Presenting tangible heritage through virtual reality in education contexts.

A Dissertation Submitted to

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The Degree of **Master of Design**

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Declaration

I declare that this written submission represents my ideas in my own words, and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the Institute and can also evoke penal action from the sources that have thus not been properly cited, or from whom proper permission has not been taken when needed.

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APPROVAL SHEET

This thesis entitled "**Presenting tangible heritage through virtual reality in education contexts**" by **Ambreesh Kumar Arya** is approved for the degree of Master of Design from IIT Hyderabad.

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Dedicated to

My Parents

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Chapter 1: Abstract

Global trends in heritage related work point to an increasing use of cutting edge computing and technological setups. This emerging digital paradigm, which includes new tools and platforms such as virtual, augmented, and mixed reality, has revolutionized the documentation, representation and dissemination of the historical monuments (Addison 2000). This has positively impacted diverse sectors such as tourism, archeology, cultural heritage preservation, entertainment etc. Digital cultural heritage is transforming the education sector as well. It is opening up new avenues in academic research and is also significantly influencing stakeholders in school and higher education. In line with these developments, the project is constituted in the following domain:

360 degree Virtual Reality (VR) immersive experiences of historical monuments based on school syllabuses.

1.1 Problem Identification

The project has been done to explore the affordances of the technology of VR in presenting tangible heritage in different formats, specifically for school educational contexts. Through student interviews, it was identified that here is a gap in the present scenario where students are not able to visualize many of the objects or places that were taught in the syllabus (Rasheed et.al. 2015). This was more pronounced in the field of history, where many students realize that what they visualized through reading text was not exactly what they saw when they actually visited the place. According to teachers, it was observed that students showed a decline in interest in the field of study of such subjects since the facts and data delivered through regular teaching methods were learnt by students without a relation to the physical appearance of the place. This causes a disconnection between reality and what is learnt.

Many historical sites have physical properties which appeals to people if they are actually present at the place. This can give a sense of size, color, sound etc. of the place and could help create connections with the history of the place. If this could be simulated, such an experience could be delivered at a place far away from the actual site. If such a system is provided in early stages of education, it could increase the curiosity and sense of exploration in students. Also it would enable students to better visualize places which could also enhance their creativity.

This project explores how an immersive education system like virtual reality/augmented reality would help to enhance the teaching and learning experiences related to history and historical sites. This project is limited to historical sites which are near to schools and presently existing either in prime or ruined state.

Figure 1: Z.P.H.S Kandi

1.2. Objectives

The broad objectives of the project are as follows:

1. To explore the affordances of the technology of VR in presenting tangible heritage in different formats, specifically for school educational contexts.
2. Developing low cost technological systems for production and deployment of VR content across schools in India. This involves the development of hardware, software and content development.
3. To develop scalable and flexible methodology/frameworks for capturing local tangible heritage and presenting them in multiple formats using the technology of VR.

1.3 Scope and Limitations

Reviews of existing literature on digital heritage, especially heritage projects using VR technologies, pedagogy (instruction using multimedia, teaching and learning through VR) and VR technologies specifically for heritage education reveal certain problem areas which the proposed project intends to address. Some of them are:

1. Low levels of immersion and presence in the simulated environments which reduce their effectiveness as a pedagogical tool/medium of presentation.
2. High costs involved in VR devices and heritage content creation.
3. Lack of context specific frameworks for effective integration of heritage ecosystems and educational institutes.
4. End users' hostility in using VR technology to access heritage related content.
5. Limited language support.

6. User dissatisfaction in accepting the simulations as substitutes for actual heritage.
7. Misleading and false information about heritage ecosystems in simulated renderings.
8. Technology induced physical discomforts such as motion sickness, eye strain etc.

Chapter 2: Related Literature and Study

2.1 International review status

Various international projects offer insights into the modalities of presenting heritage content through Virtual, augmented and mixed reality. One popular mode is serious games for cultural heritage (Ma, Qi and Zhao 2009; Anderson et.al. 2010; Mortara et.al. 2014; Sylaiou et.al. 2015). When it comes to on site/near site VR/AR reconstructions of heritage a range of VR/AR projects have been executed. These include Archeoguide (Vlahakis 2001), Project ENAME (Pletinckx 2000) to name a few. Portable virtual exhibition systems such as MNEME (Bruno et.al. 2010), Pure Land: Inside the Mogao Grottoes at Dunhuang, Pure Land Augmented Reality Edition (Kenderdine, Chan and Shaw 2014) have also been very successful in propagating cultural heritage. Among VR systems and exhibitions in museums and virtual museums, Kivotos (1999) and Tholos (2006) of the Hellenic World have been extensively evaluated for their effectiveness in disseminating cultural heritage. In addition to this user studies on virtual museum Projects have been done (Barbieri, Bruno, Muzzupappa 2017). Projects delivering VR cultural heritage on the web include ARCO, 3D MURALE (Bruno et.al. 2010) Virtual Heart of Central Europe (Zara 2004) and so on. Yet another modality of presenting cultural heritage is VR/AR on mobile platforms for cultural heritage (Chang et.al. 2015; Harley et.al.2016; Nagata, Giner and Abad 2016, Petrucco and Agostini 2016).

A series of articles on VR/AR for cultural heritage education and pedagogy have been published by Tost and Economou (2009), Huang, Hui Li and Fong (2015), Palombini (2016), Tom Dieck, Jung and Tom Dieck (2016), and others. Research on technical and methodological aspects of using VR/AR for cultural heritage has also been extensively done. These include testing of theories and hypotheses for historical scenarios using 3D models and VR game engines (Rua and Alvito, 2011) Open source technologies (Basto, Pela and Chacon 2016), evaluations of wearable technology in museum contexts (Mason 2016), optimizing and managing complex reality based 3D models for real time fluent interaction with VR devices and motion trackers (Palacio, Morabito and Remodino 2017).

2.2 National review status

At the national level, relevant studies in the area of VR/AR, digital heritage, and education have been conducted in industry and academic circles. Rasheed et.al. (2015) present an indigenous VR application called Fanny World, a low cost VR app (accessible through Google cardboard VR kits and Android mobile phones) which delivers 360 degree spatial immersions of various monuments (Golconda Fort– portions related to these monuments are included in school textbooks) in Telangana and Andhra Pradesh. Project EYE-SEE (2016), which is an extension of the Fanny World app, updates the methodologies, workflow and scalability pertaining to use of low cost VR devices in schools for heritage education. Onkar and Krishnan R. (2017) presented details of an ongoing site specific augmented reality project which would narrate a Keralan folk tale about a legendary carpenter and his mythical temple pond which assumes different shapes depending on the perspective of the viewer.

This section presents literature focusing on computational technologies in the domain of digital cultural heritage. Ghosh et.al. (2016) present a mobile based system for generating site specific short descriptions of heritage sites based on spontaneous egocentric videos captured by users. They demonstrate the efficacy of this system in the context of Golconda Fort, a heritage site in Hyderabad. Das and Garg (2011) highlight a unique aspect of digital cultural heritage which is literary architectural heritage. Their paper presents digital graphical documentation (CAD drawings, virtual 3D models) of the pavilions described in *Mayamatam,* an architectural treatise of ancient India. Another aspect of digital cultural heritage is annotation and background information. Panda et.al. (2012) present a mechanism to generate instant annotations for pictures of heritage site/monument taken in a mid-end mobile phone, without connecting to a remote server. Their paper demonstrates the functionality of the application in two Indian heritage sites namely Golkonda Fort and Hampi Temples. The application uses a Bag of Visual Words (BOW) image retrieval system and an annotated database of images. Another paper by Panda and Jawahar (2013) discusses an interactive web based annotation tool, which enables multiple users to add, view, edit, and suggest rich annotations for images in community photo collections.

The Center for Art and Archeology of the American Institute of Indian Studies launched the VMIS -Virtual Museum of Images and Sound (2012). Funded by the Ministry of Culture, Government of India, VMIS is an independent scalable virtual museum space that allows digital exhibitions and depositing of digital content. Other open source online digital databases such as Sahapedia (2016) offer a wide variety of digital content covering tangible and intangible heritage. The Industrial Design Centre at IIT Bombay has also implemented a large scale digitization project of the Ajanta Ellora caves.

Among other projects which link school education and heritage ecosystems with the help of digital platforms, Central Board of Secondary Education (CBSE) has collaborated with Sahapedia, to develop a web portal to popularize heritage education among schools in the country (2012). Students and teachers can contribute content in the form of photos, videos and other material to this web portal.

2.3 Gap areas identified between national and international review status.

VR technologies have been used in digital heritage projects to provide remote access (web based, virtual museums, portable viewing setups, digital archives) to cultural heritage or on-site/near-site augmentation of heritage components such as lost structures. In the context of education, these technologies have been used to offer remote experiences of heritage through simulations. They have also been used in museum settings to present instructional material, walkthroughs etc. and for web based e-learning solutions.

In India, very few attempts have been made to seamlessly integrate VR/AR platforms, heritage, and education. This could be due to the high costs and cutting edge technologies demanded by VR/AR setups.

Chapter 3: Methodology and Framework

3.1 Approaches / detailed methodologies of the research work:

360 degree Virtual Reality immersive experiences of historical monuments based on school syllabuses

Literature Survey

Literature surveys has been divided into three major subsections.

a. ***Modalities of presenting digital heritage using VR technologies:***

Publications related to this domain offer pertinent insights into the various modalities of presenting digital heritage using VR/AR technologies such as serious games for cultural heritage, on site/near site VR/AR reconstructions/augmentations of heritage, portable virtual exhibition systems, VR systems and exhibitions in museums, VR and cultural heritage on the web, VR/AR on mobile platforms for cultural heritage etc.

b. ***Technical and Methodological aspects of using VR for cultural heritage.***

Literature on the technical and methodological aspects of using VR for cultural heritage focus on various themes such as testing of theories and hypotheses for historical scenarios using 3d models and VR game engines, context specific methods for digital reconstructions of tangible heritage, optimizing and managing complex reality based 3d models for real time fluent interaction with VR devices and motion trackers etc.

c. ***Digital heritage in educational contexts and the use of VR as pedagogical tools.***

Literature on digital heritage in educational contexts and the general uses of VR as pedagogical tools discusses various aspects such as advantages and challenges of VR in educational settings, applications and comparative studies of professional and low cost head mounted devices in immersive education, VR and various modes of pedagogy, evaluations of AR learning environments (ARLE) through user studies and user testing, grammar of narratives for cultural heritage dissemination in digital environments for virtual museums, immersive VR simulations and effects on spatial awareness, immersive VR for learning about archeology and the past in cultural heritage settings.

1. System study

a. *Identification of target government schools.*

The choice of target government schools, has been determined by various factors such as location of schools, proximity of heritage elements to schools, heritage covered in syllabuses, school infrastructure and student strength .

b. *Identification of tangible heritage.*

The history syllabus has been scrutinized thoroughly to identify tangible heritage components covered in the textbooks. In the late state these will be presented as VR experiences.

c. *Site assessments/field work.*

Various sites related to the chosen tangible heritage components has been assessed by team field visits. Main reason behind initial stage field assessments was to identify the feasibility of sites for VR presentations, possible impediments etc. Interviews with school kids and teacher, focus group discussions (Tourist), surveys and pre-test was the deciding factors.

d. *Acquiring Permissions and Approvals.*

After initial site assessments and field work, permissions and approvals from the concerned official authorities (regulatory bodies/authorities responsible for primary and secondary school education such as Panchayat members, DEO, AEO, DPI etc., regulatory bodies governing heritage components such ASI, cultural organizations, NGOs etc.) has been acquired.

2. Prototyping and Pilot Studies

a. Documentation: 360 photography, scanning etc.

Digital documentations of Tangible heritage such as photographs and videos, 360 degree photographs and sound recording etc.

b. Presentation, language, user interface/narrative outlines.

In this stage, various representations of heritage content such as language support, map visualizations, user interfaces and narrative outlines has been developed.

c. VR application development.

Various digital representations of heritage content has been incorporated into a coherent narrative. Components of this interactive environment has been integrated into a game engine and a cohesive simulated world has been generated based on the 360 photographs, language support, maps and sound effects.

d. Application user test.

Various user level tests of the developed interactive environment has been conducted at this stage. This includes user interviews, surveys, experiments, focus group discussions etc.

3. Field Deployment

a. ***VR system implementation in school and user testing.***

In this stage, the developed indigenous VR technological pipeline and the simulated content has been implemented in the identified target government schools under predefined conditions. Various user level tests of the developed interactive VR environments and the indigenous system has been conducted at this stage.

