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## Application and Research of VR in Education

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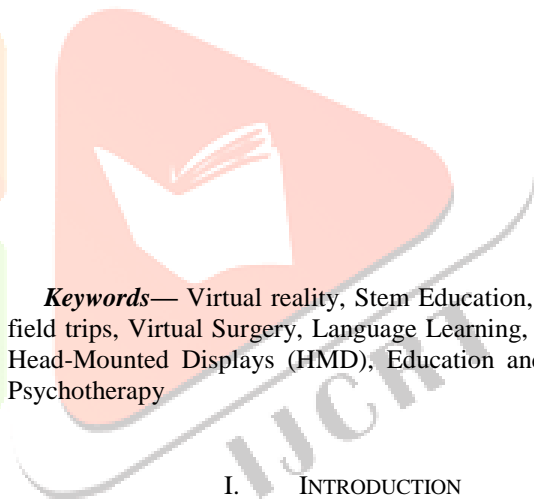
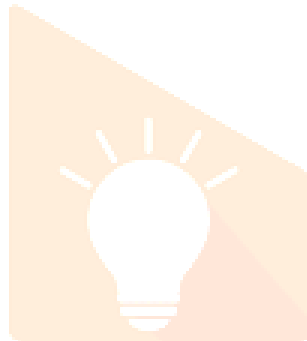
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**Abstract**— Virtual Reality (VR) has gained significant interest in education due to its immersive and interactive capabilities. However, the design and implementation of VR-supported learning are often based on technical perspectives, lacking well-defined learning theories and custom-designed models. To provide learners with a natural interaction experience and rationally support learning using VR technologies, a learning model considering both pedagogy and technical affordance is proposed. This model is used to design and implement an educational application of computer assembly with two sessions: the learning session and the game session. The VR device offers visual feedback and provides a profound immersive experience for learners. The learning session helps students construct knowledge and explore virtual situations using controllers. The interactive game fosters computer assembly learning. An evaluation with 32 college students was conducted, analyzing users' learning behaviors and performance. Results showed that VR learning of computer assembly provided a good usability and learning experience, with no difference in performance between reality and VR learners. Challenge and task completion time showed a significant positive correlation. Virtual reality plays a crucial role in the evolution of education, as it allows users to interact in real-time in a tridimensional space generated by a computer using their feelings. Education can be seen as a discovery, exploration, and observation process, and the specific characteristics of VR can transform it into a powerful tool for education evolution. With VR acting in education, we can discover, explore, and build knowledge about places and places.

**Keywords**— Virtual reality, Stem Education, Immersive field trips, Virtual Surgery, Language Learning, simulation, Head-Mounted Displays (HMD), Education and Training, Psychotherapy

### I. INTRODUCTION

In a dynamic educational environment where innovative methods are constantly being sought, the integration of new technologies is a beacon of transformative potential. Virtual reality (VR) has emerged as a prominent contender in this field, offering an innovative approach to learning and pedagogy. This study focuses on the ability of VR to reshape traditional educational environments and aims to explore and clarify the diverse applications of VR in education and its implications for research. Education as we know it is on the brink of a paradigm shift driven by the immersive and interactive possibilities of VR technology. The appeal of taking learners beyond the confines of the traditional classroom into an experimental simulated environment promises unparalleled engagement and understanding. This study highlights the diverse uses of VR in education and concurrent research efforts aimed at understanding its impact. The intersection of VR and education offers a wealth of possibilities, from virtual field trips that transcend geographic boundaries to interactive simulations that bring abstract concepts to life. In starting this study, our overall goal is to analyze the practical applications of VR in education and to recognize the tangible benefits it brings to both teachers and learners. This study attempts to provide a comprehensive overview of the current state of VR in education through a survey of existing literature, case studies, and emerging trends. Additionally, we aim to contribute to the ongoing

debate by highlighting the evolving role of VR in shaping the future of learning environments. While navigating this virtual frontier, the following sections unravel the complex web of integrating VR into education and provide insights into VR's potential to revolutionize the educational experience.

## II. LITERATURE REVIEW

Virtual reality (VR) technology has significantly advanced in recent years, allowing for more immersive and interactive educational experiences. It is being explored for applications across various fields, including medicine, engineering, and architecture. VR is also being used in education for training and simulation, especially for skills that are difficult, expensive, or dangerous to practice in real settings.

