Extended Reality : It's Impact on Education

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Abstract— Extended Reality (XR) refers to all virtual and real environments generated by computer graphics and wearable devices. The "X" in XR stands for "computer-assisted reality," which includes Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR) (VR). This article discusses modern educational techniques, the recent application of XR in education, the scope of XR in various disciplines of education, market analysis statistics, and the technology's affordability in developing countries. The research also looks at how XR can improve student motivation and active learning at several stages of education, including primary, secondary, and higher education.

Index Terms—Extended Reality, Virtual Reality, Education, Gamified learning

1 Introduction

XTENDED Reality (XR) refers to all-natural and virtual collaborative environments and human-machine interactions generated by computer technology and wearables. The "X" represents a variable for all current or future spatial computing technologies and includes elected forms which include augmented reality (AR), Mixed Reality (MR), and Virtual Reality (VR), and the measures included between them (Figure 1). Virtual Reality (VR) immerses users in a completely virtual world created by computer technologies. Augmented Reality (AR) improves the user's current presence by superimposing images, videos, or graphics on the user's natural environment. Mixed Reality (MR) integrates virtual content in the physical environment using infrared scanning hardware mounted on the front of a head-mounted display. VR first came into existence in the late 1970s. Researchers at the Massachusetts Institute of Technology developed an early VR mapping simulation that allowed users to move through the streets of Aspen, Colo.

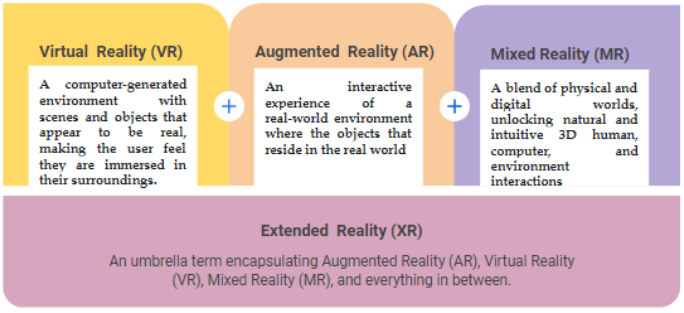

Figure 1.Description of various components in XR

Implementing XR technologies as a learning tool has become one of the most active fields of innovation and research in different universities. XR technologies provide students with a unique learning experience that may be unattainable in a traditional educational format. XR training has been shown to improve student performance in a variety of classroom simulations. It has developed from the "conceptual phase" to the "implementation phase," There is now a practical application in different contexts.

This article addresses all aspects of XR in elementary, secondary, and post-secondary education and application-based examples of its use in various sectors. It also sheds light on the existing and potential applications of certain XR elements. I also provided market analysis figures to demonstrate how XR is growing economically, the future, and will transform the world.

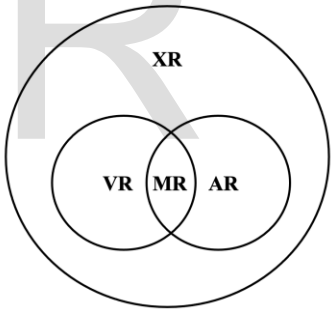

Figure 2. Venn diagram representing XR and its components. XR: Extended Reality, VR: Virtual Reality, AR: Augmented Reality, MR: Mixed Reality.

2 Approaches of Modern Education

In a survey of several thousand knowledgeable workers over the past 20 years, Carnegie Mellon University's Robert Kelley asked a simple question: "What percentage of the knowledge you need to do your job is in your head?" In 1986, the average was 75%. In 2008, ten years after the Internet boom, this percentage dropped to 8-10% [3]. Experiential learning is learning through experience. 90% of the skills today's knowledge workers need are experiential. Students need to have hands-on skill training for increasing employability and being efficient while in an organization. Digital media simulations demonstrate their ability to increase student engagement and foster in-depth understanding. The Covid-19 pandemic led to a paradigm shift in the education sector towards blended learning at all levels of education. Blended learning is not just a mere mix of online and face-to-face

modality but refers to a well-planned combination of meaningful activities in both directions [4]. A few practical approaches to modern education have been discussed below.

Blended Learning: Before the COVID-19 pandemic, learning in schools was more teacher-centered, where the teacher would present information to the students who would passively receive the knowledge.

