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A Review of Extended Reality (XR) Technologies in the Future of Human Education: Current Trend and Future Opportunity

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Abstract:
Nowadays technology development in real life will reflect on education inexorably. Today, the concept of Extended Reality (XR) technologies (XRs), such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), as very promising technological tools for education. The purpose of these technologies is to facilitate human life. In this context, educational technologies create new opportunities for students and teachers every day especially in education field. With various virtual environments (VE) and imaging systems, content that needs to be learned can be presented independently of school and classrooms in a low-cost and safe environment. As a result, teachers can create their own content with various applications, providing them with freedom of flexibility, and creativity. In this context, it is seen that XR has started to be used in various fields in education. When these fields and subjects are examined, it is observed that there is a concentration in the fields of education. The purpose of this narrative review is to describe the accelerators of XR (VR, AR, MR) technology in education settings. This literature review was conducted by conducting a systematic search of relevant articles and literature reviews through the university's online library, Google Scholar, Web of Science, IEEE Xplore, and the ACM Digital Library. In this paper, the authors demonstrate the main components of XR technology in the educational process. A comprehensive review of XR technology including education, and learning was provided. The authors identify limitations and conclude with future work of XR in educational uses.

Keywords: Extended reality; Virtual reality; Augmented reality; Mixed reality; New technologies; Human education

1. Introduction

Over the past 50 years, the quality of education worldwide has improved remarkably at all levels. There has never been a greater challenge faced by expanded education systems than COVID-19. A massive pandemic affected over 1.7

billion students, including 99% of students living in low- and lower-middle-income countries. In line with these findings, 87% of the world's student population is affected by school closures due to COVID-19. UNESCO is launching distance learning programs for students who are at risk. In 195 countries, schools and universities have been closed due to the COVID-19 pandemic. The COVID-19 pandemic has a negative impact on society, but positive impacts can also be expected, including the continued spread and adoption of tele-education that promote digital transformation [1].

Nowadays, learning and teaching processes in classrooms are being transformed by educational technology tools [2]. Education is rapidly developing as it becomes more capable of adopting high technology tools and integrating them into its instructional methods. The main purpose behind technology integration aims to enhance teaching and learning. To support learning and engage students, it is crucial to use the best and latest learning strategies and tools. The objective is to provide students with an enriched education that provides access to information and materials unavailable elsewhere. The use of new technologies in classrooms has produced good results in teaching-learning processes. The governments have forced universities to switch into online learning and virtual education overnights. The introduction of new methodologies involving the use of new technologies is positive for universities. The advancement of computing power in recent years has led to significant advances in virtual reality (VR), augmented reality (AR), and mixed reality (MR). Recent attention has been paid to the term XR (extended reality), which encompasses VR, AR, and MR technologies more broadly.

XR technologies are a promising technology that can create similar experiences that are comparable to real experiences in the physical world. The authors use the term XR technologies to refer to VR, AR, and MR. There has been a great deal of interest in VR, especially after COVID-19. The lockdown forced the students to learn through different methods of learning beyond traditional face-to-face class settings. An example of these technologies is VR which has the potential to transform education in all fields as well as in the real world. VR is a computer-based simulation of a virtual world that is completely immersive and interactive. VR technology offers many capabilities for supporting education that has the potential to be effective. VR provides a sense of reality by enabling students to access virtual environments (VEs) and interact with the students or avatars using all senses. There is no time or place restriction for students who have access to these environments and educational opportunities.

Virtual learning environments (VLEs) are one clear example of how education has been transformed in the past decades. Nowadays, people experience a similar trend with the proliferation of augmented and virtual reality (AVR) technologies in universities. Technology is advancing in leaps and bounds and is being used in a growing number of environments. It is increasingly present in the academic world and in the way teachers and students manage teaching and learning processes. One example that represents how new technologies are being embraced by educational establishments is the development of virtual laboratories [3]. These have various functions, from simulating the environment of a science laboratory to teaching procedures that use equipment and materials that are not widely available, to recreating difficult-to-replicate phenomena, in addition to showing students how to handle ICT and developing new, more stimulating learning strategies, and new forms of assessment.

Virtual and augmented reality is one of the key technologies for higher education in the medium and long term [4]. The scope of this research was mainly focused on the concept of XR technology and what is important to implement it as a new technology in education. Moreover, the authors will explore the future direction of XR technology in education field. In conclusion, the authors discuss how XR technologies can be used in education, as well as their future and limitations.

2. Methodology

The objective of this study is to understand the potential and challenges of extended reality technologies in learning and education, especially during the COVID-19 pandemic. Moreover, in this paper, the authors examine the potential opportunities and challenges that the education sector must overcome to succeed educational process. The purpose of a narrative review is to provide clarification, interpretation, and critique of the literature. Using a narrative review approach, a systematic literature review was conducted Figure 1. The researcher compiled (VR, AR, MR) research studies into a narrative review to present the first synthesis of pedagogical considerations across XR technologies. The researcher selected and analyzed the literature using a systematic approach to reduce bias [5]. In the absence of a consistent focus, a common technology, or a common methodology, we were not able to conduct a meta-analysis because of the large variety of variables within the studies.