VR field trips allow students to visit simulated environments they couldn't physically go to, giving them experiential learning and a sense of "being there". This increases engagement and conceptual understanding, making VR field trips as effective as traditional teaching methods.

VR can be integrated as an instructional tool alongside traditional classroom teaching, increasing student motivation and enjoyment of material, and improving classroom dynamics. VR lessons also improved recall of material compared to just traditional lectures in one study.

Benefits of VR in education include increased engagement, experiential learning, accessibility, efficiency, safety, visualization, and individualized learning. Students can learn at their own pace in VR environments tailored to their individual needs and interests, and VR training can be customized and adapted throughout the learning process.

However, there are challenges to using VR in education. Costs of VR headsets, equipment, and custom VR learning environments can be prohibitive for many educational institutions. Technological limitations such as "VR sickness" and lack of haptic feedback and tracking limitations also reduce realism.

Integrating with pedagogy requires designing VR lessons based on learning objectives and instructional design principles rather than just technology. More interdisciplinary collaboration is needed to optimize integration into curriculum sequences. Teachers need training on how to incorporate VR into the classroom, guide students in VR lessons, and troubleshoot technologies.

As VR uses continue to grow, it holds great promise for enhancing learning through its experiential and engaging nature. Key recommendations include incorporating VR design and implementation into teacher training programs, developing guidelines for integrating VR effectively into curriculum, and making VR hardware, software, and content more affordable and accessible for mainstream educational adoption.

## III. APPLICATIONS

### A. Stem Education

Virtual reality technologies have recently been actively used in education, teaching, and many different disciplines. VR technologies are an important component in the current process called the fourth industrial revolution and many leading companies invest in these technologies. VR is defined as a computer-based simulation platform that allows users to experience a three-dimensional environment very realistically using some specialized equipment. VR is environments that perceive the user's position and actions in an interactive environment containing 3D computer simulations, provide synthetic feedback to one or more senses and help them experience the feeling of being immersed.

Expanding upon the discourse surrounding virtual reality technologies, it becomes evident that these innovations have garnered significant traction across diverse educational domains. This burgeoning interest is particularly pronounced within the context of the fourth industrial revolution, where major corporations are channeling substantial investments into the development and integration of VR technologies.

In the lexicon of VR, the term is delineated as a computer-based simulation platform designed to afford users a highly realistic three-dimensional environment through the utilization of specialized equipment. Moreover, expound upon VR as immersive environments that discern the user's position and actions within an interactive space replete with 3D computer simulations, delivering synthetic feedback to the user's senses and engendering a profound sense of immersion. It follows that VR emerges as an innovative computer-aided simulation technology that facilitates users in experiencing a heightened semblance of reality within dynamic and interactive virtual landscapes.

Within the VR milieu, students are enveloped in realistic settings that enable them to emulate real-world scenarios, fostering exploration, interaction, and manipulation of objects via avatars serving as their virtual counterparts. This affords students the tactile perception of objects akin to the physical realm, coupled with instantaneous feedback from instructors, thereby cultivating a genuine sense of presence in the virtual milieu. Virtual environments in VR platforms may either replicate authentic locations or manifest as entirely imaginary constructs, affording users unprecedented experiences such as navigating the nucleus of an atom or traversing the surface of celestial bodies—an experience transcending the confines of conventional physics.

Akin to the real world, users can engage with objects, move within the virtual environment, communicate with peers, generate objects, and participate in interactive activities and gaming experiences. This real-time interactivity, extending beyond conventional textbooks, facilitates the formulation of flexible and adaptive learning strategies that cater to diverse educational needs.

Critical to the efficacy of learning activities within VR environments is the establishment of activities that instill in students a profound perception of the virtual space as authentically real. The sensation of being an integral part of the VR environment is cultivated through the principles of immersion and presence. The interplay of these components is deemed pivotal in shaping the user's interaction within the VR landscape, prompting considerable investments by corporations, universities, and organizations cognizant of the significance of enhancing user interaction with content and media.

The integration of digital technologies, particularly VR, within educational frameworks is a discernible trend, with ongoing deliberations on their incorporation in Science, Technology, Engineering, and Mathematics education. STEM education, conceived with the aim of addressing deficiencies in students' performance in global assessments, is envisioned as a catalyst for nurturing scientific and technological acumen, aligning with the evolving demands of contemporary economies and labor markets. In this transformative process, STEM education is poised to equip students with critical reasoning skills, the ability to approach real-world problems from a scientific perspective, and the capacity to contribute to national development and industrialization.