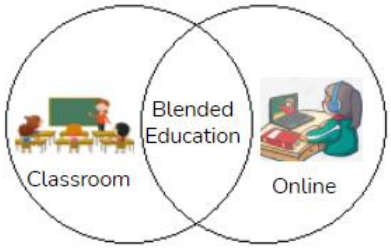

Figure 3.Blended Learning

A blended learning platform supports high student engagement to enhance student and teacher interaction. It enables flexibility and accounts for time management, with more flexible teaching and learning environment that improves student learning outcomes and provides better opportunities for experiential learning.

Experiential learning: It requires the student to work on a practical task, "learn by doing," reflecting on the experience. Mixed reality supports experiential learning in numerous ways. In various education domains, XR elements can be integrated into the practical sessions. The students can get hands-on experience using equipment that may otherwise be very expensive, or processes, which could be complex enough to allow all students to participate. For instance, students studying automobile engineering can extensively use mixed reality to see the working of the gears, look at cross-sections, and analyse their working mechanisms.

Project-Based Learning: It's a methodology in which students design, iterate, and publish project-based learning assignments using a combination of online and face-to-face education. In this field, XR has a lot to offer.

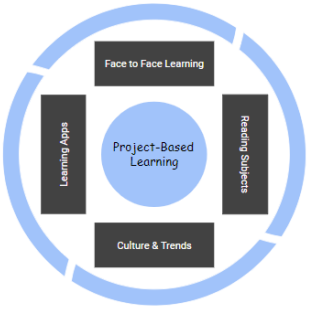

Figure 4.Process Involved in Project based Learning

When assigned the task of drawing a house, students studying architecture, for example, create the place using illustration software and exhibit their work using VR or AR. Such presentations will have a more significant impact, and analyzing the issues and implementing solutions will be much easier.

Gamified Learning: Gamification is an educational approach that introduces concepts to students in a game, making learning fun. With engaging gamification, learners can have a practical learning experience with increased memory and recall.

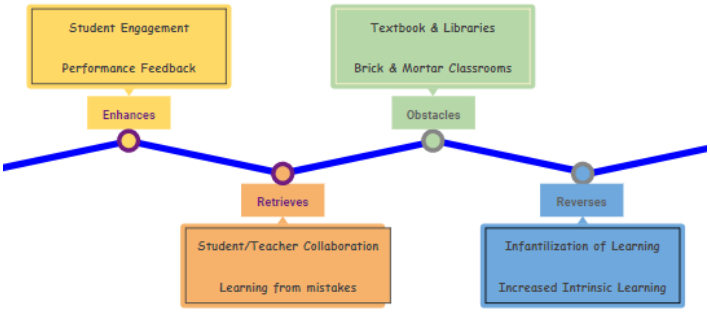

Figure 5.Different aspects of Gamified Learning

Badge and reward systems have quickly become popular tools for rewarding students for their achievements and milestones. XR can contribute to gamification in many ways, not only in elementary fields but also in flight training, architecture, and automotive [5].

3 Recent use of XR in Education

XR technologies as learning tools have become one of the most active fields of innovation and research in different universities [6]. Studies have shown that students can quickly customize an avatar as a personal representation of their body. When students accept a digital object as a tangible object, it is known as the Proteus Effect, a phenomenon in which their avatar characteristics change an individual's behavior within virtual worlds [7]. This section discusses a few XR technologies that have been commercialized in recent years.

- XR Immersive Labs[2017]: Kinesiology is the study of the mechanics of body movements. The XR immersive labs can significantly enhance student motivation to learn kinesiology. Extended realistic lab activities can enable students to learn by interacting with visual content, illustrations, and demonstrations of various kinesiology content and concepts [3].