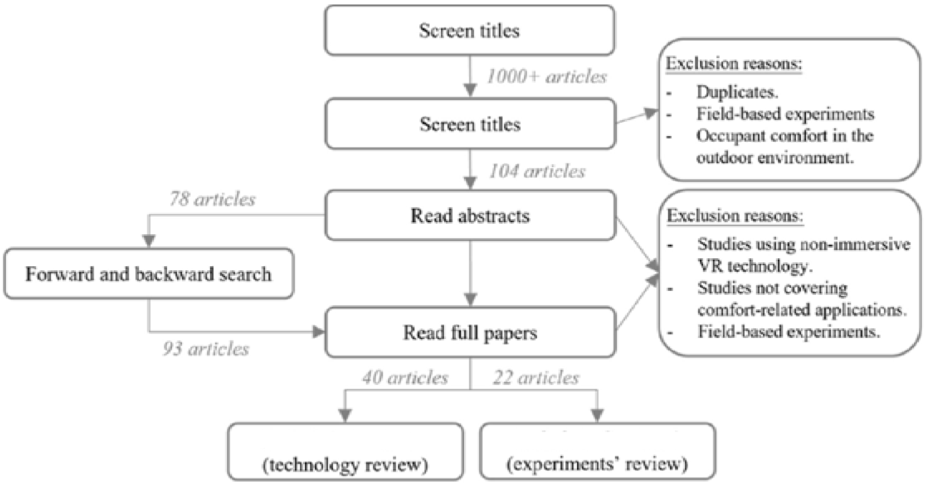

Figure 1. Research methodology

2.1 Data collection and analysis procedure

Our search focused on publications that introduce new reality formats to various disciplines, such as human-computer interaction (HCI), and computer science. First, the authors searched common academic databases, including the Scopus database, Web of Science, Google Scholar, ACM Digital Library, IEEE Xplore and literature reviews. The search was conducted using multiple terms including extended reality, virtual reality, augmented reality, mixed reality, new technologies, learning and education. The selected studies were peer-reviewed, with the use of XR technology in educational settings, and published in English in available conferences and journals.

3. Extended Reality

Emerging VR Technologies have been developed since the 1960s. Developed in 1962 Sensorama uses 3D visual, auditory, tactile and scented stimuli and even wind is also used to enhance the immersion experience. In 1961, the first Wearable Vision Systems Head Mounted Display (HMD) was developed. The most famous of these was a system called "The Sword of Damoklesi", which consisted of 2 pieces hanging from the ceiling and worn on the head, and it was able to track the place and eye according to the position of the users' in the virtual environment created from this fog. Another wearable system is the "corded gloves" developed in 1977. In addition to this, a tool called "Virtual Boy" was developed for virtual games in 1995.

In the 2000s, Wearable Vision Systems continued to develop and become more ergonomic. The most famous of these is the system called "Oculus Rift" which is still being developed and widely used. This system consists of head-mounted viewing glasses only. With the Oculus Rift, users can directly connect to three-dimensional virtual environments. However, many private organizations have also started to develop these VR glasses for games and other purposes such as Samsung VR, Sony Morpheus, Hp reverb G2 and HTC Vive. In addition to these, simpler applications are being developed with projects with smaller budgets. For example, Google Cardboard and Microsoft VR kit. Anyone with a smartphone can dive into VR applications using these glasses and feel the environment as real. Automated Virtual Environment (CAVE) rooms are another VR application. In these rooms, images and sounds are projected onto the walls with the help of projectors, and users can interact with these images by using special glasses associated with these projectors.

Extending Reality (XR) encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). XR describes all real-and-virtual combined environments between human and computer input. VR, AR, and MR are all covered in this review, but we will refer to them as XR for clarity. VR consists of the complete immersion of a user in a synthetic environment without being in the real world. It is important to understand how VR works as well as the differences between fully immersive, immersive, and non-immersive as well as 360-degree pictures and videos are considered in a virtual environment. VR refers to a computer-generated, fully artificial digital environment in which a user can perceive and interact with the environment through a variety of peripheral devices [6, 7]. VR refers to the experience of being immersed in a simulated environment given by a device called a HMD. The purpose of a virtual environment is to create a strong sense of immersion and/or presence for the user, regardless of the state in which VR is experienced.

In contrast with conventional user interfaces, participants in VR are immersed in the virtual environment, interacting, and communicating with virtual objects and avatar representations through various types of input devices. A key feature of VR is the view-independent anchoring of the virtual environment. Conventional two-dimensional images and videos are anchored to the image surface or other device that displays them. When the image surface is moved, the image appears to each observer equally. VE is designed with anchoring so that the display device displaying them does not affect the position or location of the environment but is separate from it. The observer is free to move the display in space without the environment moving with the display. The display device creates a window through VE which users can look at and interact with it. In addition, each observer has an independent view of the virtual environment. The benefits of XR can provide enhanced content understanding, improved physical tasks, higher motivation, and engagement.