In conclusion, the trajectory of VR technologies in education represents a paradigm shift, offering immersive and interactive experiences that transcend traditional pedagogical approaches. The integration of VR into STEM education underscores a concerted effort to bridge educational gaps and prepare students for a future characterized by higher-skilled,

knowledge-based industries. This shift is emblematic of the transformative potential of VR technologies in shaping the landscape of education and fostering innovation.

### B. Immersive Field Trips

This research delves into the realm of educational applications within virtual reality with a particular focus on immersive virtual field trips for elementary school students. The study investigates the potential of VR technology, specifically head-mounted displays, to enhance students' learning experiences, perceived presence, motivational beliefs, attitudes, and teacher-student interactions during virtual field trips. Traditional school field trips, while valuable for experiential learning, often face practical challenges, leading to a need for alternative approaches. Utilizing computer visualization techniques, virtual field trips offer advantages such as showcasing inaccessible areas, enhancing learning experiences, and aiding in understanding complex processes.

In recent years, the integration of virtual reality technology in education has garnered attention, particularly in the form of immersive virtual field trips. Traditional school field trips have long been recognized for their potential to enhance students' knowledge and motivation through real-world experiences. However, logistical challenges such as transportation complexities, time constraints, and administrative support issues can hinder the successful implementation of these trips. Virtual field trips present a viable alternative, addressing concerns related to distance, time, safety, and the complexity of field sites.

Immersive VR experiences, facilitated by head-mounted displays, provide a unique avenue for students to explore virtual environments with a heightened sense of presence. This study aims to delve into the pedagogical capabilities of immersive virtual field trips, shedding light on students' learning experiences, perceived presence, motivational beliefs, attitudes, and teacher-student interactions during these innovative educational activities.

The application of VR in education, specifically in the form of virtual field trips, has gained traction as an alternative to traditional experiential learning. Computer visualization techniques offer advantages such as showcasing inaccessible areas, broadening learning experiences, and aiding in the understanding of complex processes. While pedagogical explorations of virtual field trips have been conducted, the educational impact of immersive VR with HMD remains relatively unexplored, necessitating a closer examination.

VR technology, initiated in the 1960s, has evolved to provide realistic experiences that immerse users in virtual worlds. Two main types of VR—desktop-based and HMD-based—differ in display devices and control mechanisms. HMD-based VR, utilizing headsets with small displays in front of each eye and VR controllers, offers a more immersive experience than desktop-based systems. Despite potential challenges such as motion sickness, students express satisfaction with HMD-based VR learning.

The study aims to contribute to the existing literature by investigating the impact of immersive virtual field trips on students' learning experiences, perceived presence, motivational beliefs, attitudes, and teacher-student interactions. This research is particularly pertinent given the limited academic evidence regarding the educational influences of HMD-based VR in immersive virtual environments.

This preliminary study employs Cardboard headsets with the Google Expeditions app for immersive virtual field trips in elementary schools. The age-appropriateness of Cardboard ensures the feasibility of involving teachers in leading students through these experiences.

The research design encompasses a qualitative exploration of students' experiences, perceptions, and interactions during immersive virtual field trips. Through observations, interviews, and content analysis, the study aims to uncover behavioral patterns in teacher-student interactions and provide comprehensive insights into the potential educational benefits of immersive VR in elementary education.

This research initiates a comprehensive exploration of immersive virtual field trips in elementary education, utilizing HMD-based VR technology. The study seeks to uncover the impact of these virtual experiences on students' learning outcomes, perceived presence, motivational beliefs, attitudes, and teacher-student interactions. By delving into the pedagogical capabilities of immersive VR, this research contributes to the ongoing discourse on integrating technology into education, offering valuable insights for educators, researchers, and policymakers alike.

### C. Soft Skills development

While traditional educational tools can feel boring or artificial, immersive VR training creates highly memorable and impactful experiences without the potential risks of real-world impact. This video shows an example of a VR training simulation where employees interact with avatars to practice leadership and conflict resolution skills.

Not only is VR highly effective, these tools can also reduce the costs and logistical hurdles associated with traditional in-person training. Many employees already have access to mobile or desktop devices in their home offices, and VR programs are often more engaging and can be completed faster (and cheaper) than alternative programs.