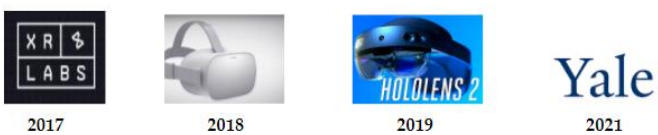

Figure 6.Evolution of XR in Education

- Walmart[2018]: Walmart recently acquired 17,000 Oculus Go VR headsets to expand its successful pilot of high-risk training scenarios, such as the chaotic shopping environment that can occur on Black Friday. Walmart found that the virtual reality training modality resulted in higher knowledge retention and higher employee satisfaction at Walmart Associates [9], [10]. In this regard, teachers or trainers can customize virtual classrooms so that content-specific information and resources are continuously available in the virtual environment [11], [12]. Thus, students may experience impractical or dangerous science experiments regardless of logistical, geographic, or accessibility issues they experienced [13], [14].
- Microsoft HoloLens2[2019]: Microsoft HoloLens is a pair of mixed reality smart glasses developed and manufactured by Microsoft. The HoloLens was the first head-mounted display to run the Windows Mixed Reality platform on Windows 10. It has significant applications in the field of education. HoloLens2 can use it from digital human anatomy and neuroanatomy to architectural engineering, and the list is endless [8].
- Yale[2021] : '3D Modeling for Creative Practice' is a Yale University class dedicated to learning the tools and techniques of 3D modeling in the context of critical, creative, and art-oriented discourse taught by the Faculty of the Art School, Justin Berry Will. Justin's challenge in the summer of 2020 was conducting a personal study course in the socially detached manner required due to Yale's responses to the COVID19 pandemic. More importantly, how would you give students access to the high-performance computing workstations they need for classes while the teaching facilities at the Center for Collaborative Media and Arts are now closed? XR came to a great relief during this time. With the support of the ITS help desk staff, HP hardware sponsorship, hard work, and a little luck, it all worked out for the Fall 2020 semester [15].

4 SCOPE OF XR IN DIFFERENT EDUCATION FIELDS

4.1 Primary Education

Primary education is usually the first level of formal education that occurs after preschool/kindergarten and before high school. Objectives as virtual excursions: Students can take a tour to Mars with XR, which stimulates the imagination while the teachers teach about the climate, the matter that exists on mars, etc. A few examples, taking inspiration from [16], have been presented here.

- Designing an escape room: These tests would test spatial awareness and make the students think about creating mentally challenging tracks. The user first chooses a theme like a dungeon or horror house or goes one step further by creating a maze with several rooms of increasing difficulty. This can be done with a class test in the room and see who can do it the fastest. Unity, the cross-platform game engine, offers an accessible introduction to virtual reality. While it is a preferred option for advanced game developers, it is also suitable for those with basic programming skills and will help the students learn.
- Create a virtual theme park: Another ideal project for students is to invent an imaginative interest. Students can create a roller coaster or plan narrative scenes for a fun ride in the dark. Virtual reality is an excellent environment for designing and building theme park attractions because the user can create a smaller attraction model and quickly add or remove items. In the virtual environment, they can tackle different stages of development, from mock-ups where they can visualize mechanical components and decide what kind of stage will be placed while driving. When the model is ready, they can conduct test runs without interacting directly with most of their surroundings; this is a great way to build the world.

4.2 Secondary Education

In high school, VR headsets tend to be more popular than immersive classrooms. This is because the effects on older students with headphones tend to be more significant. With the entire field of view closed, the feeling of immersion with a VR headset is unmatched. Also, unlike elementary school students, high school students can better use headphones and require less information and guidance from the teacher [17]. Steam's VR Museum of Fine Art [18] allows users to get up close to paintings and sculptures, including the Mona Lisa, without dealing with crowds or protective glass. The first release of the Virtual Reality Museum includes 15 high-fidelity sculptures with more to follow. It also contains two famous paintings that have been scanned and rendered in great detail. Undoubtedly, both the sculpture and painting collections will be expanded in future versions. The artwork is carefully organised into four exhibits, each with its theme.

4.3 Post-Secondary School/Higher Education

XR education has evolved into higher education as an area that offers a uniquely practical learning experience and helps motivate students to acquire the skills and knowledge they desire. Research studies found an association between the use of XR technologies and improvement in students' academic performance, motivation, social and collaborative skills, and psychomotor and cognitive skills [6]. A few examples have been presented as follows.

- Archaeology: Using VR / AR / XR Archeology to not focus on software, hardware, or the latest technological

innovations, but on how archaeologists can design, create, or curate experiences to educate students and the public about the cultural importance of archaeological inspiration. Furthermore, illuminate spaces, objects or themes, which are successful techniques to help a visitor better understand the original context of a thing in a museum or gallery [19].