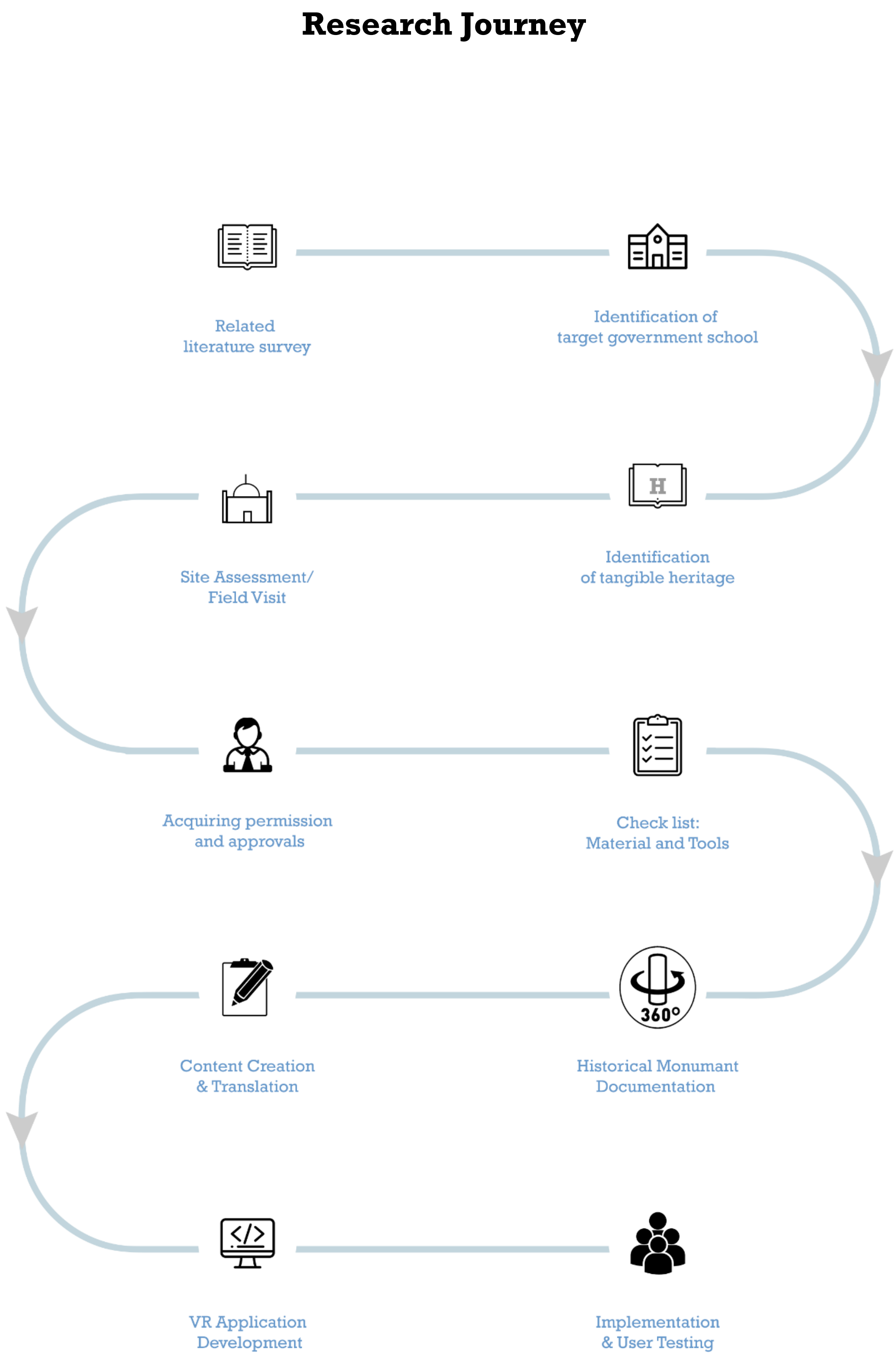


Figure 2: Research Journey

Chapter 4: Documentation of Monuments

One of the key factor of this project is to document all historical monuments in 360 degree photographs. To do that we used consumer grade Ricoh Theta S, 360 cameras with decent image quality. It produces nicely-stitched 360 panoramas at 14MP with a 5376 x 2688 resolution.

To capture the complete essence of the history and its importance, other documentation method has been taken into consideration, like interaction with local people/visitors, taking notes, Tour Guide, Sound Recording, Photography and Mapping,

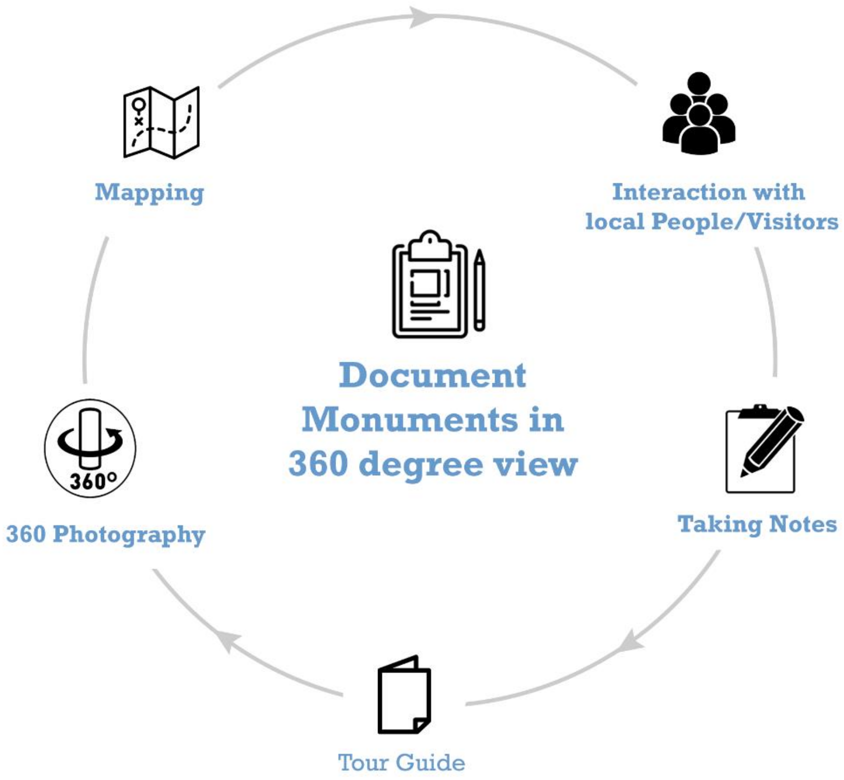


Figure 3: Monument Documentation Process

4.1 Charminar

location_1

location_2

Figure 4.1.1: Charminar in 360

4.1 Charminar

location_3

location_4

Figure 4.1.2.: Charminar in 360

4.1 Charminar

location_5

location_6

Figure 4.1.3: Charminar in 360

4.1 Charminar

Figure 4.1.4: Charminar in 360

4.2 Qutub Shahi Tombs

Figure 4.2.1: Qutub Shahi Tombs in 360

4.2 Qutub Shahi Tombs

Figure 4.1.2: Qutub Shahi Tombs in 360

4.2 Qutub Shahi Tombs

location_5

location_6

Figure 4.2.3: Qutub Shahi Tombs in 360

4.2 Qutub Shahi Tombs

Figure 4.2.4: Qutub Shahi Tombs in 360

4.3 Paigah Tomb

location_1

location_2

Figure 4.3.1: Paigah Tombs in 360

4.3 Paigah Tomb

location_3

location_4

Figure 4.3.2: Paigah Tombs in 360

4.3 Paigah Tomb

location_5

location_6

Figure 4.3.3: Paigah Tombs in 360

4.3 Paigah Tomb

Figure 4.3.4: Paigah Tombs in 360

4.4 Warangal Fort

location_1

location_2

Figure 4.4.1: Warangal Fort in 360

4.4 Warangal Fort

location_3

location_4

Figure 4.4.2: Warangal Fort in 360

4.4 Warangal Fort

location_5

location_6

Figure 4.4.3: Warangal Fort in 360

4.4 Warangal Fort

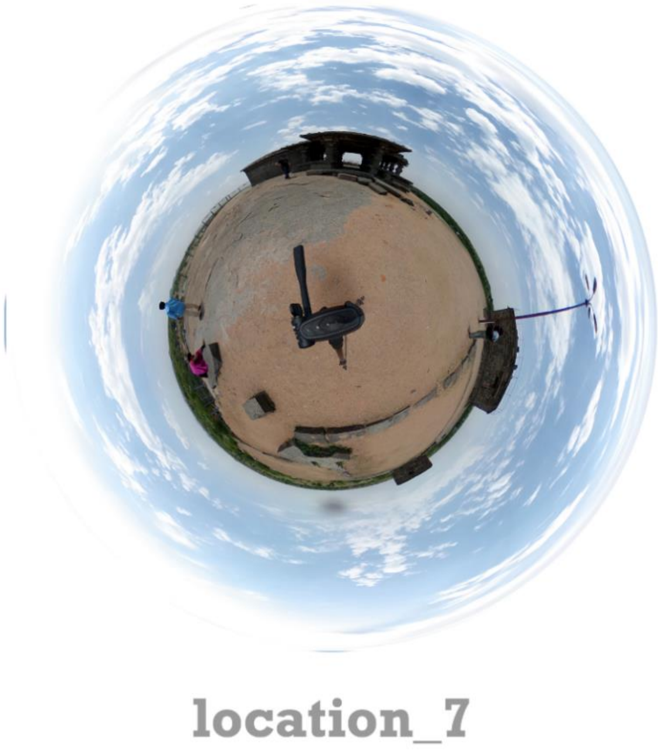


Figure 4.4.4: Warangal Fort in 360

4.5 Golkonda Fort

location_1

location_2

Figure 4.5.1: Golkonda Fort in 360

4.5 Golkonda Fort

location_3

location_4

Figure 4.5.2: Golkonda Fort in 360

4.5 Golkonda Fort

location_5

location_6

Figure 4.5.3: Golkonda Fort in 360

4.5 Golkonda Fort

location_7

location_8

Figure 4.5.4: Golkonda Fort in 360

4.6 Bramhalingeshwara Temple

location_1

location_2

Figure 4.6.1: Bramhalingeshwara Temple in 360

4.6 Bramhalingeshwara Temple

location_3

location_4

Figure 4.6.2: Bramhalingeshwara Temple in 360

4.6 Bramhalingeshwara Temple

location_5

location_6

Figure 4.6.3: Bramhalingeshwara Temple in 360

4.6 Bramhalingeshwara Temple

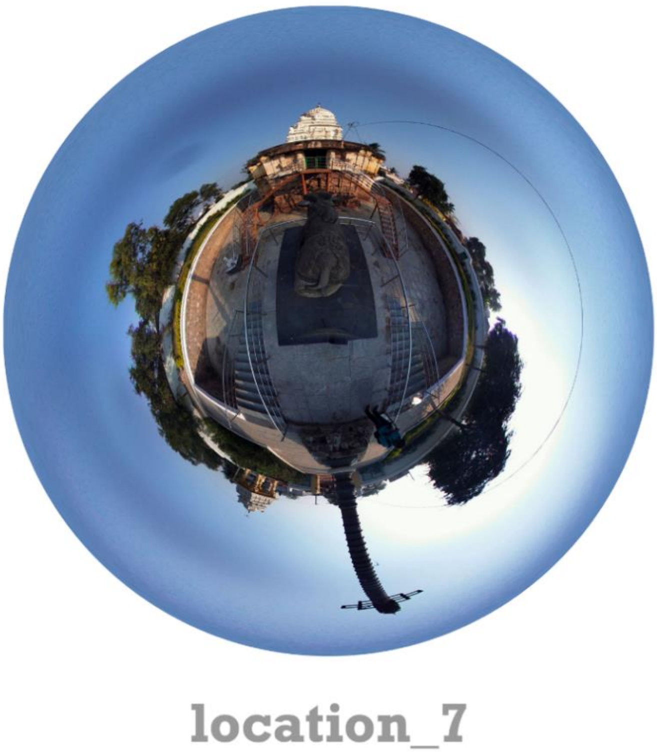


Figure 4.6.4: Bramhalingeshwara Temple in 360

4.7 Gol Gumbaz

location_1

location_2

Figure4.7.1: Gol Gumbaz in 360

4.7 Gol Gumbaz

location_3

location_4

Figure 4.7.2: Gol Gumbaz in 360

4.7 Gol Gumbaz

location_5

Figure 4.7.3: Gol Gumbaz in 360

4.8 Ibrahim Rouza

Figure 4.8.1: Ibrahim Rouza in 360

4.8 Ibrahim Rouza

Figure 4.8.2: Ibrahim Rouza in 360

4.8 Ibrahim Rouza

Figure 4.8.3: Ibrahim Rouza in 360

Chapter 5: HMD Prototyping

5.1 Understand the currently available HMD in the market.

In the past few years, researchers have been working on Virtual Reality (VR) and Augmented Reality (AR) systems (K. S. Hale, Steaven M. 2015). These systems create a visual sensation to the user in the form of virtual or mixed reality. The rendered images are updated on the screen of the Head Mounted Display (HMD) according to the movement of the user. The HMDs available in the market are bulky and wired to user's computer that executes the software. These systems require a processor with a good computational power and a Graphic Processing Unit (GPU).

