Future of Smart Learning with Mixed Reality

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ABSTRACT
Learning is an ever-evolving, continuous process of life that never ends. While books have been a great inspiration and digitization guaranteed the preservation and spread of knowledge, they couldn't effectively provide practical knowledge about real-world situations. In ancient times, before the invention of paper, people used tablets made from clay, papyrus, and vellum for the transfer of knowledge. These tablets were used in drafting important contracts as well as simple things like consumer complaints. The Chinese used bamboo and silk for writing. Though these alternatives served the purpose for centuries, they would not prove to be the flag bearer of learning in the progressive society. The invention of paper in around 100 BC changed the era by effectively preserving the transfer of knowledge. Paper was the epitome of spreading literature and literacy and was until the invention of computers in the early 19th century. With the evolution and advancement of computers in the early 20th century, came the digitalization era where knowledge was not bound in the physical constraint of a paper or a community and could be preserved forever. With all that's happening around us every day, there is so much to learn and no way of experiencing and effectively implementing it in the real world. Mixed Reality is the next epitome of knowledge transfer without the limitation of confined space and realizing the world as one knows it.

This paper highlights the innovative applications of mixed reality which can be used to enhance day to day learning experiences in most rudimentary things like storytelling to teaching the most complex things to young minds with ease and efficiency. This paper also reflects upon various applications of mixed reality in the field of education and tourism industry.

General Terms
Mixed Reality, Augmented Reality, Virtual Reality, Smart Learning

Keywords
Mixed Reality, Target based AR, Recognition based AR, Augmented Reality, Alternate Reality, Virtual Reality, Virtual Environment, Marker, Markerless, 3D Model, Visualization.

1. INTRODUCTION
Mixed Reality (MR) is a combination of digitally generated virtual computer objects with real-world objects to give a sense of an alternate reality to the user. It is achieved by mixing Virtual Reality (VR) and Augmented Reality (AR). While virtual reality is the projection of objects in a computer-controlled digital environment, augmented reality is an overlay of virtual objects in the real environment giving a sense of a false reality, thus the name coined is Mixed Reality.

The traditional “chalk and talk” teaching method and the use of unchanged textbooks fail to engage students and lead to inferior learning outcomes[2]. The traditional techniques used repetition and memorization of information to educate students. These methods may sometimes be effective but fail to inculcate the visualization of these problems in real-life situations. Lack of visualization may restrict the development of their critical thinking, problem-solving, and decision-making skills. Using modern technologies like mixed reality can enhance students' engagement in lectures and also make them more productive. Recent research studies done by Geer and Sweeney (2012) have also shown that the adaption of multimedia, animation, computer-based simulations, and a variety of media applications in explaining concepts have increased the understanding and collaboration between students [2].

Mixed Reality introduced in recent years has gained traction very quickly due to its unique concept and potential to disrupt the technology industry. Virtual Reality initially had its roots in the gaming industry and is now spreading towards all verticals of business industries. While Augmented Reality has found its way into the tourism and gaming industry, it is yet to be adapted in the education industry. Mixed reality as a tool can enhance education with immersive and interactive experiences.

When students have difficulties in understanding the abstract concept or visualizing the concept, it leads to misconceptions. Visualization of these abstract concepts has great potential for facilitating understanding and preventing misconceptions.

2. AUGMENTED REALITY

2.1 Introduction
Augmented Reality (AR) is the composite of computer-simulated reality and the real world. It projects or overlays virtual objects onto the real environment giving a sense of an alternate reality.

The boon of AR technology is that it has minimalist requirements. It can be accessed in very remote locations using just mobile devices. AR is different from VR in the aspect that AR extends reality rather than replacing it. Augmented Reality enhances the user's perception, imagination, and interaction with the real world. Thus, interactive learning is helping augmented reality in making its root in the education industry.

2.2 Components
Augmented reality systems are built upon three major buildings blocks [1]:

2.2.1 Tracking and Registration
Tracking and registration of an object in a real environment is the key to AR technology. The exact orientation and location of the subject are essential to track the exact head and eye movement of the subject. Tracking the location of the subject, movement of the user's eye and head, and adjusting the environment accordingly is to be done with utmost precision to give a realistic superimposed reality.

2.2.2 Display technology

The medium through which you perceive an alternate reality defines how immersive and realistic the subject's experience will be. There are two types of mediums in AR Technology.

2.2.2.1 Head-Mounted Displays

Head-Mounted Displays provide a fully immersive experience to the subject and completely disconnect them from the real world. Prolonged use of these display devices can often result in the subject experiencing dizziness and is not recommended by the medical fraternity as well.

2.2.2.2 Handheld Displays

Handheld Displays give the subject a sense of its surroundings while operating the handheld device. These devices use video transparent techniques to relate the virtual world to the real world. Handheld devices may provide a partially immersive experience, but are still considered a unique concept and are easily accessible via mobile phones.