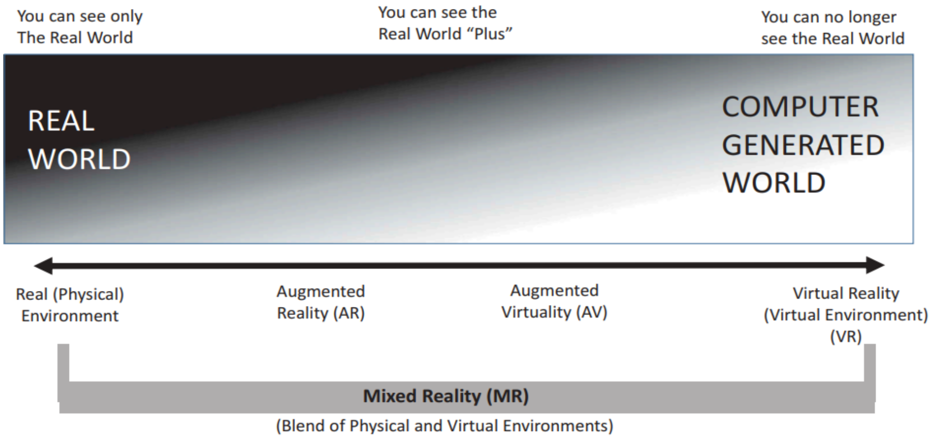

Figure 2. The reality spectrum immersive computing spectrum [8]

To improve the quality of education, the world is looking for ICT tools like remote meeting applications, online exams, virtual reality, augmented reality, etc. In the COVID-19 pandemic, information communication technology is a necessity of a modern education system. However, teachers hold mixed opinions about integrating ICT or VR/AR into their daily routines. The importance of ICT, VR, and AR tools in education has been highlighted in several pieces of research.

Augmented reality (AR) is a technology that allows real-time integration of real and virtual objects in the field of view [9]. Perception is primarily based on real-world objects, while virtual objects appear to be related to real-world objects spatially and/or semantically. In educational settings, AR-environments have great potential to enhance learning processes, which is why they are being developed and researched so extensively. Virtual and real objects are combined in AR, which is both interactive and registered in 3D. As shown in Figure 2, Milgram's Reality-Virtuality Continuum is a continuum between augmented reality and augmented virtuality, where augmented reality is closer to real reality and augmented virtuality is more like the real world [8].

The term AR refers to overlaying information or virtual objects into the real world, allowing virtual objects to coexist in the same space as real objects [9, 10].To activate an augmentation (a superimposition of 3D material), augmented reality requires a trigger. Triggers include markers, markerless triggers, image-based triggers, positional triggers, and locational triggers. Using a marker-based AR system, an artificial image is used to trigger an augmentation, such as a barcode or QR code. Several different technologies can be used to access Augmented Reality, including tablets, PCs, and HMDs. Various AR solutions exist, with varying costs, functionality, and utility in educational settings. Collaborative learning with Cave Automatic Virtual Environment (CAVE) becomes another approach for students to master complicated issues in virtual rooms [11]. At the same time, AR does not have to be limited to the field of vision. Within certain research, AR could influence all senses, such as hearing, smell, and touch [12].

3.1 Virtual reality

VR consists of the concepts of cooperation and interaction with environments produced by users and computers, appearing as real, and integrating all products and information tools of artificial intelligence. Feeling that you are in an unreal environment and interacting with non-existent objects in the environment is achieved by providing high-quality data. The higher the quality of this visual or audio data created with the help of computer programs, the more real is the perception of reality and the perception of immersion in this environment. In addition, the users' sense of being in that environment is as close to reality. The users lose the perception of time, space, and reality, especially while playing VR games. This is because the virtual environment immerses the users in it like the real world. VR is widely used in fields such as education, observation, testing, entertainment, and health. Firstly, in the field of education, Flight simulation systems are widely used to provide flight training at low cost to pilots and pilot candidates. As an observation tool, an indoor or outdoor space can be made navigable with virtual tour technology by providing a 360-degree navigable living environment so that the environment to be examined can be perceived more easily. As a test tool, with the digitalization of space and goods with VR technologies, modern production technology can design and test processes. It is widely used with the help of VR glasses in games in three-dimensional environments for entertainment purposes. Furthermore, it is commonly used in the field of health to teach risky surgeries in medical science, as well as to train nursing candidates in the field of nursing and treat phobias such as fear of heights.

VEs enable students to engage in realistic environments. It is seen that it provides rich perceptual clues and versatile feedback, enables virtual experiences to be easily transferred to real environments, interacts with content, entertains while learning, and facilitates the learning of concepts [13, 14]. Furthermore, VR technology has been observed that makes learning effective and engaging, as well as provide great advantages. The sense of being in the environment and imagination improve students' problem-solving skills and provide excellent environments for generating ideas, structuring information, and synthesising information from various sources by providing high-level interactive learning experiences for the user.

Today, VR will be extremely useful, particularly in distance education [15]. The actual environment, which is considered the most important factor distinguishing face-to-face education from distance education, may be delivered in a way that offers remote education in the same sense by employing VR systems and software. Additionally, VR can be used in areas of education that are difficult to access or experience physically [16]. These areas can be difficult to reach for the following reasons: The problem of time different historical times can be experienced through travelling through time. Moreover, physical impossibilities such as the solar system and several planets can be modelled. Further, there are ways to safely conduct training on hazard perception in technical and vocational education when faced with dangerous situations [17].