Currently there are only two major Head Mounted Display (HMD) available in the market, Samsung Oculus Rift and HTC Vive. Both likely to give their own application to use their HMD or they will use third part like Google or Sony/X-Box Game Console.

Source

Source

Figure 5.1: Head Mounted Display (Oculus Rift (Lift) & HTC Vive (Right)

VR headsets like Oculus Rift and HTC Vive are often referred to as HMDs, which simply means they are head mounted displays along with few sensor set . The goal of the hardware is to create what appears to be a life size, 3D virtual environment without the boundaries we usually associate with TV or computer screens. So whatever way you look, the screen mounted to your face follows you. This is unlike augmented reality, which overlays graphics onto your view of the real world.

All these HMD's will be connected to console or computer via HDMI cable to send the audio-visual contents and there will be one head tracker for head motion tracking. Head tracking means that when you wear a VR headset, the picture in front of you shifts as you look up, down and side to side or angle your head. In the case of Google cardboard, phone’s sensor (such as a gyroscope, accelerometer and a magnetometer) act as a head motion tracker. Now a days, people are working on infrared sensor to track motion and hand movements.

Key feature of currently available HMD’s

Oculus and HTC has set accessories which helps them to give a full immersion. Some of them are:

- Hi-Res display
- Head Motion Tracker
- Game Console

When we say full immersion that mean making the virtual reality experience so real that we forget the computer, headgear and accessories and act exactly as we would in the real world. Even with no audio or hand tracking, holding up Google Cardboard to place your smartphone's display in front of your face can be enough to get you half-immersed in a virtual world.

5.2 HMD Prototyping 1: Raspberry Pi 3 + Display Unit (Test 1)

As a part of Eye-See 1.0 project, we have developed an android application and we were using android phone and google cardboard to give the virtual reality immersion. As we are focusing on the rural school, android phones became bottle neck for us because we need to carry as much as 10 - 20 phones to conduct one history class. At the same time we were not using all the functionality of a phone. It is not feasible to distribute phones to all the kids because it has different image all together. For them, a smartphone not more than a camera and game player.

In Eye-See 2.0, we wanted to replace android phone and the same time we wanted to use older application which we have developed for Eye-See 1.0. In short, we need to develop a device which can run android application.

Required Material

Hardware: 1. Raspberry Pi 3

2. Display unit (800p * 480p)

3. HDMI and USB Cable

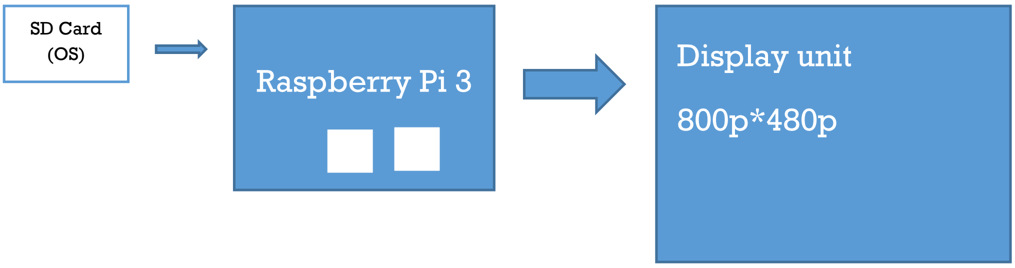
4. Power Adopter (5V)

Software: 1. Android 6.0 Beta

Raspberry Pi 3: Raspberry Pi 3 is a credit - card sized single board computer. In our prototype, we used Raspberry Pi 2 Model B. This version of Raspberry Pi is based on Broadcom BCM2836 processor. It has 1GB of RAM which is also shared with the GPU and an ARM Cortex A7 processor running with a clock of 900 MHz. It has the capability to communicate with a display unit having a resolution of 1900×1200 pixels using HDMI port. There is also a provision of placing a microSD card on the board that has the Operating System (OS). The dimension and weight of the computer is approximately 90mm×60mm and 45gms, respectively. The power rating of the device is 5V ≈ 1A. The OS installed on the device is Android 6.0 beta.

Display Unit: One of the requirements of the design is that the screen must cover the field of view of the user to achieve proper visualization of the image. A 5 - inch screen was a good choice, as it covers most of the user's field of vision when placed at a distance of 4- 5cm from the eyes. Adafruit 5" display with a HDMI and power input port is used in our design. Resolution of this screen is 800×480 pixels which is sufficient for prototype.

Block Diagram:



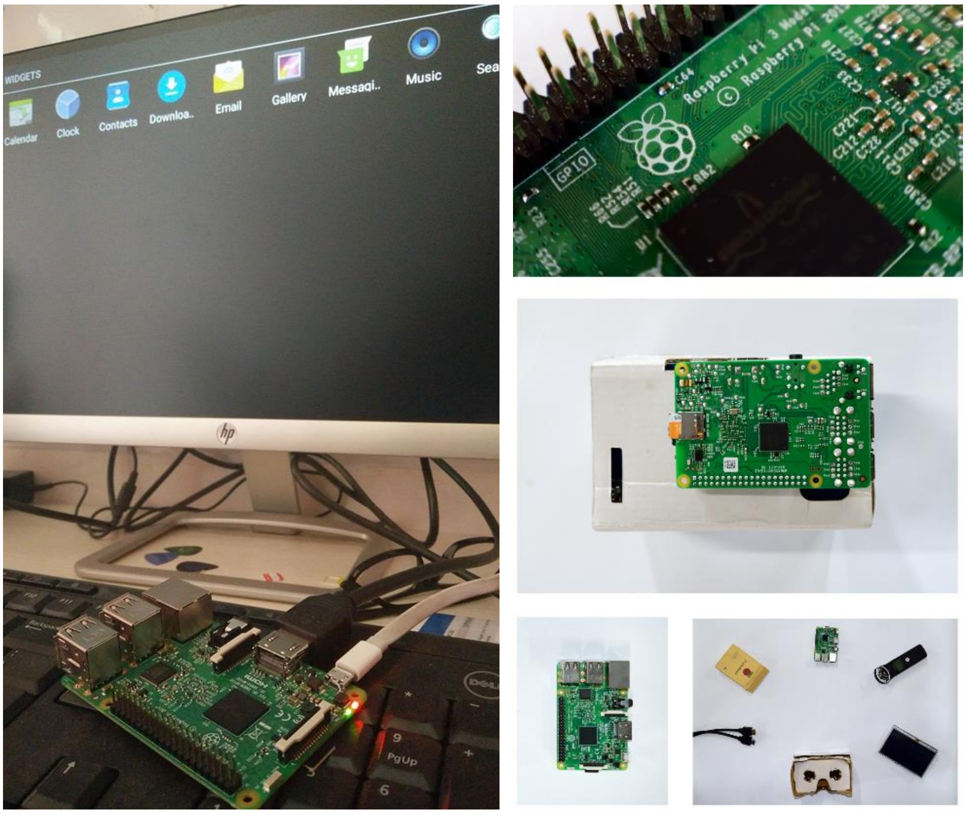


Figure 5.2: HMD Prototyping 1

Observation and Result

- Android 6.0 beta is not stable.
- Raspberry Pi 3 is not powerful enough to run the VR android application.
- There is no head-tracking system, such as a gyroscope, accelerometer and a magnetometer.

5.3 HMD Prototyping: Arduino Micro + Sensor + Display Unit (Test 2)

Main focus of this prototype is to develop a head-tracking system, with the help of Arduino Neo and gyroscope, accelerometer, magnetometer sensor.

Required Material

Hardware: 1. Arduino Neo

2. MPU6050 sensor

3. Display unit (800p * 480p)

4. HDMI and USB Cable

5. Power Adopter (5V)

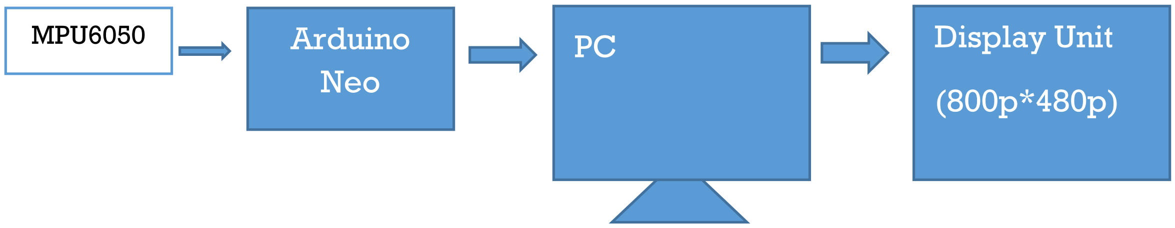
Software: 1. Game Console (Unity)

Arduino Neo: Arduino is an open-source hardware platform. It has 8-bit microcontroller - ATmega328 and executes instructions at a clock speed of 16 MHz. This module works with an input voltage of 7V-12 V fed at the DC power jack on the board. It can also be powered using the on -board USB port.

MPU6050 Sensor: MPU6050 is motion tracking unit which contains 3-axis gyroscope, 3-axis accelerometer and a DMP. Using the sensors with the sensor fusion technology, real-time motion tracking is achieved. The size of the sensor board is 4mm×4mm×0.9mm. MPU6050 has 16-bit analog-to digital convertors (ADCs) for digitizing the data given by gyroscope and accelerometer. This device can be programmed as per the requirements stated earlier. MPU6050 works with a voltage range of 2.375 V-3.46 V.

Display Unit: One of the requirements of the design is that the screen must cover the field of view of the user to achieve proper visualization of the image. A 5 inch screen was a good choice, as it covers most of the user's field of vision when placed at a distance of 4 - 5cm from the eyes. Adafruit 5'' display with a HDMI and power input port is used in our design. Resolution of this screen is 800×480 pixels which is sufficient for prototype.

Block Diagram:



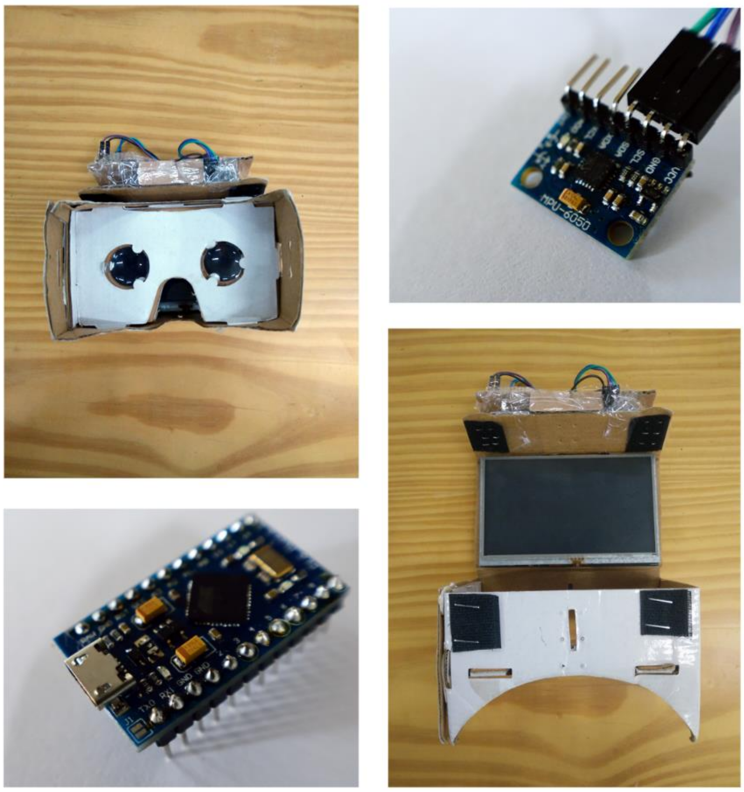


Figure 5.3: HMD Prototyping 2

Observation and Result

- More powerful sensor is needed for managing low latency.
- Sensor Calibration is needed for perfect tracking.

