Designing Virtual Reality Experiences in Education

Ramesh Chander Sharma, and Yash Paul Sharma

***Abstract*—Pedagogy of student engagement embodies creativity, student autonomy, engagement, and metacognition. We have been working on developing a framework for transformed pedagogies by designing and creating virtual reality experiences for learners. These transformative learning experiences enable learners to learn creatively by exploring and experimenting; as active citizen by making choices, taking decisions, and solving problems; engaging intellectually by generating ideas; reflecting on their own learning, and by learning how to learn through metacognition. We created virtual immersive experiences for the students using real-world content (360-degree media), synthetic content (computer-generated), or a mix of these two. Our work involved creating virtual reality content for places of historical interest in New Delhi and other parts of India. Our work is a type of high-end virtual reality low-end extended reality. We are exploring the usability of this framework in different discipline areas within the framework of theory of cognitive fit and situated learning theory, which allow a greater degree of student engagement for life-enriching experiences.**

***Index Terms*— Virtual reality, pedagogy, immersive learning, extended reality, metacognition, 360-degree media, situated learning theory**

I. Introduction

As we are moving into the next generation of the media revolution, "immersive" technologies like Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) are becoming the center of discussion in educational technologies. You must have seen the sci-fi movies, where all data capture and interpretation is just happening in front of glasses or goggles. With the advancement of science, all these technologies are available now, although mostly for commercial purposes. But these technologies equally can change the field of education if employed meticulously. 2020 EDUCAUSE Horizon Report™ -Teaching and Learning Edition is an important report (till a few years ago it was used to be published by New Media Consortium) which profiles key trends and technologies which have an impact on the future of teaching and learning. The report highlights that Extended Reality (XR) is useful to augment traditional pedagogy. XR is a mix of augmented reality, virtual reality, mixed reality, and haptic technologies which offer either fully immersive experiences or as a blend of physical and virtual world. Virtual reality provides greater immersive content for the participant to engage with, interact and manipulate the virtual objects.

The applications of these technologies are already popular in gaming, health, defence, and other industries. Educational institutions are also increasingly using these technologies, particularly when new hardware and software are available. An immersive experiences lab has been setup at the Grinnell College (https://gciel.sites.grinnell.edu/) to explore the innovative ways to teach liberal arts using immersive 3D, virtual reality, and mixed reality content. A commendable aspect of their approach is to distribute these as open educational resources for the benefit of larger education community. Another interesting example is from the Engineering Education Transformations Institute, University of Georgia (https://eeti.uga.edu/area_of_focus/research_initiation/) where through EETI Augmented, Remote, and Virtual Experimentation Grants, researchers work on projects to improve teaching and learning in engineering education, like Augmented Laboratories in Introduction to Electrical Engineering Course, Using Virtual Reality Technology for Social and Physical Engagement in Remote Laboratories, and Development of Augmented and Remote Experiential Learning Laboratory Modules for the Renewable Energy Engineering Course, among others.

The Boise State University has Games, Interactive Media & Mobile technology program (GIMM) where the students design and build mobile apps virtual learning environments (https://www.boisestate.edu/gimm/about/). The Centre for Innovation of Leiden University, together with the Leiden University Medical Centre have created an interactive immersive virtual reality program that uses 360 degree video for teaching how to provide emergency services as the Airway, Breathing, Circulation, Disability, Exposure (ABCDE) approach to critically ill patients (https://www.centre4innovation.org/stories/time-to-act-emergency-care-practising-the-abcde-approach-in-virtual-reality/). Another project by them is *Augmedicine: Transplant Cases* which is an augmented reality app using a head-mounted display (Microsoft Hololens) where medical students and teachers can view and interact with 3D holograms. Developments and research in these areas have indicated that these technologies are very significant in skill-based courses and which support competency pedagogy. In all these applications, learner engagement is prime.