3.2 Augmented reality

The concept of AR refers to the projection of virtual objects into real physical environments. In a compositing environment, virtual objects can be superimposed on or composited with the actual environment to give users a more realistic and intuitive sensory experience [18]. The purpose of AR is to simplify the user's life by bringing virtual information not only to his immediate surroundings but also to any indirect views of his immediate surroundings, such as a live video stream [19]. By using AR, users can perceive and interact with the real world more effectively. In VR or VE, users are immersed in a synthetic environment without being able to see the real world. While in AR virtual objects and cues are superimposed on the real world. This is not taken into account that AR is restricted to a certain type of display such as HMD, nor are the authors considering it to be limited to sight [9].

All senses can be enhanced with AR, including smell, touch, and hearing. The technology can also be used to replace missing senses by substituting audio and visual cues, so blind users and those with poor vision can augment their sight, and deaf users can replace their hearing by using visual cues. The researchers also examined AR applications that require removing real objects from the environment, commonly referred to as diminished reality or mediated reality. The process of removing real-world objects corresponds to covering the objects in virtual information that matches the background so that the user perceives that they are not present.

3.3 Mixed reality

Mixed reality exists on the virtuality continuum in the middle of AR and enhanced virtuality. As shown in Figure 2, MR is a hybrid of AR and VR that allows users to physically interact with virtual elements in the real environment [8, 20]. While AR enables the overlay of a virtual/digital item into the actual environment, MR permits the complete body to be integrated with real and virtual aspects throughout the reality continuum [21]. Virtual/digital overlays or objects in MR environments are not only visible to the user but can also be physically interacted with. The capability to interact with digital/virtual overlays in the actual environment distinguishes AR from MR. In spite of the fact that the cost and processing power involved in MR exceed what is accessible in the majority educational settings, continued technological improvements will allow for future explorations of MR capabilities and possibilities.

According to recent studies, XR technology allows for the co-creation of experiences for instance HMDs and goggle-type devices are capable of producing high-quality visuals as well as experiences. In the MR market, there are three types of glasses such as HoloLens, Magic Leap, and Google Glass [22].

3.4 XR devices/hardware

VR devices consist of hardware components that are capable of running VE and displaying the visual information on either an internal or external display. The most important VR equipment is the head-mounted display (HMD). VR headsets are an HMDs with stereoscopic display lenses and motion tracking such as an accelerometer and gyroscopes for tracking head or eye movements [23]. The users wear an HMD device that consists of two screens, which display different stereoscopic images to form a VR with an image source and collimating. The image was created utilizing optic techniques to look like a genuine image and surrounds the user with realistic audio and visual effects. Some VR devices work as standalone systems such as smartphones and tablets without the need for external hardware to display a virtual environment.

VR has become a major technology trend as a result of the recent release of HMD and VR devices such as the Oculus Rift, HTC Vive, and HP Reverb G2. The VR headset hardware is called Oculus Rift as shown in Figure 3. An Oculus Rift VR headset offers full HD 1080 x 1200 resolution and a 110-degree field of view with an OLED display for each eye. The HMD can be connected to the PC system via a USB 2.0 or 3.0 port using an HDMI cable to display visual information. As an input device, the headset provides users with a wand-like Oculus Touch controller.

The Oculus Rift uses OLED panels for each eye with a 1080 x 1200 resolution. This panel refreshes at 90Hz. Furthermore, there is a wide field of view due to the lenses. Hence, high refresh rates, global refresh rates, and low persistence mean that there is no motion blurring or judder experienced by users on regular screens. Headphones are included and integrated with the headset which provides real-time 3D audio. The Oculus Constellation tracking technology provides the headset with complete 6 degrees of freedom as well as rotational and position tracking Figure 3. The Oculus headset is equipped with headgear and controller, as well as a basic menu navigation controller, as well as the Oculus Constellation controller. With the Oculus constellation system, headsets can be tracking the position of the person's head as well as device location. From the outside, it is equipped with an infrared tracking sensor.

In addition, immersive input devices allow participants to interact with VE more smoothly and interactively when compared to traditional input devices. Oculus Touch and HTC Vive Controller are two examples of immersive input devices. The Oculus Rift and the HTC Vive devices serve as input devices for their respective VR headsets. The Oculus Touch controllers, also known as Half Moon, offer users a sense of "hand presence". There are two physical buttons, an analogue thumbstick, trigger button, and infrared LEDs for tracking on each controller. Moreover, Oculus Touch provides haptic feedback through hand tracking.

Figure 3. Oculus rift and oculus sensors

On the other hand, the HTC Vive controller is a pair of tracked input devices intended for HTC Vive HMD Figure 4. This controller is shaped like a stick, but it has a ring shape on top that makes it comfortable to grip by hand. The controller has two physical buttons, one trigger button, a circular touchpad, and 24 infrared sensors integrated into the rings [24]. The performance of both input devices is equal in terms of immersive engagement and tracking. Therefore, Oculus Touch controllers enable hand gestures for display displayed through virtual spaces.

Figure 4. HTC Vive and controller

HP Reverb G2 is part of Microsoft's Windows Mixed Reality (WMR) family, along with HoloLens and HoloLens 2. In addition to WMR headsets, the platform includes Microsoft's Mixed Reality Portal software. HP Reverb G2 is a WMR headset, so no additional sensors are required instead, its built-in cameras track movements outward Figure 5. Headset hosts inside-out tracking with four cameras. Tracking is usually offered in three degrees of freedom in headsets that track a learner’s movements throughout a virtual environment. HP Reverb G2, a VR headset with astoundingly high-resolution lenses, is easily one of the best out there due to its ability to eliminate screen door effects and generate an amazing sense of immersion. Among the VR HMD features are displayed 9.3 million pixels compatible with WMR and dual 2.89-inch LCD screens within 114 degrees of field of view, as well as Fresnel-Aspherical lenses 90Hz refresh rate and 2160 x 2160 resolution per eye 4320 x 2160. On the one hand, HP Reverb G2 connecting via a cable to a computer is required. This is the most common way to deploy HMDs in VR because they provide the best performance.

