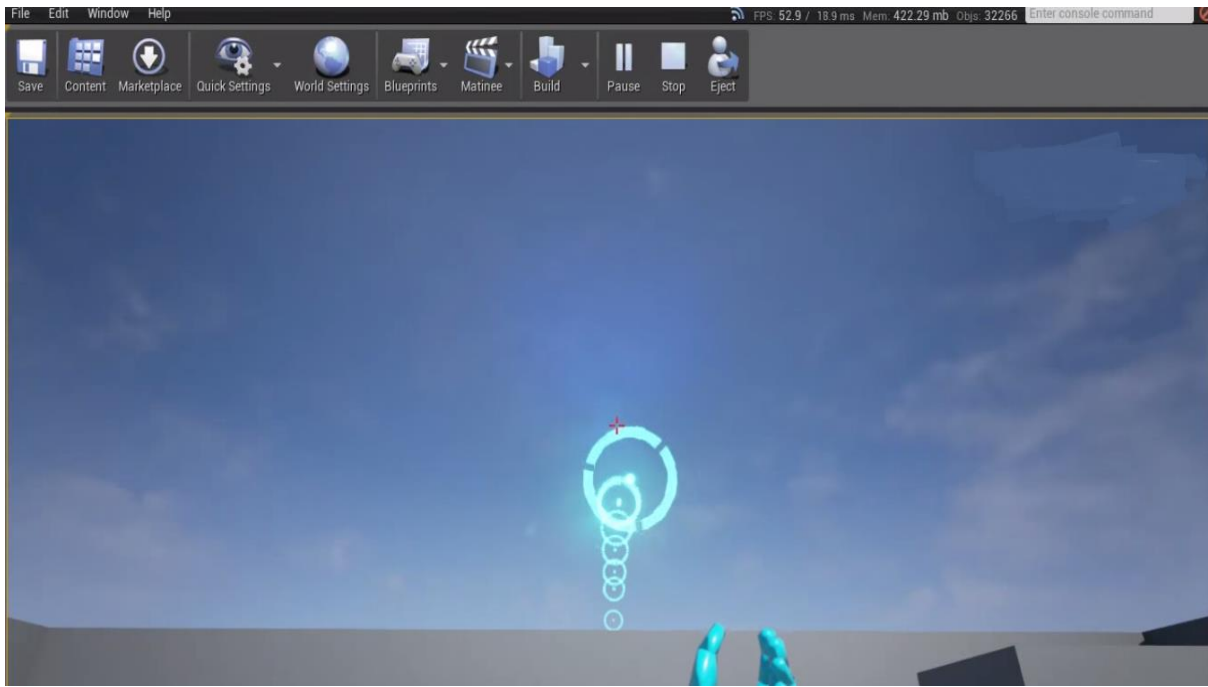


Fig 4.11: View of Projectile from first person POV

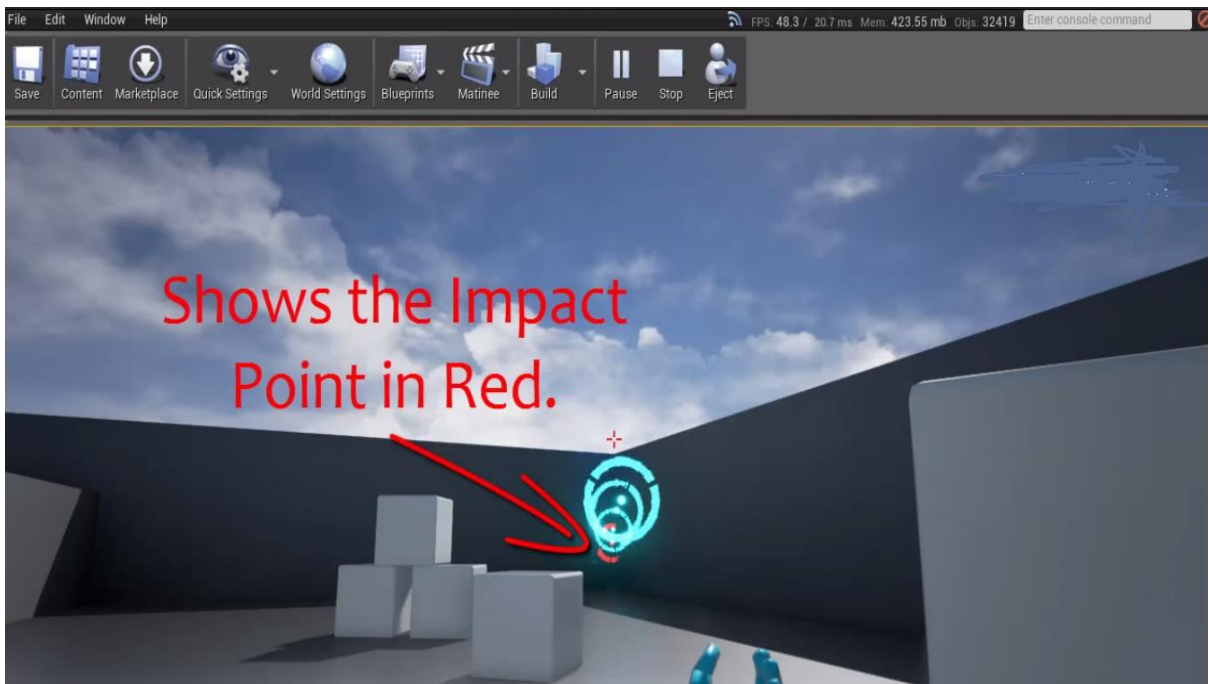


Fig 4.12: Showing the impact point of the projectile thrown

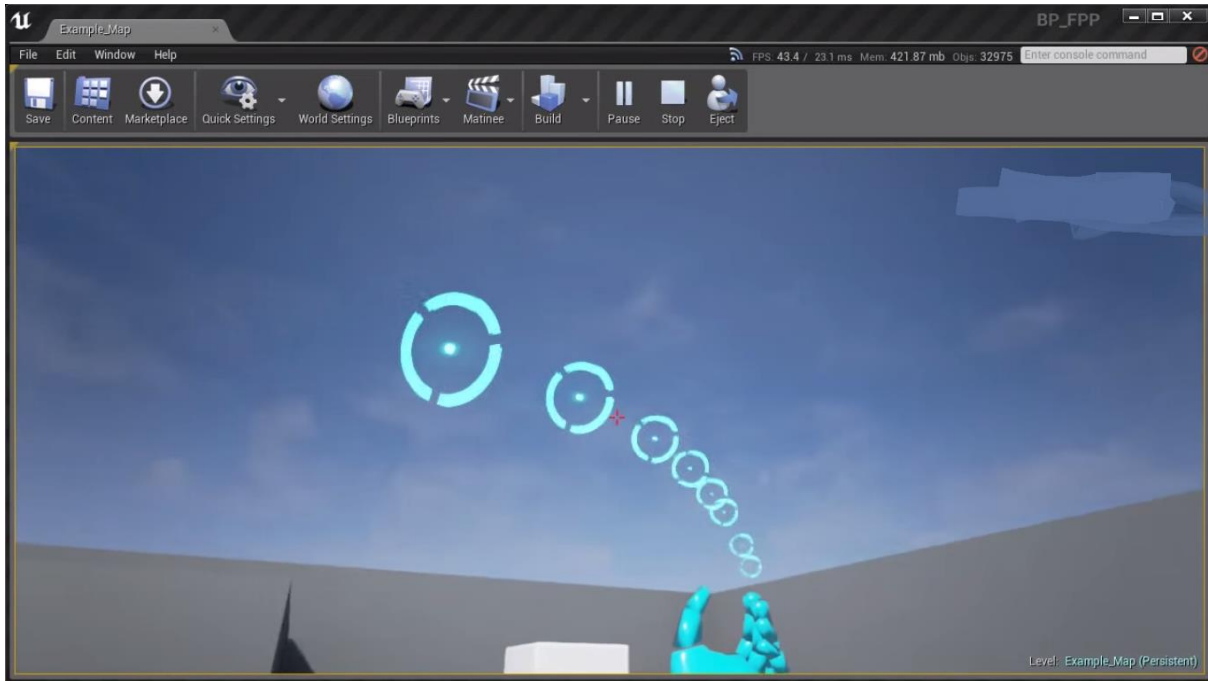


Fig 4.13: View of projectile from another angle

Chapter 5

RESULTS

In this section we take a look at the results of the preliminary feasibility study, which was discussed in an earlier chapter. The simulations made via the three methods were shown to a group of students. This was done so as to gauge the response towards a new technology like Virtual Reality using traditional and VR methods. It also introduced them to a new way of learning. Other questions involved a straight comparison between the simulations shown and asked them to rate their experience. A much specific question was also there, which asked them to give their thoughts on whether VR could be utilised for education or not. The questions concerning students' personal response to the experience of VR and the average scores are as follows: (On questions where a 10 point scale was given, several students chose an answer higher than the allowed number. We counted those answers as ten, but we wish to convey the enthusiasm with which the students responded.) These are the answers of one of the students in the seminar.