5.4 HMD Prototyping: Air Mouse + Display Unit (Test 3)

Fly mouse is a concept promoted in 2011. It means the mouse can fly in the air and its alternate name is air mouse, It can sense the direction and the change of speed with a built-in gyroscope. People can control move of cursor of electronic products like android TV box and computer by moving air mouse. People do not need the traditional keyboard and their hands can be most free. With fly mouse, users can control computer devices, play motion sensing games, surf on the Internet and chat with friends on the couch.

Advantage of Air Mouse:

- 2.4GHz wireless transmission.
- Build-in Gyroscope.
- Battery powered.
- Plug-n-Play.
- Fast and accurate.

Display Unit: One of the requirements of the design is that the screen must cover the field of view of the user to achieve proper visualization of the image. A 5 - inch screen was a good choice, as it covers most of the user's field of vision when placed at a distance of 4 - 5cm from the eyes. Adafruit 5" display with a HDMI and power input port is used in our design. Resolution of this screen is 800×480 pixels which is sufficient for prototype.

Required Material

Hardware: 1. Air Mouse

2. Display unit (800p * 480p)

3. HDMI and USB Cable

Software: 1. Game Console (Unity)

Block Diagram:

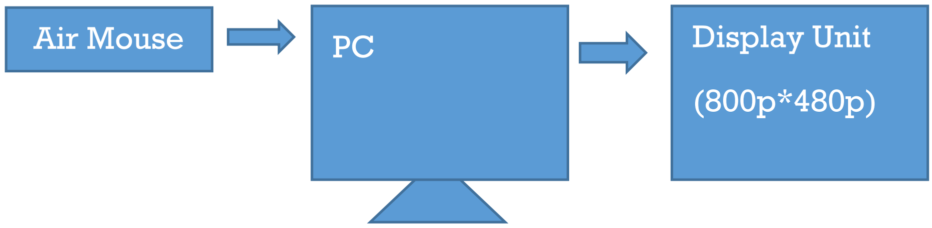


Figure 5.4: HMD Prototyping 3

Observation and Result

- Plug-n-Play.
- Fast and accurate.
- Less Complex System.

5.5 Comparison

Scale: 1=Poor to -5=Good

HMD Prototyping	Installation Time	System complexity	Head Tracking	Immersion Level
Raspberry Pi 3 + Display Unit	**3**	**2**	**1**	**1**
Arduino Micro + Sensor + Display Unit	**2**	**4**	**2**	**2**
Air Mouse+ Display Unit	**3**	**3**	**4**	**4**

Table 5.5: HMD Prototyping Comparison

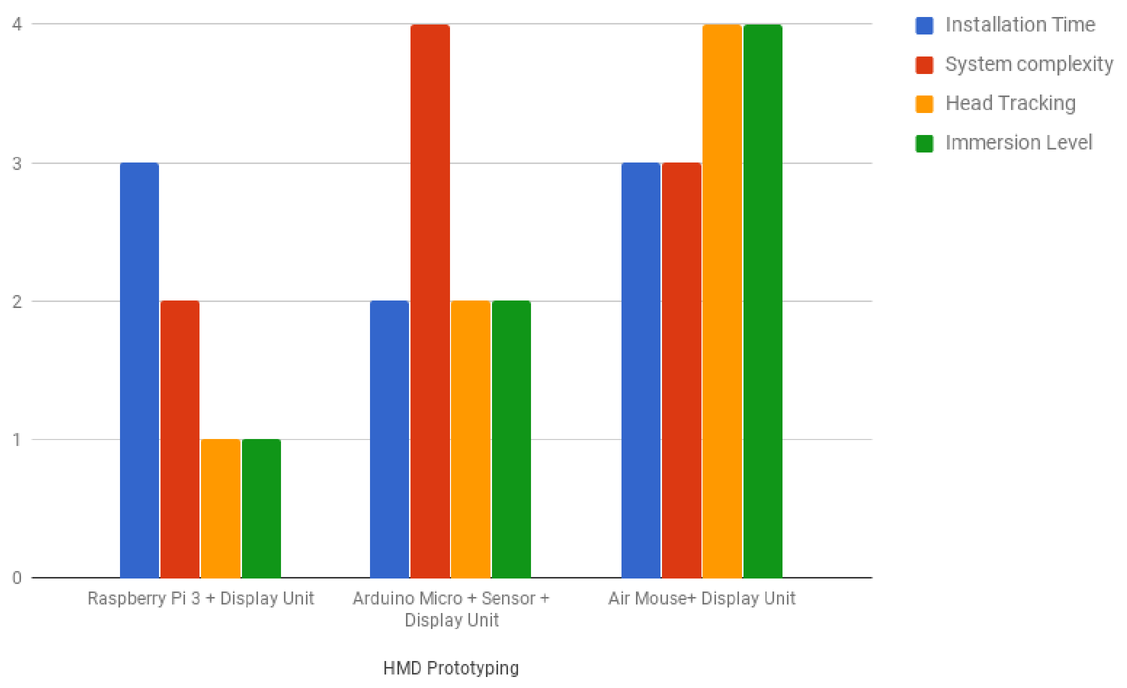


Figure 5.5: HMD Prototyping Comparison graph

Chapter 6: Application Development using Unity

Unity is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop video games and simulations for computers, consoles and mobile devices. First announced only for OS X, at Apple's Worldwide Developers Conference in 2005, it has since been extended to target 27 platforms. Unity is notable for its ability to target games to multiple platforms.

The reason behind selecting Unity as a game engine was its ability to support different VR development platforms such as Gear VR, Google Cardboard, Google Daydream, Play station VR, Oculus Rift and HTC Vive etc.

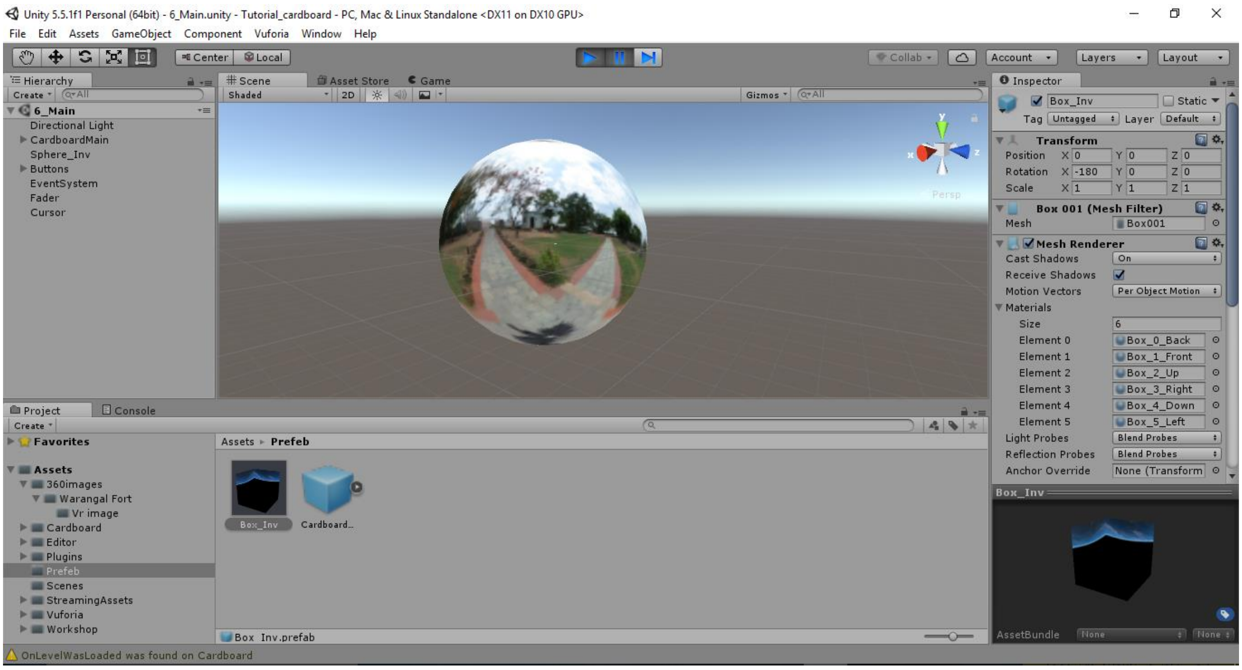


Figure 6.1: Unity Developer Screen

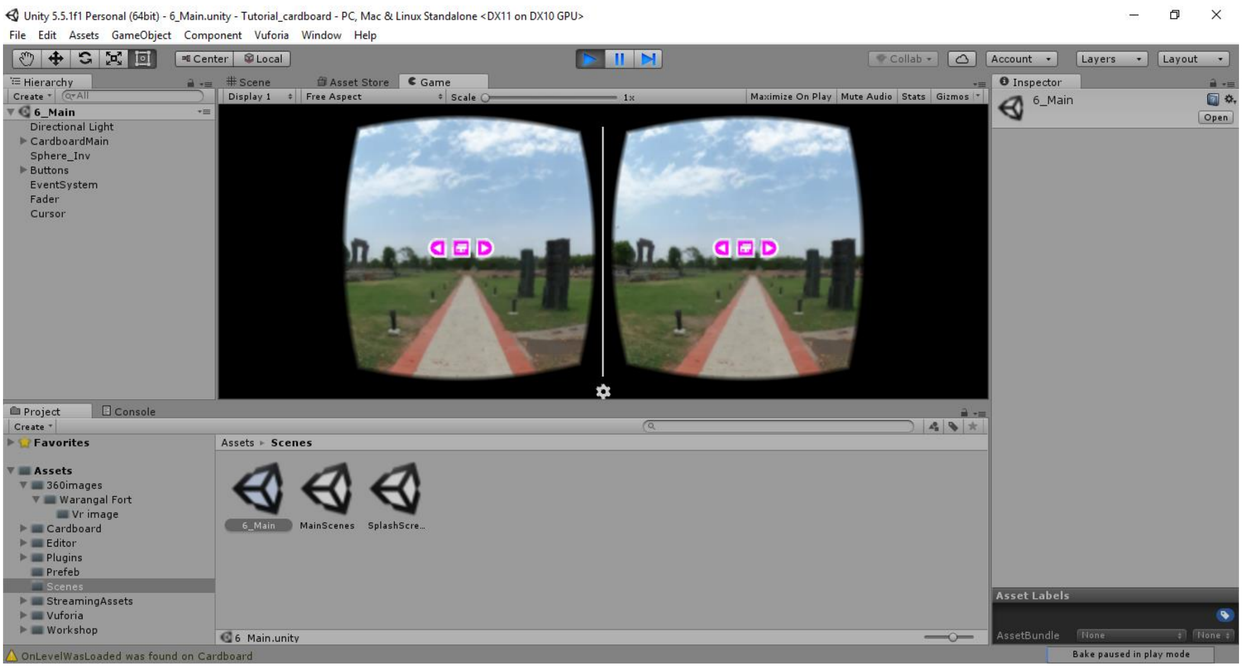


Figure 6.2: Unity Developer Screen

Developer's Brief:

As we know VR has been a fairly esoteric and specialized discipline, there are still aspects of it that haven't been studied enough for anybody to make authoritative statements. In these cases, we put forward informed theories and observations and indicate them as such. User testing of your content is absolutely crucial for designing engaging, comfortable experiences; VR as a popular medium is still too young to have established conventions that address every aspect of the experience.

Here are some best practices, which I found while working on VR application development.

1. **Viewing platform and Field of View:**

   Google Cardboard: 90 degree

   The FOV of the virtual cameras must match the visible display area.
2. **Development tool:** Game engine: Unity
3. **Output Display:** Adafruit 5" display (60Hz)
4. **Binocular Vision**

   Binocular vision describes the way in which we see two views of the world simultaneously—the view from each eye is slightly different and our brain combines them into a single three-dimensional *stereoscopic image*

   Objects that you know the user will be fixating their eyes on for an extended period of time (e.g., a menu, an object of interest in the environment) should be rendered between approximately 0.75 and 3.5 meters away.
   (Unity, 1 unit will correspond to approximately 1 meter in the real world)

   The images presented to each eye should differ only in terms of viewpoint; post-processing effects (e.g., light distortion, bloom) must be applied to both eyes consistently as well as rendered in z-depth correctly to create a properly fused image.