- Medical: Extended Reality devices offer many benefits for medical applications, including realistic 3D viewing and non-contact interfaces that can be used in sterilized environments. The motivation behind the use of XR in education is that students or patients can gain a better understanding of anatomy through 3D XR views than through traditional materials. Examples of educational applications of XR are the HoloAnatomy application from Case Western Reserve University [20] and the Stanford Virtual Heart Project (SVHP) [21]. The HoloAnatomy application for Microsoft HoloLens allows users to explore human anatomy using the device's holographic display. The SVHP was created to help families better understand the anatomy of their children's hearts. The project was later expanded to include Stanford medical students to help visualize normal and abnormal anatomy. Students use SVHP to learn about congenital heart defects and visualize surgical procedures.

5 Market Analysis Statistics and Affordability

Global demand for XR will have a compound annual growth rate (CAGR) of 45% for 2020-2026, reaching $346.39 billion in 2026. Global XR production was valued at $25.4 billion in 2019 and is expected to grow by 46.5% annually over 2020-2026. Since 2012, 12 companies have made investments in VR and AR startups. Over two years, the value of the assets made was around $5.5 billion; this is most notable when comparing the global VR and AR market size of $ 6 billion in 2016. The North American region currently dominates the market with the most significant global market share in revenue. Still, XR plays in a balanced global video game market with the present value at $106 billion. With 6.9 million militaries in high-income countries and an average annual cost of $2,000 for virtual reality software, financial projections for the global impact of XR on the military market can be vastly underestimated [22], [23]. Virtual reality and augmented reality can grow global GDP by as much as $ 1.5 trillion by 2030. That is the key finding of the economic impact assessment conducted by PwC economists for this report [24]. Table 1 lists the involvement of technology giants in virtual reality, a list compiled by Goldman Sachs Global Investment Research [25].

Company	Date	Details
Qualcomm	Jan-12	Raised seed funding for the mobile augmented reality start-up Blippar
Google	Apr-12	Introduced augmented reality glasses, Google Glass, to the public
Sony	Mar-14	Sony announces Project Morpheus, later renamed PlayStation VR
HP	Mar-14	Launched Aurasma 3.0, an augmented reality platform that it acquired through Autonomy
Facebook	Mar-14	Acquired Oculus, a virtual reality startup, for $2bn
Samsung	Sep-14	Revealed its own head-mounted display. Samsung Gear VR, partnering with Oculus
Google	Oct-14	Invested $542mn in the startup Magic Leap
Intel	Apr-15	Invested in Series A funding for the virtual reality start-up WorldViz
Apple	May-15	Reportedly acquired Metaio, augmented reality software maker
Disney	Sep-15	Led a $565mn funding round in Jaunt. a VR content startup
Microsoft	Oct-15	Acquired Havok, a 3D physics engine used for video games
Comcast and Time Warner	Nov-15	Participated in a 530.5mn funding round for Nex VR, which captures live events in VR
Apple	Nov-15	Acquired Faceshift, a facial recognition capture and animation company
Fox	Jan-16	Acquired minority stake in Osterhout Design Group, a VR/AR HMD maker

Table 1. Involvement in virtual reality by technology giants

The COVID-19 pandemic has increased the demand for extended reality devices due to the unexpected lockdown situation in key regions like Europe, Asia-Pacific, and North America. Employees of various organisations are working from home in the wake of COVID-19, increasing the need for virtual meetings, training courses, and conferences. The pandemic has also affected the manufacture of extended reality devices worldwide and has temporarily halted the delivery of extended reality devices worldwide.

By 2022, India's AR and VR industries are projected to rise to US$ 5.9 billion and US$ 0.5 billion, respectively, making it one of the world's largest suppliers of immersive technology [26]. In the education sector, startups like BYJU'S and Vedantu are developing more interactive and knowledgeable content using augmented and virtual reality. Companies like Cadbury have developed Cadbury play pad [27], a children's gaming app. One of their games provides a unique augmented reality experience that promotes learning in a gamified form; it lets children view animals in their natural habitat, providing an interactive and functional interface.

4 Conclusion

Extended Reality (XR) offers immense potential to enhance the teaching and learning experience in the education sector, delivering a unique hands-on experience that other educational technologies may not be able to provide. It can improve student motivation and active learning in various academic subjects, including engineering and science, as well as the arts and archaeology, at the elementary, secondary, and post-secondary levels. The study addressed the various XR technologies now in use and gave a synchronized list of organizations planning to incorporate them into their respective industries. XR is on the

cusp of exponential growth, which will result in significant economic growth and realistic adaptation in a variety of industries. Extending reality technologies, both those that exist now and those that may appear sooner or later in the future, have numerous applications in every business.

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