How did you feel about experiencing VR? (1: did not enjoy - 10: enjoyed extremely)

8

Do you want to experience VR again? (1: not at all - 10: very much)

9

How do you rate the experience of VR compared to normal gaming or generic visualization techniques? (1: not so different – 10: different and exciting)

9

The students were overwhelmingly pleased with VR technology. The raw averages are high and show the students' appreciation of the experience of VR. It can be seen that general student acceptance of this technology will be high.

The answers to comparison question were pretty much what was expected. They ranged from “MATLAB simulation is informative, but less attractive” to “Unity should be utilised in classes every day”. The negative parts in the answers in regards to VR were about fewer features in the simulation and not about interactivity. This can easily be changed by incorporating the necessary changes in the interface of the software. The question where the students were asked to rate their experience yielded the following results.

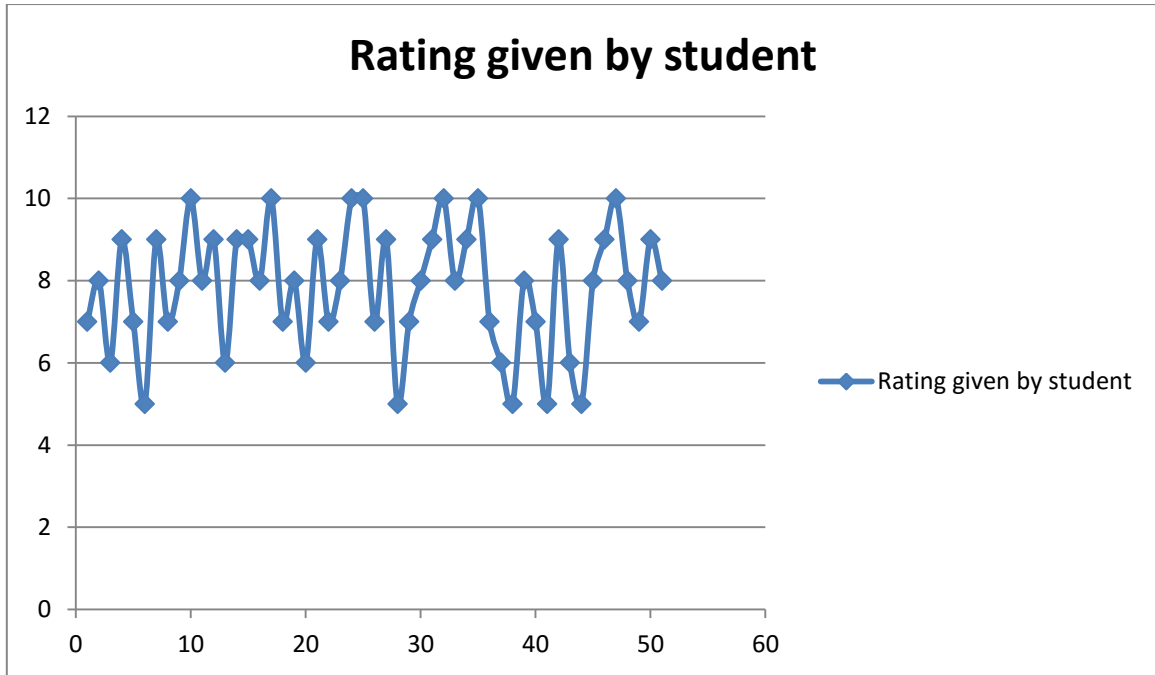


Fig 5.1: Chart with ratings corresponding to each student

This chart can be easily understood when plotted into a pie chart which distributes them according to the total number of ratings for each number. Fig 5.2 illustrates just that.