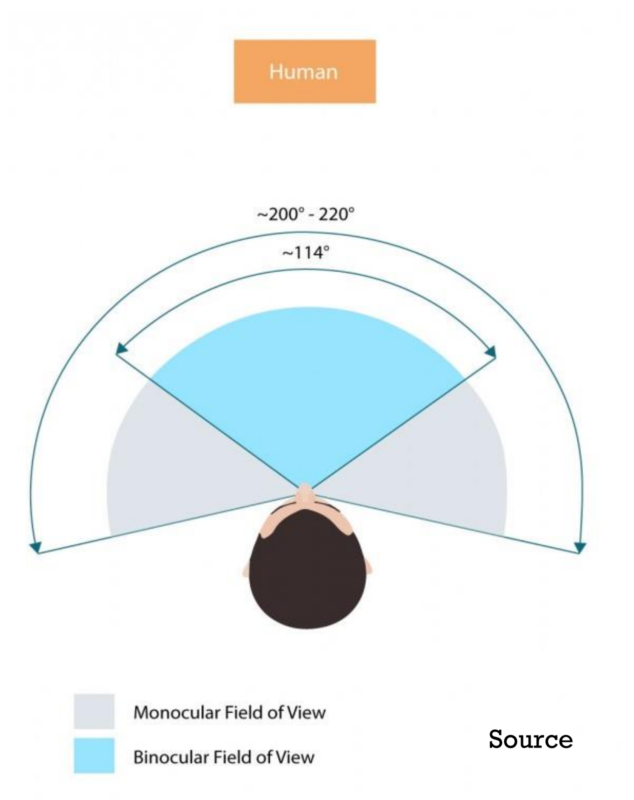


Figure 6.3: Binocular Vision for HMD

5. **Minimizing latency:**

   Your code should run at a frame rate equal to or greater than the display refresh rate.

   Low motion-to-photon (< 20ms) latency is necessary to convince your mind that you're in another place (Presence).

   We encourage developers to implement the predictive tracking code provided in the SDK.

6. **Head Tracking:**

   Use the SDK's position tracking with 6DoF position tracking and head model to ensure the virtual cameras rotate and move in a manner consistent with head and body movements; discrepancies are discomforting.

We should combine the information from gyroscope, accelerometer, and magnetometer sensors through a process known as *sensor fusion* to determine the orientation of the user's head in the real world, and to synchronize the user's virtual perspective in real-time.

7. **UI in VR:**

UIs should be a sit approximately 2-3 meters away from the viewer.

UI should fit inside the middle 1/3rd of the user's viewing area. Otherwise, they should be able to examine the UI with head movements.

360 degree view in pixel: **3600px * 1800px,** UI in VR: **1200px * 600px.**

Feedback, one of a critical aspect of UI. Implement it with low latency.

8. **Sound:**

When designing audio, keep in mind that the output source follows the user's head movements when they wear headphones, but not when they use speakers. For complete cinematic VR experience, all sound should be processed in into Binaural Sound.

9. **Limitation:**

Low Resolution: The resolution of the VR headset is pretty bad. We need 8k display per eye to get a crisp VR experience that is 15,360 × 7680-pixel display.

Text Readability: Because of the display's resolution, all of your beautifully crisp UI elements will look pixelated. Try to avoid using big text blocks and highly detailed UI elements.

10. **Testing**:

To get a real sense of proportions, testing the application with a VR headset is necessary at development stage.

11. **Simulator Sickness:**

Simulator sickness refers to symptoms of discomfort that arise from using simulated environments.

Numerous factors contribute to simulator sickness, including:

Acceleration: Minimize the size and frequency of accelerations.

Degree of control: Don't take control away from the user.

Duration of simulator use: Allow and encourage users to take breaks.

Binocular disparity: some find viewing stereoscopic images uncomfortable

Field-of-View: Reducing the amount of visual field covered by the virtual environment may also reduce comfort

Latency: Minimize it; lags/dropped frames are uncomfortable in VR

Distortion correction: Use professional software like Adobe after effects.

Flicker: Do not display flashing images or fine repeating textures

12. Design for VR: UX Consideration

Comfort: try to improve the factors, which contribute to simulator sickness.

Interface and feedback: depth and motion is the key deciding factor.

Sound and Music: all processed into Binaural Sound.

Interaction: use appropriate input device and method.

Movement: Moving a player around is quite a bit more complex in VR because there are no more simulated barriers between the user and the environment.

Chapter 7: User Testing and Results

We live in an era where the rapid technological developments resulted in the expansion of knowledge and to a significant change of views on how we educate students. However, certain subject matters, such as the history, have been sidelined to such an extent, that their teaching focuses solely on providing information. So, it is becoming increasingly imperative to reconsider how we teach such subjects, and to establish new and technologically enhanced- teaching methods.

Aims: The Main focus of this study to understand the adaptability of Virtual Reality and Head Mounted Display Technology within the school premises for teaching history.

System Design: Current setup supports one user at a time and it requires an operator (Teacher/Technician/Computer Operator) to conduct a class. However operator wants to conduct a group activity by using Virtual Reality. He/she just have to connect all HMDs to the system by using HDMI hub.

Place and Duration of Study: A total of 70 students participated in the study coming from 2 High schools located in Sangareddy, Medak. The duration of the experiment was between, May 2017 to June 2017.

A. Zilla Parishad High School Kandi, Sangareddy (8^{th}-Grade)
B. Zilla Parishad High School Sangareddy, Sangareddy (8^{th}-Grade)

Methodology: For comparing the adoptability of the system, first we took a small session on Virtual Reality and Head Mounted Display Technology. In second session, a pre-developed VR application along with HMD was installed in the class so that students and teachers can interact with it. Research data was collected using focus group discussion, individual interviews, and questionnaire. Testing often involve the evaluator in the setting as both an observer and participant.

Evaluation Findings: Based on literature review, there are factors on which we can measure the adoptability of technology in the field of teaching/learning. In our case these factors are: Prior Knowledge about subject, interest towards computer technology, willing to adopt new teaching methods and experience with VR prototype.

Results:

Experiment with Students

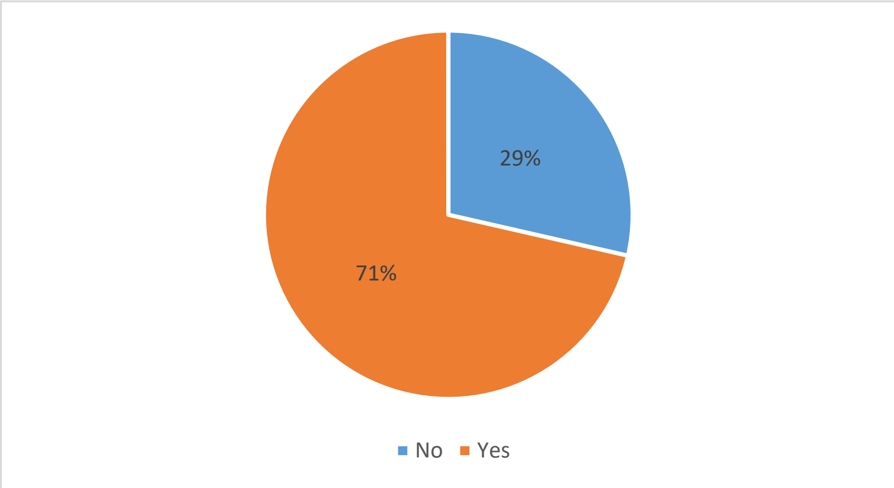


Figure 7.1: Percentage of students who likes history subject. (Appex. 1.B)

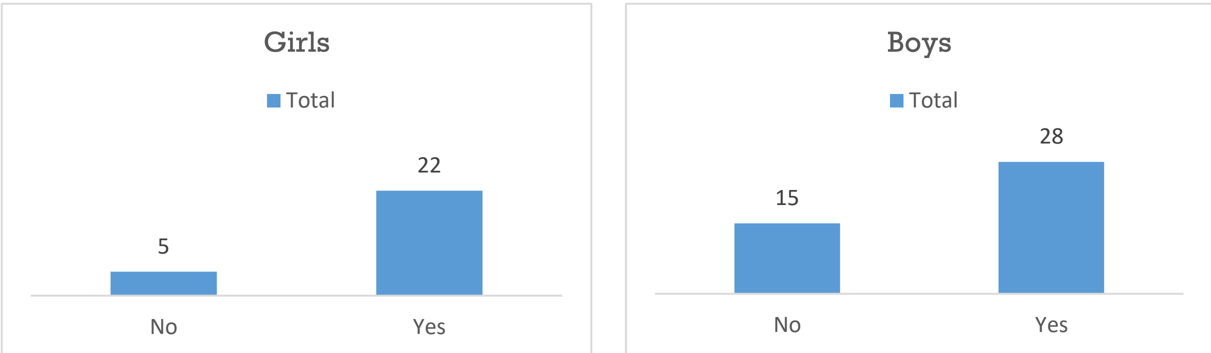


Figure 7.2: Total no. of Girls and Boys who likes History Subject. (Appex. 1.B)

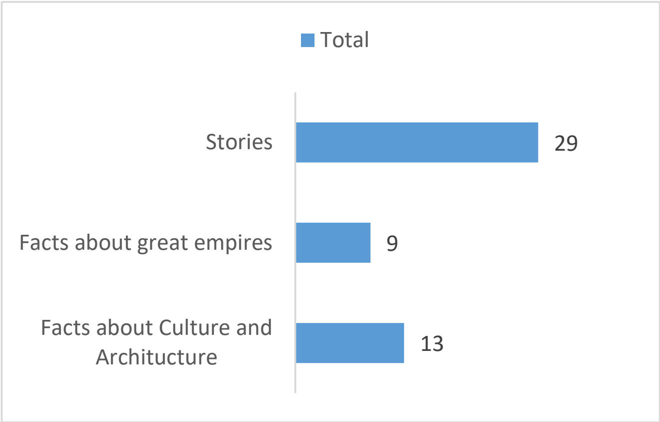


Figure 7.3: What student like the most about history subject. (Appex. 1.C)

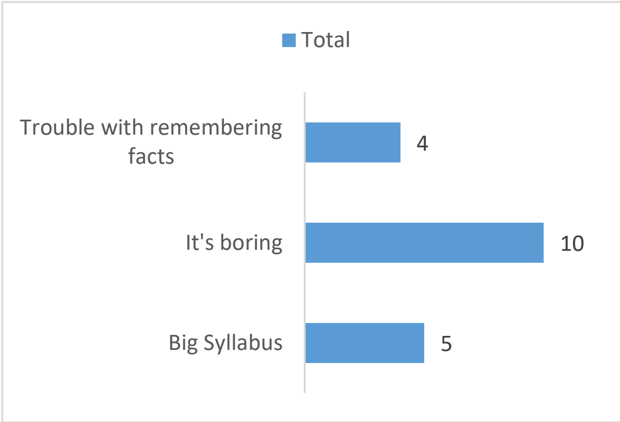


Figure 7.4: Why student doesn't like the history subject? (Appex. 1.C)

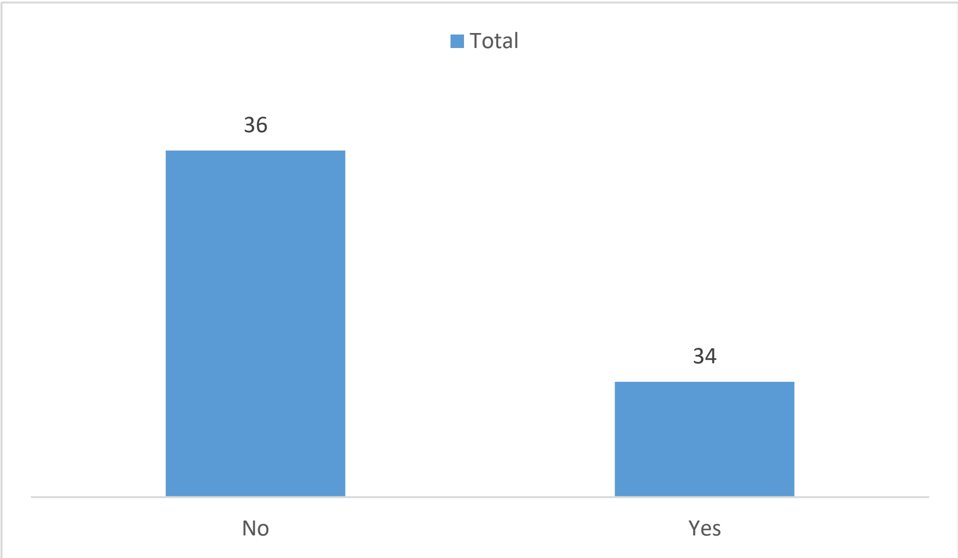


Figure 7.5: Total no. of students who have visited at least one historical monument. (Appex. 1.D)