VR Simulation for Customer Service Training First, VR simulation is a stress-free way to practice high-stakes conversations. For example, one of the companies we studied, H&R Block, is a global tax preparation company that hires 5,000 new call center agents each year, 1,600 of whom join during the busy second half of tax season. These entry-level employees are expected to field complex and emotional calls from a variety of (often angry) customers within their first few days on the job. To be successful in this role, these employees need interpersonal skills such as active listening, remaining calm under pressure, and the ability to summarize and solve problems.

VR Simulation to Improve Presentation Skills VR is also an effective tool to improve presentation skills. For example, Cognizant, a multinational technology and services provider, is experimenting with using VR simulation to train new employees to better articulate their value proposition when pitching to potential customers. These new hires are tasked with using different types of data to explain complex products and tell compelling stories. Otherwise, you risk losing important customers. To help these employees improve their presentation skills, Cognizant has developed a multi-level VR-driven training program. First, new hires complete an interactive digital course on data-driven storytelling. Next, practice your customer presentation using a VR avatar that plays the role of a customer. Finally, an AI engine based on Google NLP and Parallel Dots API analyzes the presentation's keywords, emotion, tone of voice, and body

language and translates this analysis into actionable feedback for users.

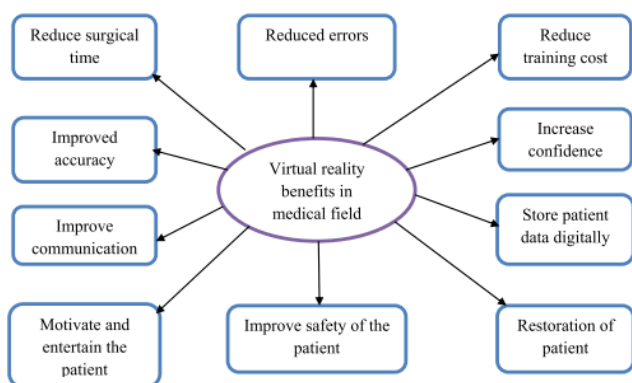
VR Simulation for Employee Assessment Finally, VR can help managers assess the current skill level of employees in various key competencies and allocate their training resources more effectively. For example, senior executives at HPE Financial Services (HPEFS) wanted to find a way to streamline the training of salespeople before they meet their most valuable high-value customers. They decided to test their VR solution with 340 salespeople. Each salesperson performed a 30-minute role play using an avatar designed to simulate an executive-level customer. These role plays were recorded, shared with the delegate's supervisor, and used to determine whether the employee should enroll in further training at basic, intermediate, or advanced levels.

#### D. Language Learning

Virtual reality (VR) is changing the way people around the world learn languages, providing unique, immersive, and interactive experiences. Additionally, VR overcomes common hurdles such as shyness or not having access to native speakers or tutors. In the past, learning a language required a large number of books, extensive writing practice, and a traditional classroom environment. Today, with advances in digital platforms and technology, that has fundamentally changed. Virtual Reality (VR) is a cutting-edge tool that completely revolutionizes language learning. Unlike traditional methods where learners receive information primarily passively, VR causes active participation. Mondly VR and Noun Town emerge as an innovative milestone in the evolution of language education, offering interactive lessons in 30 different languages with a focus on vocabulary development. Motivating learners by using visual translation techniques instead of memorizing words from textbooks replaces monotonous experiences with dynamic ones and improves foreign language skills. AI voice analysis technology is seamlessly integrated to improve your conversation skills with real-time corrections to ensure success in real-life scenarios with native speakers. The immersive nature of VR offers incredible advantages over traditional classroom learning. With realistic scenarios and interactive lessons at your disposal, you'll feel like you've been transported directly into the target language environment, such as a lively Spanish restaurant or stimulating conversations with villagers.

Building language skills through the VR language learning platform provides more room for interaction than traditional methods. You can interact with virtual characters, imitate real situations and improve his communication skills in the target language. These highly dynamic experiences offer a new approach to practicing conversational skills and nonverbal communication cues. Every action leads to an immediate reaction, strengthening your memory while learning new vocabulary.