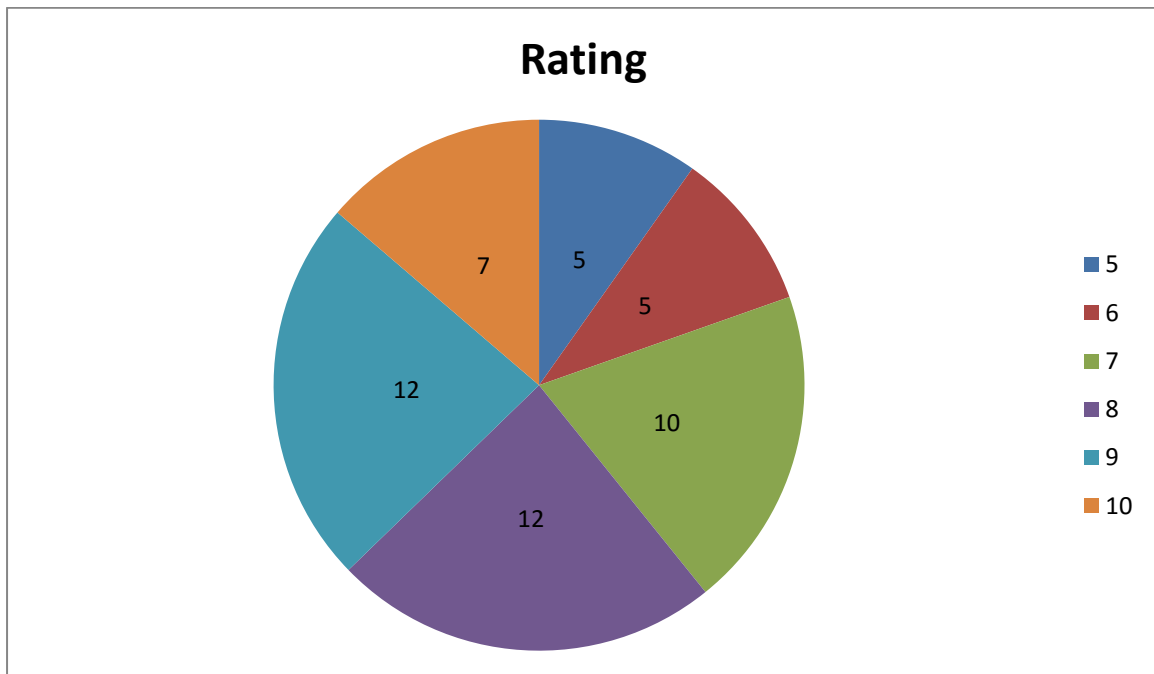


Fig 5.2 Distribution of the ratings

The distribution of rating is majorly between 7 and 9. This proves that the majority crowd was pleased or enthusiastic about the usage of VR and the technology in general. The people voting at 5 and 6 were discouraged due the fact that VR headsets were costly and also required high end hardware to run. While their concern is genuine it was not something that was related to the potential of VR rather more generic in nature.

We also asked several questions that allowed for open-ended answers:

What was the one thing you liked best about VR?

What was the one thing you liked least about VR?

If you could go into any virtual world that you can imagine, what would it be like?

We found patterns in the answers to the open-ended questions. With regard to what people liked best about VR, many of the students mentioned enjoying activities within VR such as being able to move and pick up objects in the world ("you get to go anywhere"; "picking up objects"). Many others commented positively about the experience of being immersed in a virtual world ("experiencing a new place without going far"; "I felt like I was in space floating through the world I created"; "Being IN it, not seeing it just on a screen"). The answers to what the students liked least about VR verified our videotape observations, and perceptively echoed complaints by many professionals in the field. The resolution ("the screen was kind of fuzzy"), the hardware ("too many wires to get tangled in"), the software ("Swivel 3-D"), the lack of control ("couldn't move the right way"), and being dizzy ("feeling dizzy at the end") are all issues that are being actively explored in the development of VR systems.

The students' responses varied on the most important things they found out about VR. Many commented on learning about what the VR state of the art was ("with a few more years of development, it could be used for almost anything"; "it needs work"; "the technology can be that advanced we cannot imagine"). Others talked about how much fun it was ("it was really fun"; "it's AWESOME!!"). The most common comment was that they learned that world building and VR takes a lot of work, with many people also commenting that the effort was worth it ("how hard people have to work to gain such an experience, and how fun certain work can be"; "your hard work definitely pays off well"; "how much work it takes").

After this we also asked

What would you change in VR?

What did you learn today?

Can VR be used for education?

The overwhelming answer to what students would change about VR is *more*. They want more objects, more movement, more color, more sound, more detail, and everything bigger ("More space and more buildings to pick up"; "more moving objects"; "more color and music" "More"). Again, this reflects the technical thrust of VR research. We found the students' VR fantasies a fascinating part of the survey . Many students imagined utopias ("A pollution-free, evil-free, sadness-free, tree-filled world, like a almost perfect world"), historical worlds ("a medieval world with castles and towers"), outer space ("a forest on Mars"), water worlds ("underwater where I could swim alongside the dolphins and whales"), the physical world ("Virtual cities"), games ("a world of stunts like bungee cord jumping, sky diving, etc.") and elaborate visions that are difficult to categorize ("I would like to go inside a volcano, travel the lava tube and get blown out when it erupts."). The variety of answers showed tremendous imagination and indicated that VR appeals to the students' sense of adventure. The answers to what they learnt were also intriguing ("learned how vast and significant development of the virtual world can be very mesmerizing"; "Today's experience was extremely different and exciting learned about the oculus and a little about its structure and also experienced a different world wearing it."). Their thoughts on whether VR can be used for education or not were exciting ("Yes, it certainly will be as it has a great potential to improve learning efficiency and capability of students."; "this technology can be used by ppl to have a view of the inside parts of the body (by doctors) machines by mechanics and much more."). Some even provided broader and more enthusiastic answers ("Yeah absolutely yes. It can have booming industry. The whole world works want to visualise the things and its results without initially investing everything in it. It has got uses in education, biomedical, research, better visual effects etc.").