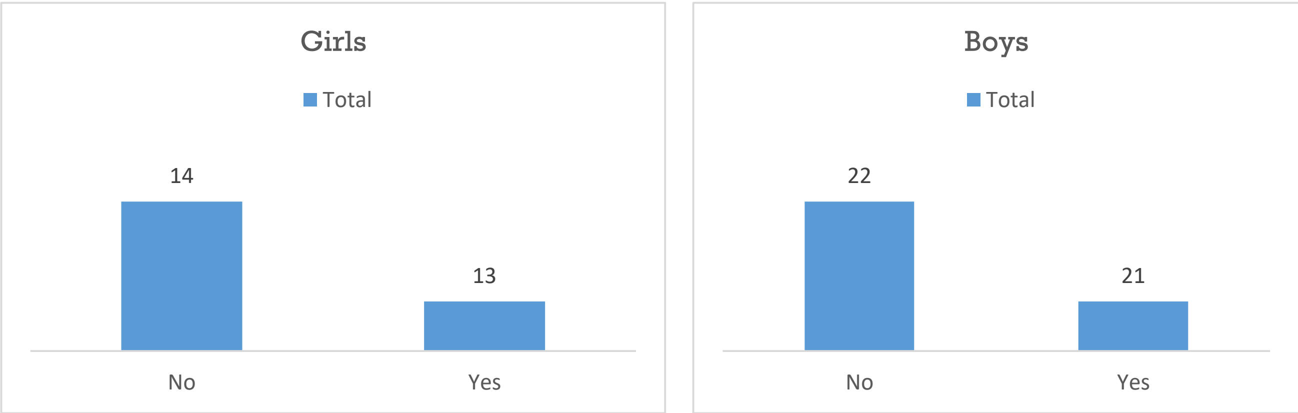


Figure 7.6: Total no. of girls and boys who have visited at least one historical monument. (Appex. 1.D)

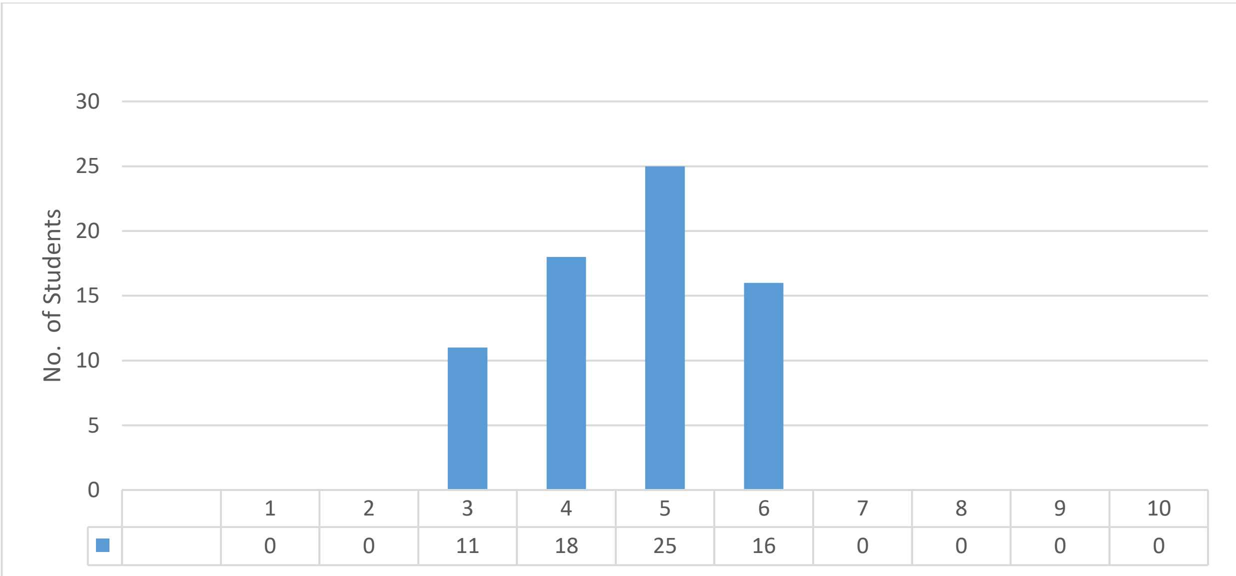


Figure 7.7: Computer literacy scale for students. (Appex. 1.F)

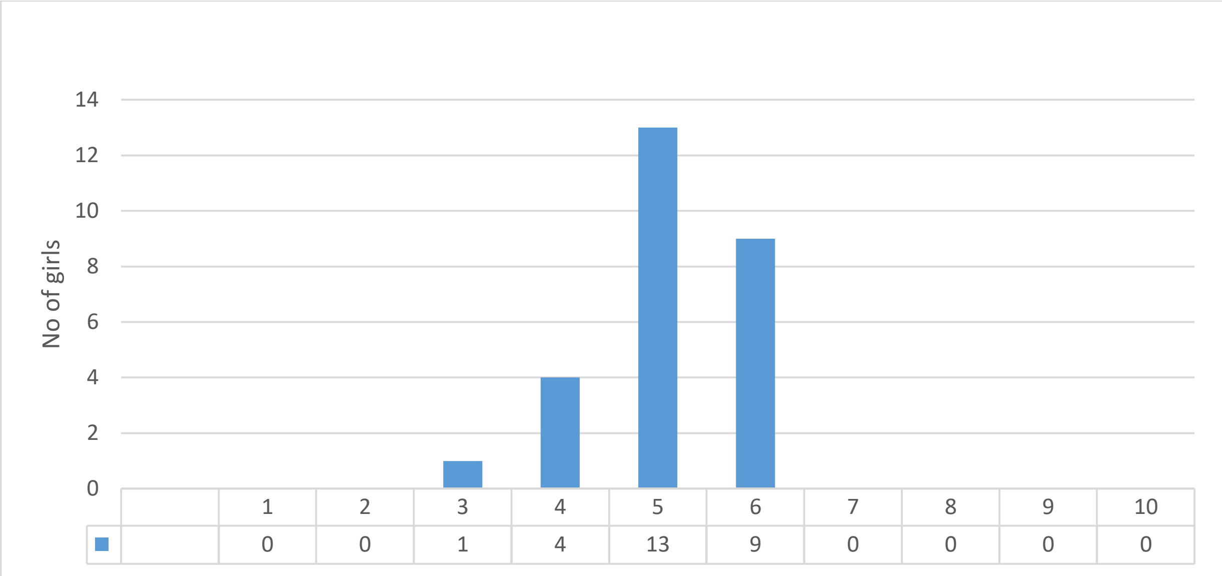


Figure 7.8: Computer literacy scale for girls. (Appex. 1.F)

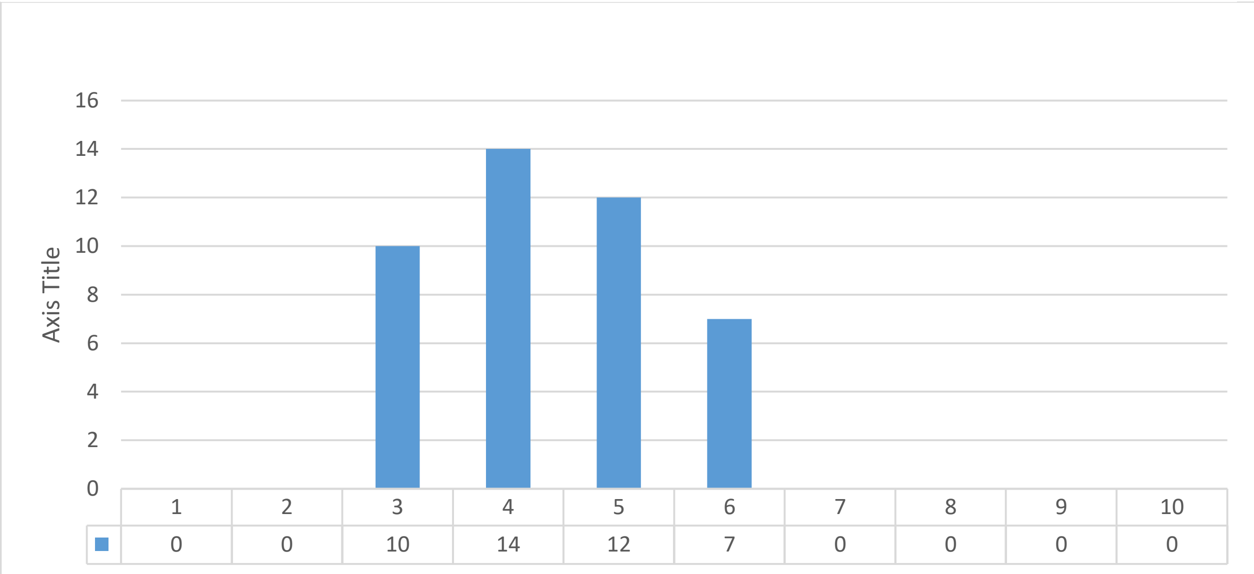


Figure 7.9: Computer literacy scale for boys. (Appex. 1.F)

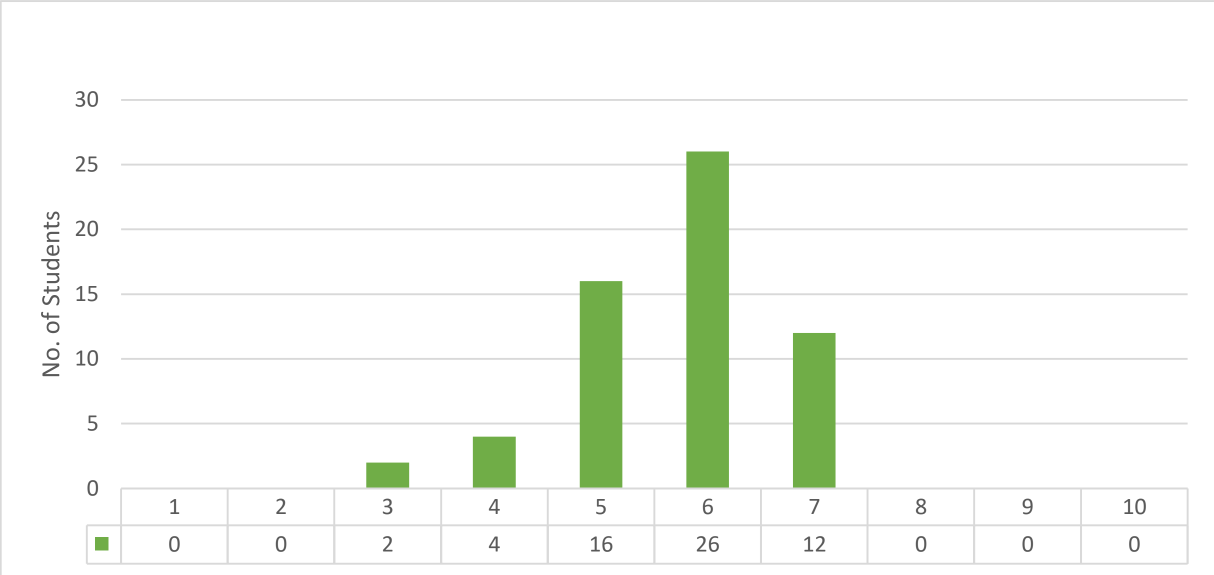


Figure 7.10: Rating scale for experience and comfort with HMD Prototype. (Appex. 1.H)