In India, the National Council of Educational Research and Training (NCERT) has created an ePathshala Augmented Reality (AR) App which enables the students, teachers, and educators to interact with the content of the NCERT textbooks. This augmented reality app offers interactive 3D simulations to the users. As a self-learning tool, the pedagogy behind this initiative allows the user to visualise and comprehend the concepts through interactive 3D simulations, laid over illustrations, maps, or diagrams as provided in the NCERT textbooks. This is an example of marker-based AR / Image recognition AR, where, an image acts as a marker to trigger. The camera of the device scans the marker, which is different from the surrounding environment and triggers the application to place the content. Content has been used in the form of images, Audio, Video, Animation, etc. While rotating the marker camera, the content on the marker moves accordingly, but a deflection from marker may cause

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deviation in projecting the content. The Marker-based AR is mostly handled through mobile apps. So, the users first have to download the app on their device to experience the AR. In this case of the NCERT AR App, various images are used as marker. The camera of the mobile phone scans the image marker and projects a 3D simulation of this image. Now, the learner can interact with this 3D simulation on mobile screen and by orienting the camera in different corners, the shape of the cell in 3D can be seen from various angles. To interact with the different parts of the cell, for example, mitochondria. This makes mitochondria from the cell to be visible in 3D along with voice description for better understanding.

In the next section, we explain our work where we created virtual reality-based content for the places of heritage importance as these are protected monuments.

II. Our Work on Virtual Reality Experiences For Heritage Places

In this section, we elaborate on our work using virtual reality. Virtual Reality means feeling the imaginary (virtual) world / "near-reality". It is basically an experience taking place within a simulation, which can be similar to or completely different from the real world. The immersive artificial environment is created by using software and presented to the user in such a way that the user accepts it as a real environment. Currently, Head Mounted Devices (HMD) are required to feel the immersive user experience in Virtual Reality. HMD may be stand-alone like Oculus rift, HTC Wibe, etc., or commonly available HMD with supported mobile devices. Virtual reality tours of the important monument and other places of interest as per educational-based text have been developed and mapped with the concept being taught. Depending upon the immersive experience, VR may be non-immersive, semi-immersive, and fully immersive. Our work so far has been for the first two categories as for fully immersive experience the current hardware is expensive.

We have covered places like Mahatma Gandhi Ashram at Wardha, Gandhi Smarak at New Delhi, Qutub Minar in New Delhi, Taj Mahal in Agra, Uttar Pradesh, and other Monuments in and around National capital. Virtual Reality Tours of different types (depending upon the development software) have been developed. VR content was captured by using 360 degrees Camera like Theta S, LG360 CAM, and Insta360R. The captured content was further synthesized by using H5P, Adobe Premiere Pro, Adobe Creative Cloud, and other Portals like story spheres, Lapentor, etc. Apart from this large number of content is updated on street view. The developed content is freely available. Mobile based cheap HMD (Head Mounted Devices) or VR boxes (including Card board) were used to feel the immersion.

We created these works as semi-immersive VR which can be seen with HMD devices. Like 360 degree these VR tours can be seen through simple desktop and through HMD to have a semi-immersive effect.

A. 360 Degree Virtual Tour - Mahatma Gandhi Ashram – Wardha, India http://360degree.mijr.org/?page_id=4410

Mahatma Gandhi, popularly known in India as the Father of the Nation, has been one of our leaders whose efforts led to the independence of India from the British rule. This project gives a virtual tour of his Ashram (the place where he lived) in Wardha, Maharashtra State, India.

B. Virtual Reality (VR) Tour of Tomb of Ghiyassudin Tughluq, New Delhi

The tomb of Ghiyassudin Tughluq is situated in Tughluqabad, New Delhi, India. The tomb is located in front of Tughluqabad fort. The virtual tour of the tomb provides an overall view of the tomb and its surrounding. A brief history of the Ghiyassudin and the tomb is also given in different scenes (panorama) of the VR tour. Since, it is an interactive eContent, it can be uploaded on any portal/website just by adding the following code: *<iframe src="https://360.goterest.com/sphere/tomb-of-ghiyas-al-din-tughluq" style="border:0px #ffffff none;" name="myiFrame" scrolling="no" frameborder="1" marginheight="0px" marginwidth="0px" height="400px" width="600px" allowfullscreen=""></iframe>*

Move the cursor to see around. Click on the info button (flag) to see the information, click on circle image to move further. Four buttons on the bottom: 1. Planet view, 2. Toggle Gyroscope, 3. See the monument on Map, 4. VR setting for using VR Box. This VR tour can be seen in two ways: 1. Without VR box and 2. With VR box. For without VR box, the tour is available at the following link: http://360degree.mijr.org/tomb-of-ghiyassudin/

Fig. 1. Landing screen of Ghiyassudin Tomb.