Figure 5. HP reverb G2 virtual reality headset

The majority of VR headsets such as Oculus Rift, HP reverb G2, and HTC Vive rely on external hardware or desktops to run those graphically intensive 3D environments. In spite of the fact that VR headsets appear to provide the most immersive experience, most VR headsets require external hardware to run such as Oculus Rift and HP Reverb G2 which require a high-performance computer specification to work. As a result, its portability is somewhat limited unless a user chooses to use a more portable desktop PC over a VR-Ready laptop. At present, Oculus Rift, HP reverb G2 and HTC Vive are the two most popular VR headsets for PCs [25].

In HTC Vive, two tracking stations provide 360 degrees of motion tracking. Therefore, the Vive appears to offer more freedom in terms of room-scaling ability because the tracking allows the user to stand and walk as compared to the Oculus Rift's headset. Regarding hardware specifications and interaction techniques, the HTC Vive is similar to the Oculus Rift, including similar display and input technologies. However, there is a noticeable difference in the tracking system. The Oculus Rift costs $400, HP Reverb G2 costs $599, and the Vive costs $600. Nevertheless, these PC-based VR headsets require a PC or a laptop with a VGA card, which might also charge the overall cost. In terms of accessibility, VR headsets are easily accessible and available for purchase both online and in-store.

4. Interactivity

Interactivity integrates the user and the virtual environment by allowing the user to handle virtual objects or activities in the simulated environment interactively via sensors or input devices. Since VR is immersive and engaging, content may be transmitted over various sensory systems such as hand gestures, audio, and sound. A human-virtual environment interaction loop is implied by [26] proposed model that represented the interaction of human and virtual worlds. The interface allows communication to pass between human input channels and computer output modalities. The human obtains information from sensory channels (input) and afterwards responds to actions based on that information (output). The human output channels then transform human activities into task-based actions, which are translated into input device modalities. This interaction cycle is depicted in Figure 6. As a result, interactivity can help users to feel more of a sense of presence [27]. However, when humans interact with something, users are more interested in paying attention and become motivated. The users’ attention and engagement may be strengthened through interaction, which is considered to be essential elements in generating a feeling of presence.

VR creates a three-dimensional (3D) environment in which users can immerse themselves in a simulated world by utilising various technologies such as head-mounted displays (HMDs) and head-tracking systems, audio and sound headphones, and manipulation/navigation devices. With an HMD, users can perceive stereoscopic 3D images and determine their position within the visual environment via motion tracking sensors [29]. Additionally, users may listen to sounds via headphones and interact with virtual objects using input devices such as joysticks, controllers, and data gloves. Hence, the simulated environment gives the users an impression by a look around and moving in virtual space.

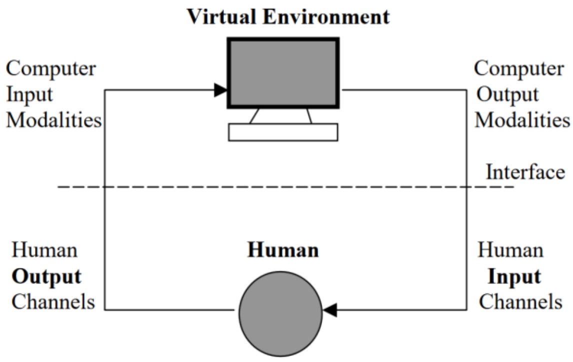

Figure 6. Human- virtual environment Interaction Loop [26, 28]

4.1 Advantages of Using Extended Reality

Since the 1990s, researchers have predicted VR will enhance and transform the interaction between humans and computers. However, VR technological advancements become less expensive, and many characteristics may be gained with 3D environments such as interaction, safety, motivation, engagement, and interest. This technology transformation can be taken place by using the main advantages of using VR as follows: VR makes it possible to interact with events and objects that do not exist and are inaccessible [30]. Moreover, it ensures training can be done safely against situations that are difficult to train because they are dangerous [17, 31]. VR considering a part of the gamification approach which increases students' participation and intrinsic motivation by supporting different learning styles in the field of education [32, 33]. Furthermore, in the digital world VR improve information access to the users through visual and auditory assets such as books, files, and movies [34].

VR technologies allow students to access the same virtual environment, work together and do interactive studies [35]. Additionally, VR applications or experiments allow users to perform experiments that would be impossible to perform in reality due to the danger involved [36, 37]. In terms of games, VR technology plays an important role in education. In spite of the fact that VR-based games lead to student motivation and improved learning [38]. On the other hand, VR improves social integration and cooperation using an environment that integrates collaboration and interaction [39]. The use of technology-based interactive devices to support learning via technologies such as VR systems that combine the physical and virtual worlds is on the rise. VR technologies lead students to prefer different learning styles. VR platforms have become a new tool to enhance creative learning. Collaboration in VR supports learners' social interaction such as promoting student engagement, self-learning, multi-sensory learning, increasing spatial ability, confidence, enjoyment, and encouraging student-centered technology. As a result, students who are afraid of being a part of class groups have become easily accepted by their friends in the group thanks to their technological skills.