There are a few challenges to achieving this vision that students have and want to experience. The biggest challenge in the field of virtual reality is developing better tracking systems, finding more natural ways to allow users to interact within a virtual environment and decreasing the time it takes to build virtual spaces. While there are a few tracking system companies that have been around since the earliest days of virtual reality. Likewise, there aren't many companies that are working with input devices specifically for VR applications. Most VR developers have to rely on and adapt technology originally meant for another discipline, and they have to hope that the company producing the technology stays in business. As for creating virtual worlds, it can take a long time to create a convincing virtual environment - the more realistic the environment, the longer it takes to make it. It could take a team of programmers more than a year to duplicate a real room accurately in virtual space.

Another challenge for VE system developers is creating a system that avoids bad ergonomics. Many systems rely on hardware that encumbers a user or limits his options through physical tethers. Without well-designed hardware, a user could have trouble with his sense of balance or inertia with a decrease in the sense of Telepresence, or he could experience cybersickness, with symptoms that can include disorientation and nausea.

The results of the preliminary feasibility study show that VR can be utilised in education. However the challenge, of providing such a niche technology without any compromises remains.

CONCLUSION AND FUTURE SCOPE

Virtual Reality as a tool can not only be used in schools to teach kids, but can also be used to educate students in higher and/or professional colleges. The use or scope of VR is unlimited and is only hindered by the hardware available to us. Software can be developed or tailored to suit our needs. Higher education is becoming increasingly costly due to the involvement of research related activities. This can be overcome with the use of VR as a piece of software can be used to generate or emulate the equipment needed for research. VR also helps in easier visualization of parameters or models or equipment than traditional pictures or movies. Higher Education comprises of training as well, which is the main reason why VR was thought of in the first place. VR provides us with a safe environment to work in and a more interactive one as well. It can provide us with instant feedback and corrective measures as and when necessary. Training in hazardous areas can be fatal; use of VR to emulate such conditions reduces hassles tremendously. Immersive VR can offer great advantages for learning: it allows a direct feeling of objects and events that are physically out of our reach, it increases the learner's involvement and motivation while widening the range of learning styles supported.

Apart from this possibility, it will also help in improving the student teacher relationship. With traditional methods the feedback is possible at specific times only. In this, it is possible to record and get instant feedback as the system is monitoring the performance continuously. Teachers' workload is reduced and is more interaction based than before. They are no longer required to draw on boards or use slides/pictures to explain concepts. Now they can use the time efficiently to get to the students' brain and get him to think in ways which is not possible via traditional methods. In the age old methods, we cannot go in depth or explain concepts involving 3D elements, but here it would become very easy. Movement of elements and/or naming of elements can be a breeze.

VR, despite all the recent advancements in this field, is still in nascent stages. The potential use or appeal of this technology raises a few questions. As with all technologies this also has its upsides and downsides. The questions being raised are not only ethical, but also fundamental. Taking some parallels from the existing world we can make out that gamers in future will get less interactive and more introvert than now. In VE's where the space is

personal the damages can be huge as it may lead to the person getting addicted and not leaving his space. This can be very much possible with artists as they get to create their own worlds which may or may not conform to the rules of the real world. In spaces where social interactions take place it can lead to lesser physical meetings than now even where we are getting hooked to our phones. Simple use of VR in education can also have an adverse effect as the student's ability to imagine can get diminished. The rapidly expanding field of VR with all its applications can be put to bad use by rogue programmers who may create games/environments which may affect the behaviour of the user. It is our duty as engineers and creators to keep an eye out for such potentially catastrophic uses of such a beautiful technology and prevent them from happening.

Future works that can be done is to implement the methodology fully along with the development of software. Software development can also go hand in hand with the development of hand tracking solutions. A 360° degree tracking of head and hand is very crucial and is a big challenge at the moment. Along with this eye tracking inside HMDs can also be implemented. The framework can also be tested for higher education.

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