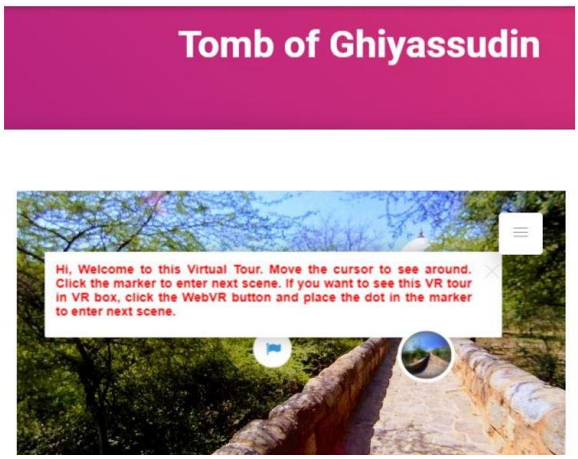


Fig. 2. Information Marker on Virtual Reality Content.

To view with VR box: Open the link http://360degree.mijr.org/tomb-of-ghiyassudin on your mobile phone. Place the mobile in VR box. Click on WebVR button to split the screen. Enjoy the tour (Fig. 3).

Fig. 3. VR Box View.

C. 360º virtual tour of Raj Ghat Smadhi of Mahatma Gandhi https://youtu.be/pw_z-h0Lqu8

Rajghat is world renowned heritage place in Delhi, India. It is also known as Smadhi Sathal of Mahatma Gandhi. The virtual tour of Rajghat was developed by using sophisticated technologies like VR camera which provides an immersive view of the area. The tour can be viewed on TV, Laptop and mobile by using Virtual Reality box.

1) To view the VR tour on Laptop: Open the file with VLC player and rotate the screen to see around.
2) To view in mobile with VR box: For best immersive experience, use VR box. Download VR viewer app on your mobile phone (https://play.google.com/store/apps/details?id=com.xojot.vrplayer).

Also, keep a copy of the VR tour Rajghat on your mobile. Open the VR tour in VR viewer app and toggle to VR setting. Place your mobile in VR box and enjoy the program.

D. Interactive Virtual Tour of The Great Buddha Statue http://360degree.mijr.org/?page_id=4410

The Great Buddha Statue is situated in Bodh Gaya in Bihar State of India. Bodh Gaya is one of the important historical and religious places where Mahatma Buddha took Nirvana. This statue is 80 feet tall and 12000 stonemasons were engaged to build this statue.

Fig. 4. Front gate of VR Tour of The Great Buddha Statute (various markers to know more about the place).

Fig. 5. Image marker helps to see the story in VR Tour.

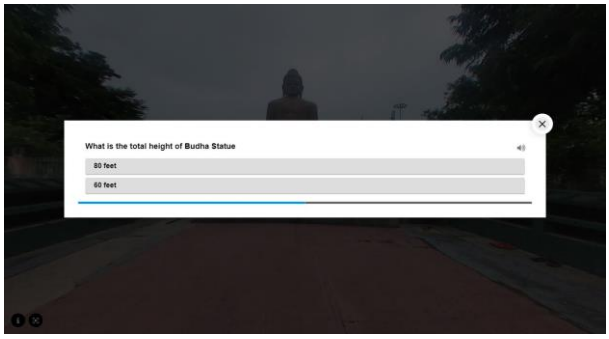


Fig. 6. Students can explore Assessment markers to check their knowledge.

These works can also be experienced as non-immersive VR by using the Desktop system or any project screen. Users can see only the VR on-screen, and interaction is possible by using traditional keyboards, mice, and trackballs. To render non-immersive VR, we do not require high-end devices or specialized hardware; any regular desktop, monitor, laptop, or mobile phone can be used. Users can navigate through various markers and other information in VR.