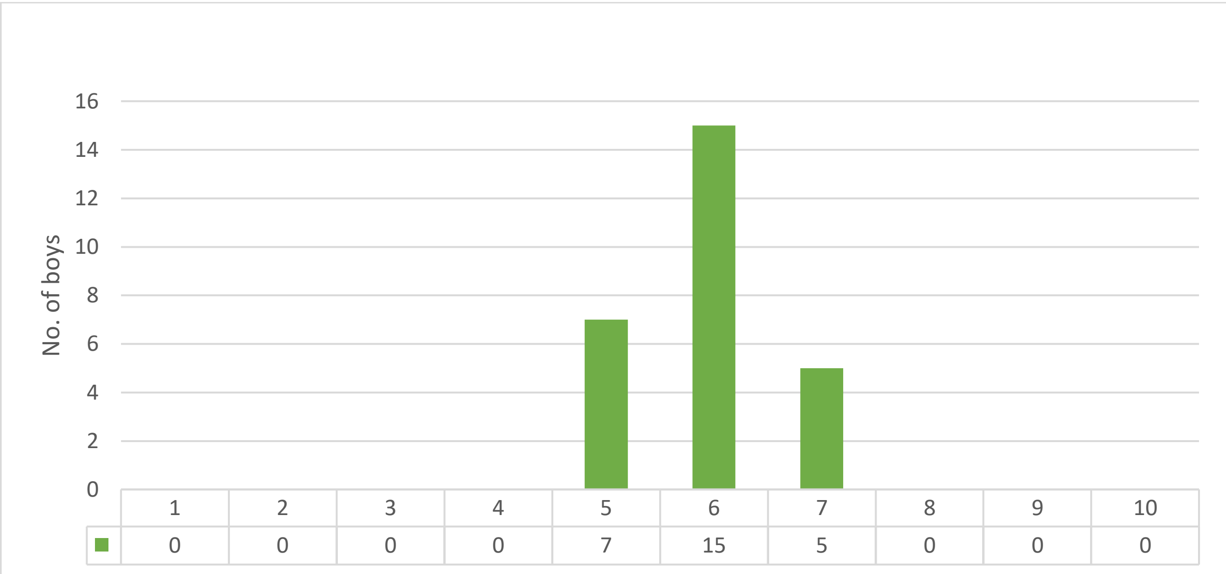


Figure 7.11: Rating scale for experience and comfort with HMD Prototype by Boys. (Appex. 1.H)

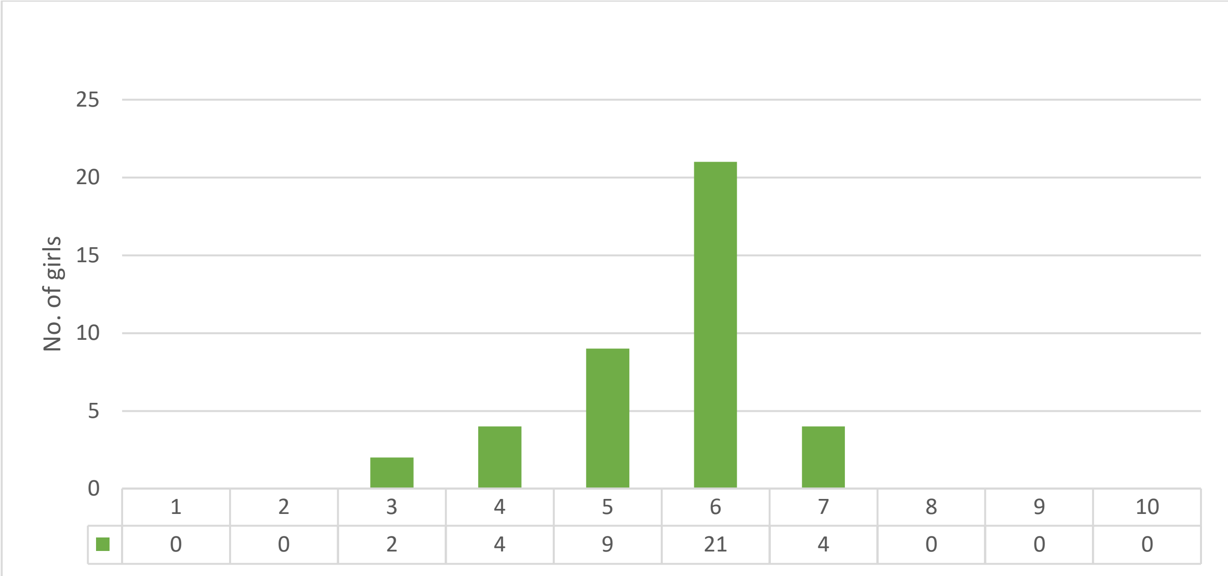


Figure 7.12: Rating scale for experience and comfort with HMD Prototype by Girls. (Appex. 1.H)

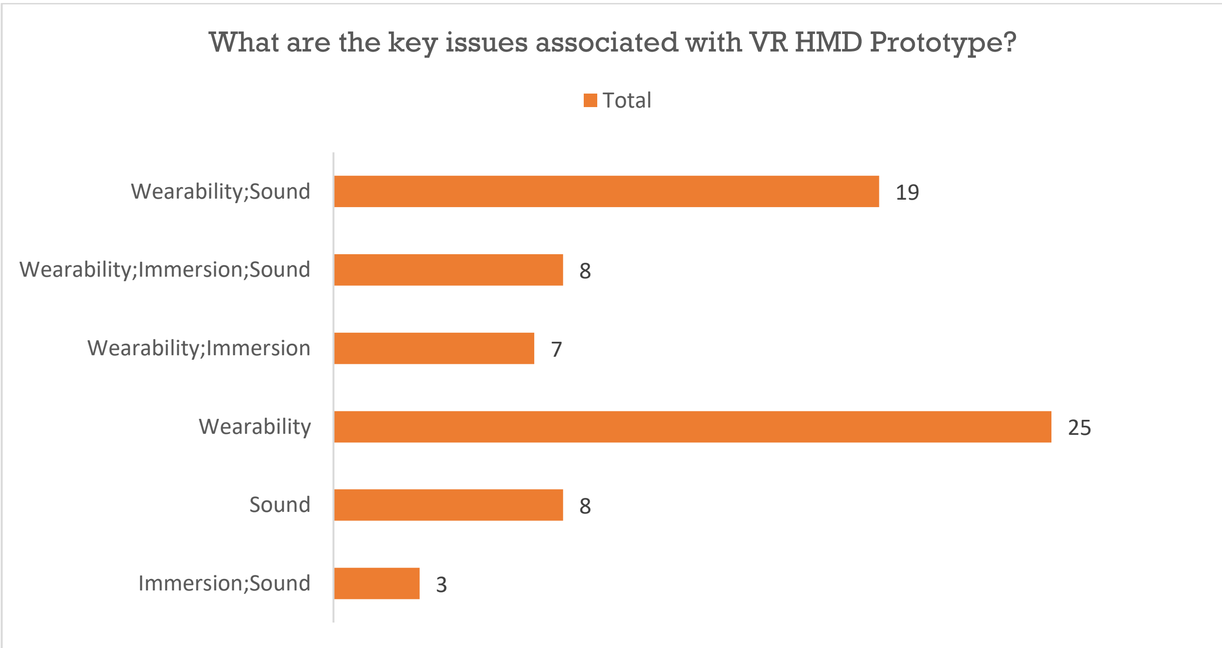


Figure 7.13: Issues related to HMD Prototype. (Appex. 1.I)

Experiment with Teachers

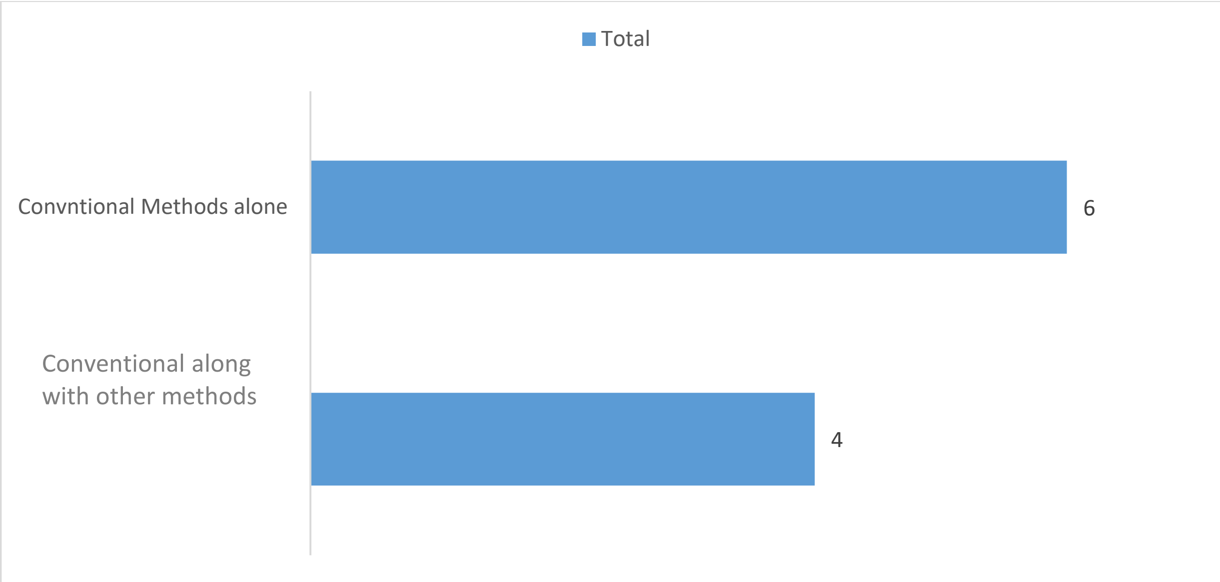


Figure 7.14: Preferred methodology for teaching history subject. (Appex. 2.B)

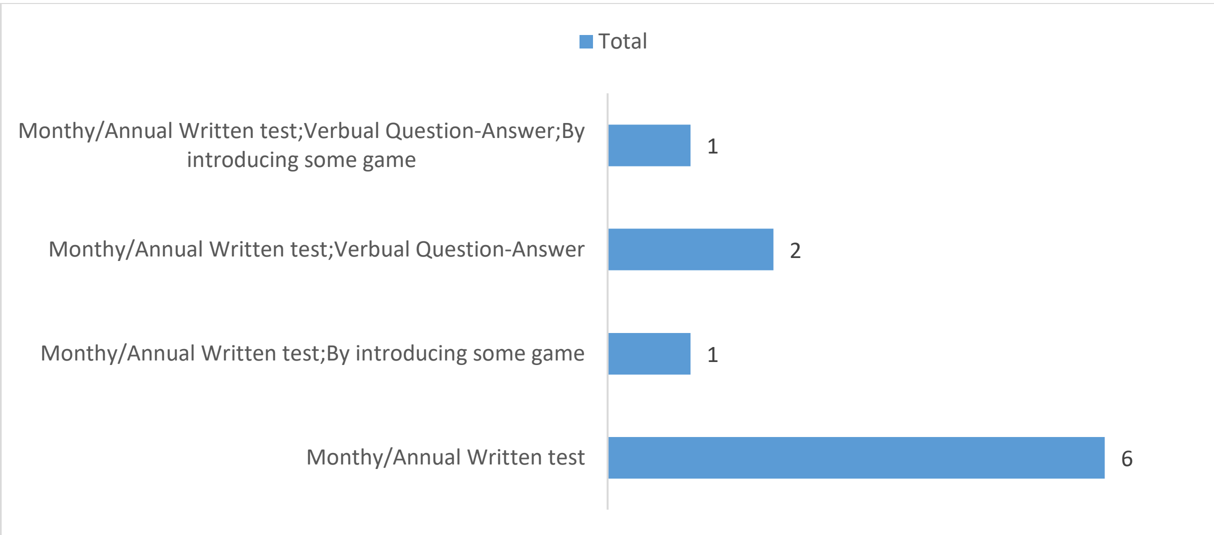


Figure 7.15: preferred methodology for evaluation. (Appex. 2.C)