5. Components of Extended Reality for Human Education Use

VR is the technology of the future, and many companies are investing time and money in its development. Some key components are necessary to provide a VR experience. The hardware and software are the two most important subsystems. Hardware is categorized into VR input/output devices, while the software is categorized into application software and user interface software. There are several key elements of VR technology [40, 41]. Firstly, the virtual world is a 3D environment that allows the user to explore the VR world as they choose. Essentially, it imitates the real world and allows users to interact with it in a virtual environment.

Secondly, immersion is two types of immersion: physical and mental. Immersion is the experience of being present in a virtual world. Immersion, both mental and physical, allows your mind to suspend disbelief that users are in a virtual environment. There are numerous techniques and equipment that can assist you in achieving complete immersion. First, Non-Immersion Systems: These are systems that use not complex VR applications via computer screen, keyboard, and mouse. Secondly, Full Immersion Systems: These are the systems that provide the closest experience to reality with the help of high-quality graphics and performance [42, 43]. Thirdly, Half Immersion Systems: These are systems such as flight simulators, which are among the first two systems, combining stereoscopic images with high-performance software, wide field of view and tactile sensation.

Finally, sensory feedback as follows the optimal stimulation of the senses, including sight, touch, and sound, can be accomplished with the help of appropriate software and hardware components. Sensory feedback became necessary when our senses began to play. Many accoutrements, like as HMDs, hand accessories, hand controls, and special gloves, are important for the effective stimulation of these senses. Ultimately, interactivity represented by users who may interact with the system's material is one of the reasons why VR is so popular in a variety of fields such as medicine, business, and game development. Interactivity is determined by factors such as range, speed, and mapping, and the benefits of being able to move in all directions as well as the capacity to adjust the environment according to our preferences are the best interactivity that VR offers.

With the development of technology in recent years, the concept of VR has gained importance. VR applications have been developed and used since the 1960s. Today, the concept of VR is used in many fields such as the military, education, medicine, and entertainment. VR is a process by which a person interacts with computer-generated 3D images or simulations of the environment in a real or physical way, through special electronic devices such as headgear with screens or gloves with sensors fitted [44]. Within the framework of this definition, the concepts related to each other within the concept of VR emerge such as immersion, perception, and telepresence.

5.1 Types of extended reality for human education

There are three types of VR environments: low-immersive, semi-immersive, and full-immersive [45, 46].VE is producing more immersion levels when users experience less awareness of their surroundings when they are interacting with them, and vice versa. For example, a typical desktop PC setup can be used to demonstrate low-immersive VR. VR systems of this type usually use conventional input devices to interact, such as keyboards, mouse, and joysticks. Compared to low-immersion VR systems, semi-immersive VR systems offer a moderately higher level of immersion and interactivity. An example of a semi-immersive VR system is a desktop PC with 3D stereoscopic monitors, a 3D TV, or a 3D holographic tablet. By wearing 3D glasses, users can view information on stereoscopic displays. Interactive input devices are available with some semi-immersive VR systems. For instance, a haptic input device would provide six degrees of freedom and touch feedback. A VR system delivers a powerfully immersive experience by not only isolating the user from the real world but also supplying them with virtual information. A VR wearable headset, such as the Oculus Rift or HTC Vive, that features head tracking, OLED screens, and surround sound, is a typical example of an immersive VR system. The CAVE systems are also types of immersive VR systems, and they usually consist of a cube-shaped VR room that utilizes multiple projection screens as walls. CAVEs are large VE where multiple participants can interact and access virtual information collaboratively.

5.2 XR system taxonomy for human education

To provide a more intuitive explanation of VR system classification [47], proposed a VR system taxonomy that not only considers the level of mental immersion but also incorporates VR technology and hardware examples, as illustrated in Figure 7. VR systems can be divided into two types: basic and enhanced. VR systems with a lower immersion level are handheld mobile devices such as smartphones and tablets as well as monitor-based systems such as a traditional desktop PC setup. The enhanced VR systems can be divided into semi-immersive and fully immersive systems. Semi-immersive VR systems typically have a huge projection screen with 3D stereoscopic capabilities, such as wall projectors and an ImmersaDesks. A fully immersive VR system, such as CAVE or an HMD, usually can display VEs with a much wider field of view, making the participants less aware of their physical surroundings.