III. CALL FOR COLLABORATION

Virtual reality applications are gaining lot of traction. With the availability of suitable hardware and software, many institutions are focusing on creating content based on virtual reality. The Covid-19 pandemic has forced to plan and adopt innovative ways for instructional delivery. Virtual reality applications are a great medium for self-directed learning as students can interact with the world on their own. Our VR work is continuing with new discipline areas and creating applications for innovative pedagogy. We invite researchers, educators, and developers to join us for the following projects, we intend to continue working on:

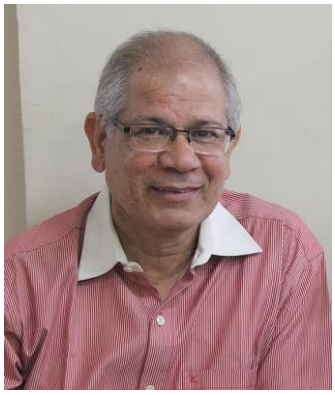
1. VR content development related to historical places, climate change, environmental degradation, VR museums, VR botanical gardens, and VR ZOOs. Our plan is to map these with educational concepts. Our objective is to create a dynamic, integrated and multi-lingual portal that would host all types of virtual reality resources (Simple 360-degree, Story spheres, Static VR tours, and 360-degree interactive VR videos, etc.). Apart from this, we also urge the donors to fund this project and as a mandate all the content developed will be freely available to all stakeholders and most probably under creative common license. So that there is a possibility of creation and adaptation of content in the future. We have conducted some experiments with HMDs and Google Cardboard Viewer (as a low cost) along with the compatible app installed on the phones of students so that they can view the content as in an immersive world. Some of the potential benefits of this project lay for Human-Computer Interaction (HCI) studies, where with the help of these we can improve upon the software and hardware applications and thereby enhancing user engagement. Our experiments with creating immersive content on heritage and historical places of India have returned good results in the form of intangible tourism experiences and they hold significant implications for tourism. It forges the cultural ties and allows users to live the history by offering an authentic encounter and cultural learning about such places of interest.

2. We also intend to develop a VR Mobile App for android and iOS devices to disseminate the content because mobile access has become a prime source of information for learners. In this era of ubiquitous learning, mobile devices are the most significant tools for the learners to access information anytime and anywhere. With better and enhanced configurations of smartphones and affordable data

packages, students are depending upon mobile devices for their learning experiences. The pandemic due to COVID-19 when educational institutions were closed to contain the spread of virus, the mobile learning through various apps and tools have been a great support. Our intention is to provide suitable VR mobile based content in the form of Apps as these can be easily viewed by students using low-cost cardboard viewers or other HMDs. Researchers working on pedagogical values of such avenues and coders developing educational apps can contribute in various ways, like researching effectiveness and efficiency of such VR Apps. We would like to work on assessing the learner's readiness, their attitude and Technology Acceptance Model (TAM) across different geographical regions as well as subject discipline areas. We also look forward to integration of Internet of Things (IoT) applications in these projects.

3. Some of our work has been on integrating VR content with H5P to create interactive textbooks. H5P is an open-source and provides us avenues to work on simplified solutions which can be integrated with learning management systems. There are ample studies that have proved the positive impact of interactive content. With suitable interactivity, the learners' knowledge, performance, behaviours, and skills can be augmented. Textbooks are still the primary source of information for the students. These are all the more, the sole resource for the students of Open and Distance Learning. The textbooks need to be didactic in nature rather than being a passive source of information. To include the element of interactivity in the text, we have worked on including live Google Maps, animations and simulations, etc. H5P offers many types of interactivities which can be integrated into the text. These are not only useful for knowledge acquisition, but they are also great for assessment of learning. We look for collaborations on this theme also where we can bring the open-source content activities integrated into the textbook contents. This would add value by offering such experiences and exercises to the learners where they can feel the examples through an immersive environment, for example, the content on cell structure or cell division can make them dive into the world of cells and how different organelle work therein.

We look forward to expression of interest and suggestions and feedback from faculty, students, researchers, and educational leaders on these topics and joint projects in bringing virtual reality content for a diversity of courses and situations.



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Yash Paul Sharma is a technology enthusiast, currently working at the Central Institute of Educational Technology, National Council of Educational Research and Training, New Delhi. Dr. Yash Paul Sharma is experimenting with the futuristic technologies like AR, VR in education. He has been involved in the development of eContent for school curriculum. He has coordinated MOOCs (Massive Open Educational Resources) on SWAYAM portal of Ministry of Education, Government of India. He is currently engaged in PM eVIDYA project and Co-coordinating the DTH Channels for School Education.