2.2.3 Real-time rendering

Real-time rendering makes it possible to provide realism to an alternate reality. Real-time rendering enables the dynamic and smooth movement of virtual objects as and when the orientation of the real environment changes.

2.2.4 Working of Marker Based AR System

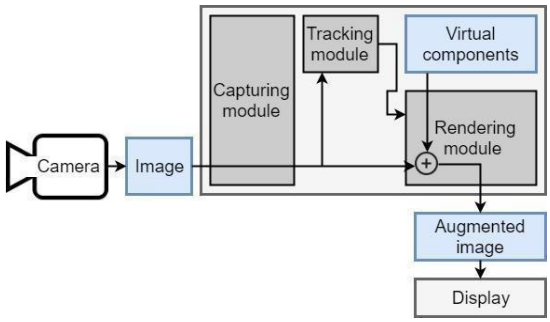

Fig 1: Flowchart for a simple Marker Based AR System

2.2.4.1 Capturing module

The device captures the image through the camera lens and deduces the location and orientation of the camera.

2.2.4.2 Tracking module

The tracking module is the most important process in marker-based AR; it calculates the relative pose of the camera in real-time. Pose refers to the free rigid body movement in a three-dimensional space, i.e. the 3D location and orientation of an object. The tracking module recognizes the AR marker/target and enables the system to project virtual objects on top of it.

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2.2.4.4 Rendering module

The rendering module superimposes the virtual object on top of the target image. It amalgamates the real environment and the virtual objects and renders the augmented image on the display screen. The virtual object can be analyzed from all angles by moving the capturing device and keeping the target as the center of attention.

2.2.5 Types of Augmented Reality System

2.2.5.1 Projection Based AR System[3]

Projection-based AR is a video projection technique, which can extend and reinforce visual data by throwing images on the surface of 3D objects or space. These projections are programmable and may serve different purposes like a virtual keypad, calculator, or digital clock. These projections can change their shape with the flow of time and show visual images dynamically.

2.2.5.2 Superimposition based AR System[5]

A superimposition-based AR System is the superimposition of static objects on real-world objects within confined space. It is another form of the recognition-based AR system. The assumption in this technique is that the static objects will not move but dynamic superimposition is also possible by anatomical motion tracking. It has many applications ranging from surgical assistance for medical purposes to military simulations.

2.2.5.3 Recognition Based AR System

Recognition Based AR also known as Marker-Based AR is based on tracking a target object in the real world and superimposing the virtual 2D or 3D object in the confined space of the target object. The target object is detected using live camera capture and overlays the rich media content stored in its local or cloud-based database onto the target object. The size of the overlaid objects can enlarge as the user moves closer to the target object[4].

2.2.5.4 Location-Based AR System

Location-Based AR also known as Markerless AR is the superimposition of virtual 3D objects in the real world based on the geographic location of the target device. It uses the Global Positioning System(GPS) sensor of the phone to detect the user geolocation and overlay the 3D objects in the real world. Location-Based AR systems are famously used in tourism and travel guidance systems.

3. AUGMENTED REALITY

With the onset of the digital age in the 1970s, digitalization was introduced into the education system. Computers stored the information in digital format available to the pupil as and when required. In the late 20th century, the internet was introduced to the world which made it possible to share and access knowledge at the click of a button over the cloud without actually storing it in the local system. In the early 21st century, schools/colleges started becoming smart classes. Projectors were used to show slides of information and spread knowledge at a faster and efficient pace. Students learned the audio-visual information that was projected on the screen. Digital learning helps students understand things better. Students commonly find Science subjects to be abstract, requiring a depth of understanding and visualization skills (Gilbert, 2004)[2].

4. IMPLEMENTED SYSTEM

The proposed system explores new ways in which augmented and virtual reality could be used to provide interactive and efficient learning.

4.1 Engineering Drawing Models

Most of the engineering students have a tough time visualizing the complex 3D models in the Engineering Drawing. Students are not able to envision the 3D models just

by viewing the 2D representation of these models. The amalgamation of drawings and mixed reality can help students to visualize the models in real-world space. This is implemented using Marker Based AR technology where unique AR model projections are registered with their 2D diagrams. When this marker is detected via a display device, it is projecting the model on top of the marker which will help students to visualize other unregistered 2D diagrams.

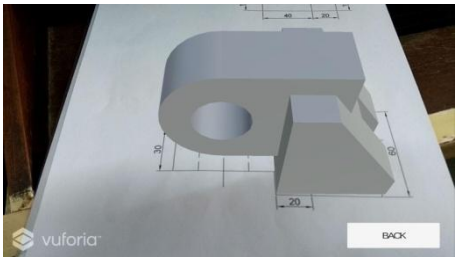

Fig 2: Orthogonal Projection of 2D structures into Isometric 3D Model

4.2 Exploration of Historical Sights

People love to visit different places with historical values but these extravagant trips need time and money. The financial burden is always the obstacle in experiencing human-made or natural wonders of the world.