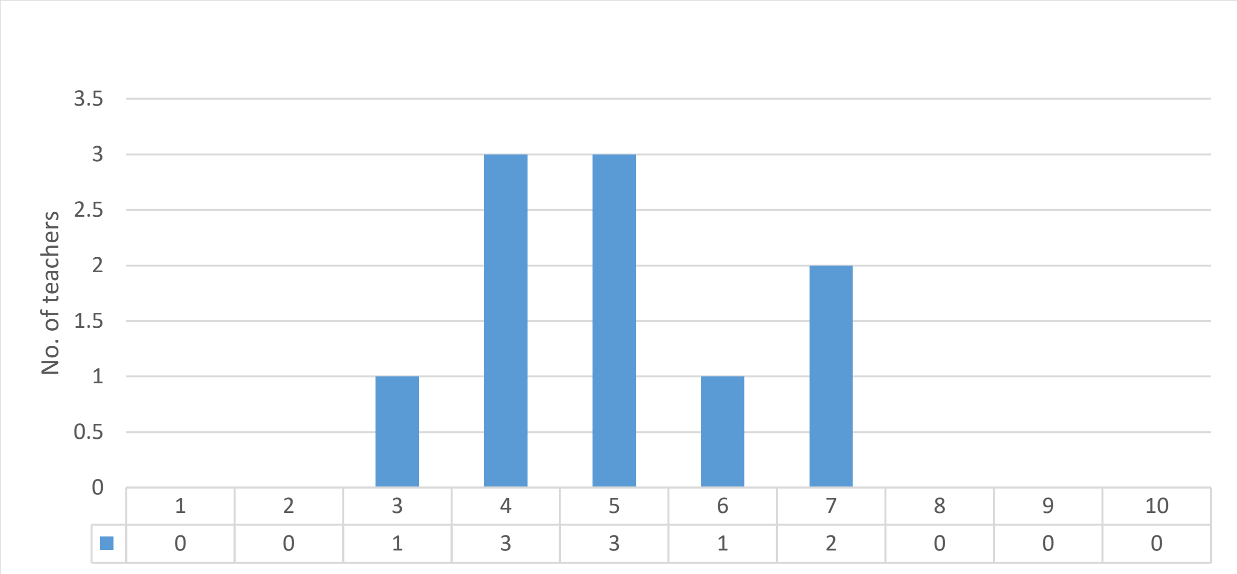


Figure 7.16: Computer literacy scale for teacher. (Appex. 2.E)

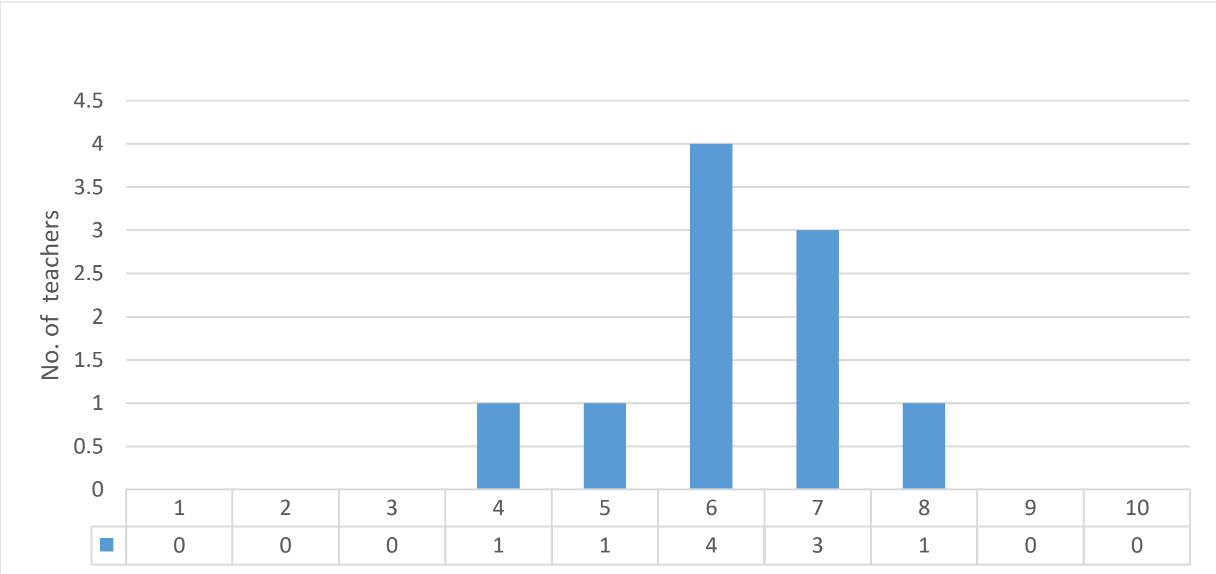


Figure 7.18: Rating scale for experience and comfort with HMD Prototype (Appex. 2.G)

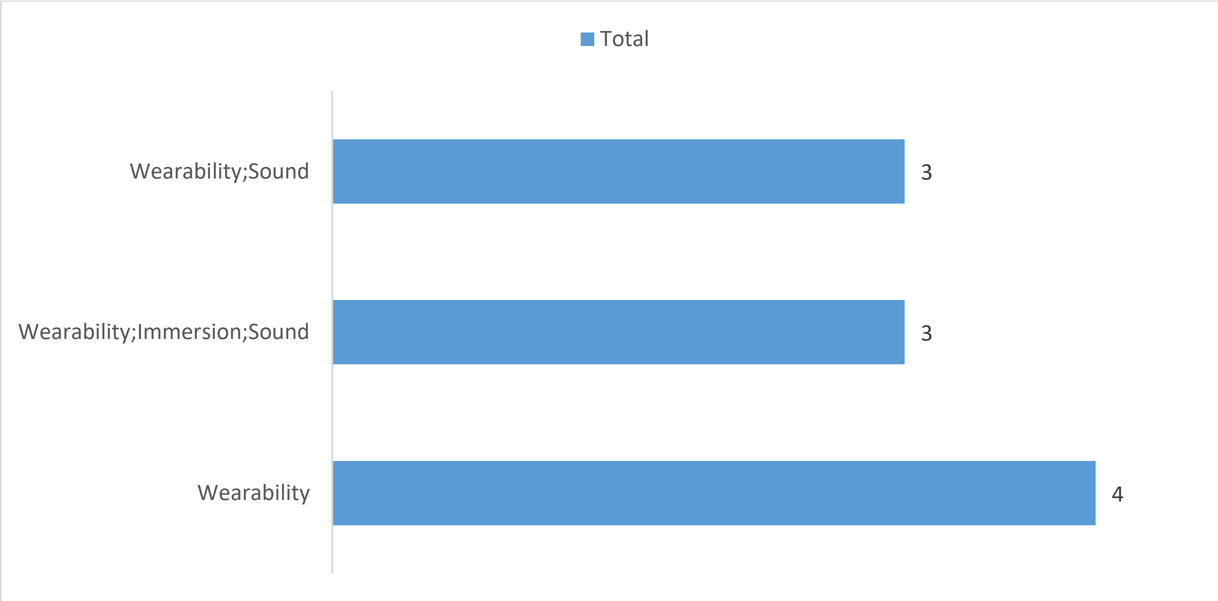


Figure 7.17: Issues related to HMD Prototype. (Appex. 2.H)

We have extended the same experiment with primary class students (Fifth-Grade).

Location

A. Zilla Parishad Primary School Kandi, Sangareddy (5th-Grade)

B. Zilla Parishad High School Sangareddy, Sangareddy (5th-Grade)

As they don't have history subject in their syllabus, so couldn't find any solid data regarding our project but we have conducted a small experiment with teachers.

Conclusion:

Social Interaction: In the majority of these efforts, a single student/teacher interacts with the virtual world; although this student may be collaborating with others in his physical classroom, there is no collaboration in the virtual world. However, this system which supported the co-visiting experience and proved that 'remote presence of historical monuments' was treated not only as an immersive experience, but also as a social place to visit and storytelling platform.

Gender: Most studies report no significant differences between the genders in the results. In our case, we can clearly see differences, female users use computer more frequently than male ones, particularly when its main function is communication and information access.

Age: VR's power of attraction seems to appeal to several age groups, from primary education through teachers. 8-10 years old (5th grade) appear more excited with VR but they were bothered about content while 12-14 years old (8th grade) work without problem in context of design.

Prior Knowledge about Subject: Prior knowledge of the subject appears to be a significant influence in procedural as well as content learning. In the case of 5th-grade, they didn't had any prior knowledge about history and its monuments, so they were focusing on seeing the monument in VR. In the case of 8th-grade, they were focusing on content part as well as visual part.

Computer Familiarity and Attitude towards technology: Based on our current prototype setup we can clearly see that person who knows how to use computer, can easily access the VR experience.

Problem VR Prototype:

Immersion: Immersive devices did not guarantee any immediate positive attitude towards knowledge. It just act as a teaching/learning tool which gives another demission to explore.

Wear ability: Wear ability was the biggest problem with current prototype: over size, wired and heavy, which eventually leads to many health related problems.

Figure 6.3: User Testing @ Z.P.H.S Sangareddy

Figure 6.3: Interaction with teacher and Student @ Z.P.H.S Kandi

Teacher's feedback:

The function and usefulness of HMD is highly satisfying given the projection of real world monuments and structures in a virtual way. The students were equally excited with the purpose of prototype which provides them with a chance to experience real world structures. Though the model shown was widely appreciated both by the students and faculty members, I personally feel the prototype must not be limited to display of historic monuments and structures. Rather if it can be extended or incorporated relating to the course curriculum like step by step process of silk weaving, different process involved in maintenance of hydro projects etc. will help the students understanding of the subjects in a great way. Also, the school administration is very much interested in procuring the prototype once it is fully developed subject to the fulfilment of course curriculum needs as mentioned above. I would like to thank the IIT-H and its students who visited the school and displayed the model to our students which I feel will go a long way in not only enhancing the subject knowledge of the study but also in overall development of the students.

G.Indira

Z.P.H.S Kandi

Chapter 8: Conclusion and Future Work

The evaluation of the educational VR HMD Prototype in terms of adoptability and usability has shown that adoptability problems do exist to some extent in current teaching and learning settings and they affect mostly those students who does not know anything about computer or computer related educational tool. However, they do not discourage users from using the prototype. In fact, a very important finding of this evaluation is that usability is proportional to prior knowledge of subject and computer familiarity.

As a lesson from the evaluation analysis, the design of educational VR has to be such that the VR environment is as sophisticated and attractive as possible but special care has to be taken about usability problems. Usability problems may cause distractions to student from the main educational goals of the application. If such problems are addressed, then the educational application can be more effective educationally for more groups of student (including those who doesn't know computer) than it would be otherwise.

Device Development: The key motivation for developing this product was to design and develop a dedicated and cheaper hardware and software for VR purposes to make portability possible. Available portable devices usage the phone's processor. The next version of the device will be developed with better display to address the problem of immersion. Even the casing design for the device will be optimized for shape and mass. We also plan to incorporate cameras in the device to make AR possible. The device will capture the images from camera and place these images in background to render in real-time. This will enable superimposing the real and virtual world images, thereby giving an entirely new viewing experience.

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Appendix

1. Questionnaire for Students

A. Gender

- Male
- Female

B. Do you like to read/study history?

- Yes
- No

C. If Yes, What do you like the most about history subject?

- Stories
- Facts about great empires
- Facts about Culture and Architecture

D. If No, then why

- It's boring
- Trouble with remembering facts
- Big Syllabus
- Other:

E. Have you visited any historical monument?

- Yes
- No

F. What is the most common study material do you use for study/reading history?

- Books/Board/Maps
- Field Visit
- Group Discussion/Game/Video/Computer

G. How much do you rate yourself on the scale of 10 for Computer literacy?

1 2 3 4 5 6 7 8 9 10

H. How do you find this VR HMD Prototype setup?

- Working and useful
- Working and Not-useful

I. How would you describe your level of comfort and experience with VR HMD?

1 2 3 4 5 6 7 8 9 10

J. What are the key issues associated with VR HMD Prototype?

- Wear ability
- Immersion
- Sound
- Other:

2. Questionnaire for Teacher

A. Tell us about your teaching methodology?

- Teacher Driven
- Student Driven

B. What is the most common study material do you use for study/reading history?

- Conventional (Book/Board/Maps/Storytelling)
- Modern (Group Discussion/Game/Movie/Computer)

C. What ways do you assess and evaluate students?

- Monthly/Annual Written test
- Verbal Question-Answer
- Presentation
- By introducing some game
- Other:

D. Does your school have digital infrastructure?

- Yes
- No

E. How much do you rate yourself on the scale of 10 for Computer literacy?

1 2 3 4 5 6 7 8 9 10

F.What do you think: Do we have to use technology in teaching/learning or we should stick to conventional methods?

- Conventional Methods alone
- Technology alone
- Both at the same time

G. How do you find this VR HMD Prototype setup?

- Working and useful
- Working and Not-useful

H. How would you describe your level of comfort and experience with VR HMD?

1 2 3 4 5 6 7 8 9 10

I. What are the key issues associated with VR HMD Prototype?

- Wear ability
- Immersion
- Sound

3. Digital Infrastructure with current settings

4. Interacting with 5th grade students