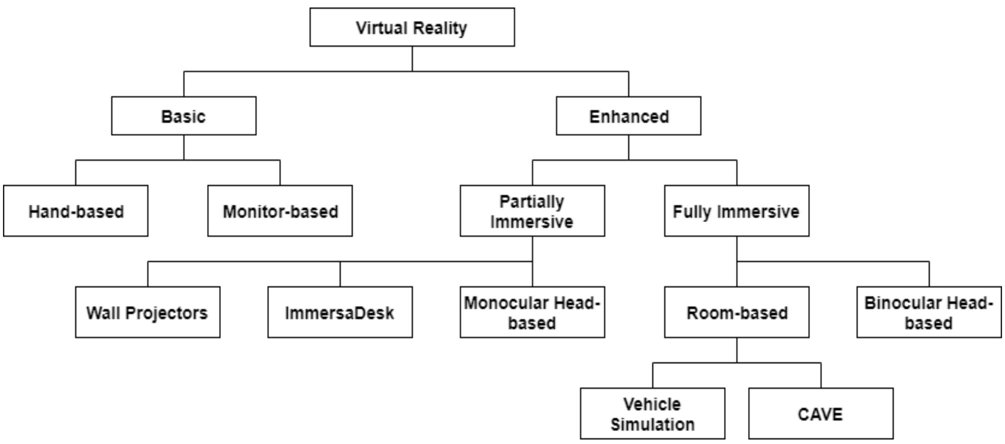

Figure 7. Taxonomy of VR Systems based on levels of immersion technology [47]

6. Extended Reality Technology in Human Education

VR technologies have demonstrated great success in education and training [48]. Typically, training takes place in classrooms and laboratories, involving presentations and hands-on practice. In contrast, certain facilities require trainees to travel to receive proper training. VR technology makes it possible to provide real-world training through VEs in an immersive and effective experience. VR simulations have been shown to provide effective instructional tools that can transfer soft skills to the classroom and the workplace [49]. Additionally, VR-based laboratories can be used for engineering, and training sessions, supporting a broad range of applications across a wide range of fields [3]. VR has become much more affordable and accessible since the recent growth of consumer-grade VR devices. With recent advancements in VR technology, interactive VR applications can also be created, applied, evaluated, and delivered at a lower cost.

In the past few years, there have been a growing number of studies focused on the development of virtual laboratories for distance learning programs [3, 50]. Due to safety and logistical issues, many environments in which engineers and scientists work are restricted to students. Immersive learning laboratory aims to give students virtual access to areas they would not normally be able to go. Consequently, students enrolled in manufacturing technology education must become familiar with complex systems and mechanical operations. However, delivering such hands-on laboratory practices to engineering students taking distance learning courses becomes an obstacle. These challenges were addressed by VCIMLAB, the virtual manufacturing laboratory for distance learners [51]. This system provides an interactive environment for the students so they can feel as if they are there. Through interaction with the designed virtual environment, they can feel what they are doing instead of just watching. Recent studies indicate that students who practice using a virtual laboratory outperform those who are trained using conventional video demonstrations [52]. VR-based laboratories have proven highly flexible and cost-effective for delivering robotics laboratory experiences to students through distance learning. In addition to this, the VR-based lab allows students to learn from their mistakes without damaging machinery or injuring themselves. Thus, it is highly recommended that VR systems are most effective as pre-training tools in educational laboratories with highly expensive or potentially hazardous equipment to help students familiarize themselves with tasks and procedures within the virtual environment in advance to prevent making critical errors on the actual equipment.

Hence, smart education labs empower teachers and students through innovative methodologies and experiential learning. As a result, improving engagement and qualification with immersive experiences and VR/AR/XR technologies. In contrast, immersive VR provides the user with the perception of being physically present in a non-physical world, which is highly beneficial in the field of education since immersive VR facilitates learning more motivating and engaging. The majority of research on immersive VR in education focuses on applications that utilize CAVEs, which are still quite expensive. Education has few applications for these devices due to their high cost and limited space. Recently, VR headsets such as Oculus Rift as well as HTC Vive are preferable to CAVE-based approaches because of their low costs and excellent portability, making immersive VR accessible in a variety of educational settings [53, 54]. The use of VR headsets to conduct immersive VR in education has been emphasized by many educators. Researchers use headsets to produce realistic visualizations of anatomy and surgical procedures of the human body [55–57]. The immersive VR environments offer trainee surgeons comprehensive views, allowing them to see close-up and 360 degrees, which will significantly improve their experience in operating rooms. With the advent of low-cost immersive VR, environments provide better interactive scenarios and vivid simulations in labs with higher levels of immersion [58].

VR Simulators in terms of student interest and engagement as interactive technology, VR provides ways for training centres to educate their students in an immersive learning environment [59]. VR and simulation are used in training not only for situations that should not occur but also for situations that are potentially dangerous by considering the skills of the trainee. Simulation is a hands-on method that is measurable and repeatable in debriefing, which is the most powerful aspect of learning [60]. A realistic simulator training program is essential for a successful learning process, providing benchmarks for virtual feedback systems. Even though VR is slated to have great success in the global market, education currently holds a much smaller share, which indicates the immense potential of this sector as shown in Figure 8. The use of VR in education covers computer science with a rate of 60.2%. This is followed by fields such as social sciences 24.7%, medicine 11.8% and mathematics 8.6%. It has been observed that the majority of the studies were conducted in countries such as the USA, England, China and Germany. The concept of using VR in education is especially concentrated at two levels. These; high school and higher education and university education [62].