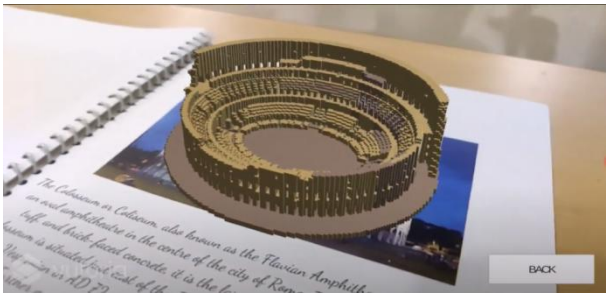

Fig 3: Model of Colosseum projected on the Image Target

Mixed Reality in tourism can save a lot of time and is available at no cost to the explorer. WanderAR is a mobile application based on AR technology in which one can enjoy the scenic view of iconic sites in its true form with comfort at home. Children will find the projection of these monuments amusing which will enlighten them about the historical importance of that place.

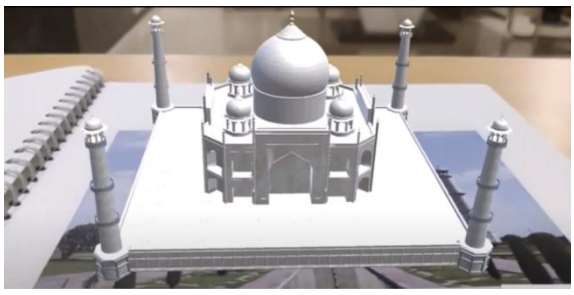

Fig 4: 3D Model of Taj Mahal projected on 2D Marker

4.3 Story Telling

Kids are always eager to listen to stories. But it would be more fascinating and indulging for them if their favourite characters would come alive and act in front of them. AR Storytelling brings alive characters which will tell their own stories in an interactive manner. Through 'AR Storytelling', kids can develop imaginative and creative skills which will help them in future.

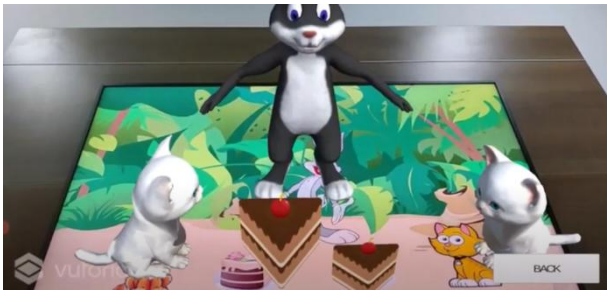

Fig 5: Animated Characters Projected on Comic Book

4.4 Painted Cube Problem

Painted Cube is a classic logical problem in which the person takes a cube and paints it on all sides and cuts it into pieces. E.g. 3*3*3 sided cube is cut into 27 small pieces. Then the person is asked to calculate the number of cubes with three sides, two sides, one side, and no side painted cubes.

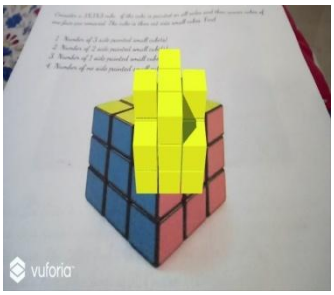

Fig 6: 3D Visualization of Painted Cube Problem

It is quite simple for a simple cube but becomes complicated when the cube is cut into small cubes from a big one and then painted. Students find it difficult to imagine how the cube would be painted when small cubes are removed. By introducing AR in the painted cube problem, students will get an idea of how that cube might look like. Specific Problems will help the students to imagine the cube for other specific problems.

4.5 Virtual Jungle

Watching wildlife animals in their natural habitat is truly an amazing experience. Virtual Jungle is a VR based mobile application which features wildlife and its various animals in the virtual world. The application has an inbuilt 3D environment which takes the user into a new world of virtual jungle. The User can roam in the forest and experience realistic models of animals very closely.

Fig 7: Realistic 3D model of Cheetah in Virtual Jungle seen through a VR Headset

For experiencing the virtual jungle, the person just needs a VR Headset(Google Cardboard) and a phone with a gyroscope and magnet. The gyroscope in the phone is

essential because it maps the axis alignment of the real world into the 3d axis of the virtual world. The magnet in the phone is used to trigger the movement of the user in the virtual world, and it is controlled by a magnet present on the side of VR Headset which when you flick it upside down, triggers the movement and stops when flicked once again. Through Virtual Jungle, one can experience a whole jungle come alive in front of their eyes.

5. CONCLUSION

Mixed reality has many applications in every field of sciences like Education, Medical, Military, Tourism, Architecture, Interior design and much more. Mixed Reality consisting of Virtual and Augmented Reality are used to solve real-life problems in day to day life.This paper discusses various ways in which mixed reality can be used in education to make it more creative, interactive and efficient. The various applications discussed in detail are exploration of historical sights, storytelling, engineering drawing models for students, painted cube problems and virtual jungle.

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