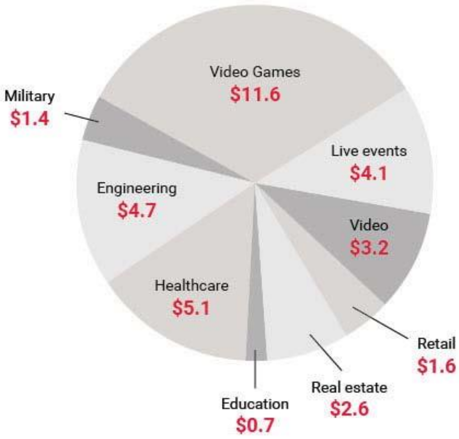

Figure 8. Global 2025 VR market share [61]

The concentration was observed in the fields of military education, medical education, surgical education, nursing education, language teaching, translation education, and basic science education [63, 64]. The CAVE system is used in various fields of study. A good example of these can be found in [65]. In this study, they aimed to teach Mandarin Chinese in vocational training using CAVE room. In addition, the researchers also created a CAVE System [44, 66] so that students could conduct experiments on the theory and concepts of relativity [67]. Also, there has been extensive work on HMD such as classroom management skills in teachers [68, 69]. According to [70], the HMD in Chinese class improved students' motivation towards the lesson. On the other hand, the HMD was used to show the hand movements of surgeons during operations using the fingers [71, 72].

A wide variety of VR studies have been conducted in various fields to design and test three-dimensional virtual environments. In this regard, an intelligent learning environment was designed to teach several subjects and conducted experiments in a Computer Science Department [73, 74]. A virtual reality environment facilitates the experience of architectural spaces [75]. Students learn and practice in a three-dimensional virtual environment filled with avatars that offered a three-dimensional learning environment [76]. In physics education, a VR application was developed to visually present neutrino data [77]. Nurse educators have developed a virtual immersion collaborative learning environment and used a virtual hospital to provide medical education [78]. Students were able to practice dental caries treatment using a three-dimensional virtual simulator developed by the university. Moreover-based rehabilitation therapies and traditional physical therapy for patients with vestibular problems [79]. In addition, VR technology was used to improve communication between doctors and patients by bridging the gap between the physical and virtual worlds and to control patients remotely, concluding that both doctors and patients could benefit from this new technology [80].

7. Limitation

Nowadays, digital transformation has been accelerated by social-distancing guidelines in response to the COVID-19 pandemic, creating a context that will continue to drive innovation. As a result of the COVID-19 pandemic, the education system has been disrupted, elective operations have been reduced, and physical participation in workshops or conferences has been restricted. As a result, technology is used to ensure the educational process. A major reason for virtual reality's limited use in education is the need for specialized knowledge and VR equipment, which can be a burden for educators.

The adoption of AR for education is accelerating due to the increasing demand for virtual learning platforms. There have been some systematic reviews of AR in education that have focused on one subject in recent years. The high research output makes it important to identify current research trends correctly and identify the areas with future potential. As shown in Table 1, some advantages, and limitations of augmented reality in education have been mentioned in several of the reviewed publications. The use of VEs is increasingly being utilized to train users to perform real-world tasks and procedures. However, there are important differences between real-world and VR-based training. The advantages and disadvantages of real-world training can be summarized as follows: In general, real-world training is time-consuming due to the efforts and time required to set up the real-world training location and to travel there. The second problem is that it could be expensive as real-world training materials must be prepared and coaches must be hired. As a third factor, it could be unappealing and unintuitive due to its lack of visual hints, such as 3D animations of skills and processes. Additionally, some skills, such as emergency procedures, could only be learned in simulators, rather than in the real world.

Table 1. An advantages and challenges of using augmented reality in education

Advantages	References	Challenges	References
Improving the accomplishment of learning, boosting confidence, multi-sensory learning, and Promoting self-study	[81, 82]	The trigger recognition lacks sensitivity, it is difficult to design, ergonomic issues, and errors affecting the GPS are an irritation to students.	[83]
Increasing motivation for learning, keeping your attitude positive, Increases the sense of involvement, allowing students to learn by doing	[84, 85]	Cognitive overload, and teachers' insufficient ability to utilize technology	[86]
Ensure students understand, technology-focused on students, provide opportunities for student interaction, and reduce laboratory costs	[87, 88]	Expensive technologies	[89]

8. Conclusion

The main objective of this research is to introduce the concept of VR and to discuss its advantages by mentioning its usage areas in education. VR technologies, where educational technologies offer new opportunities to students and teachers every day; facilitate human life and transform education in a way that is always everywhere. At the same time, the content that needs to be learned with VE and imaging systems can be presented independently of schools and classrooms, as well as the content in the outside world can be presented to schools and classes at an inexpensive cost and safe space. Students can access these environments whenever they want and have access to educational opportunities and opportunities regardless of time and place. It is seen as the most important factor that distinguishes face-to-face education from distance education.

In fact, distance education approaches such as VR systems provide a realistic virtual environment that is similar to the real world. VR can be used in areas that are difficult to physically reach and experience in education, making it a tool to develop creative learning and contribute to the development of different learning styles. VE enable students to engage in realistic environments. There is evidence to support that it provides rich perceptual clues and versatile feedback, facilitates the transfer of virtual experiences into real environments, interacts with content, entertains while learning, and facilitates concept learning. The impression of interacting with non-existent objects in an unreal environment is achieved by providing high-quality data. Since the virtual environment immerses the users in it like the real world. Especially when playing VR games make the users feeling of being close to that environment and could lose their perception of time, space, and reality.

Students' problem-solving skills are improved when they have a sense of being in the environment and using their imaginations. Additionally, it is important to provide highly interactive learning experiences in the person, as well as ideal environments for brainstorming, structuring information, and synthesizing information from different sources.

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