#### E. Medical Field:



VR applications are used to accelerate the training process without fear or risk. It is used in the medical field for a wide range of diseases. This technology helps improve his performance in the medical field. Convenient and practical technology to improve resident and patient satisfaction. VR is an essential technology in the development process using customized advanced software and hardware. First, we define the specific goals of the treatment needed and gather background information. To create virtual 3D data, various hardware and software are used to create a virtual 3D environment. The virtual reality of the required medical data is created and identified using the best possible processes. This procedure is used to plan treatment and ultimately perform the actual surgery. Applications of this technology are psychotherapy, medical rehabilitation, medical research and education. This means students can perform safe and controlled operations with virtually no risk. Learning life-saving skills can be helpful in the event of an accident or emergency. VR also educates patients about a positive lifestyle with proper guidance on diet and exercise. 3D virtual reality is an important tool for practicing medical equipment. This technology is close to the actual procedure and helps in accurately measuring the patient's body. This provides behavioral insights such as changes in vital signs and various symptoms. Healthcare professionals can now easily interact with virtual patient organizations.

Doctors can now detect blockages in blood vessels in the brain. Many surgeons are now using virtual reality to perform dangerous surgical procedures. Helps create a safe, robust and productive environment and reduce errors in the operating room. This technology can also help reduce training costs for medical students and improve the working environment for doctors.

VR plays an important role in improving the performance of medical professionals. Applications of this technology are currently useful in the study of muscles, nerves, skin, bones, and blood vessels. Medical students can now easily record patient information and compare and analyze different diseases. This technique is also useful for training in knee arthroscopy and seems to be a useful tool for gaining a better experience. It is also used to analyze and evaluate a surgeon's skills.

This technique has widespread applications in the field of orthopedics, including fracture fixation, hip trauma, and preoperative planning. Used to analyze bone movement and correct placement of implants. An immersive application of this technology is understanding complex 3D body structures in a risk-free environment

#### F. Virtual Surgery

VR is used for virtual surgery, reducing time and risk. Enables remote surgery for surgeons in various locations. Helps measure and analyze the pressure required for surgery. A technique ideal for surgical simulation that provides clear images. Surgical Planning: Virtual 3D models help surgeons better plan their surgeries. Improve communication between healthcare professionals. Rephrase Create accurate images of patients during surgery. surgeons operate virtual glasses in her 3D environment. Diagnosis: A powerful tool for accurate diagnosis by doctors and medical professionals. Eliminates the need for CT/MRI scans. Rapidly detect signs and symptoms of disease. Gather patient information for proper diagnosis. Physical Therapy: VR is revolutionizing the way people exercise. Plays an important role in physical therapy and brings better results. Useful for treating burn victims and those with cognitive impairment. Education and Training: Helps minimize risk medical education and training. Improve students' understanding of age-related issues and illnesses. Introducing innovative teaching and learning methods for medical students. Treatment of Mental Illness: Modify

Exposure Therapy for Various Mental Illnesses. Provide cost-effective treatment with low risk to life. VR fosters social interaction with virtual characters and develops life skills. Useful in treating patients with psychological problems. Better treatment of limb pain: Create virtual limbs to analyze pain in your patient's body. Improve the movement experience when limbs are missing. Increases patient confidence in identifying and controlling the cause of pain. Provides an individualized approach to each patient. Learning Surgical Techniques: Using simulation technology to enable better interaction between medical professionals. Doctors can perform virtual surgeries to ensure successful surgery. Digital storage of patient data: Data is stored in digital format for future treatment. Helps reduce red tape and solve complex problems digitally. Used in the disease research and development process. Respiratory Problem Identification: Quickly identify and assist in treatment of respiratory problems in patients. Balances heart rate and blood pressure. 4,444 patients can view virtual exercises to address these issues. Improve the efficiency of psychotherapy: A great tool for improving the efficiency of psychotherapy. It has great potential to cure various mental illnesses. Helps with regular face-to-face interactions to change behavior and address issues. Reduces depression: Use of VR technology reduces depression in young people. Improving the quality of life for adults and children. Changing the hearts and brains of depressed patients. Tracking Body Movements: VR is a useful tool for tracking patient body movements. Provides interactive options for therapeutic exercises. Generates superior exposures that resemble real-world scenarios. Quickly analyze bone movement.

#### CONCLUSION

Research indicates virtual reality offers significant potential benefits for education, including increased student engagement, improved conceptual understanding, and enhanced training opportunities through simulated experiences. However, to leverage these benefits, VR needs to be thoughtfully incorporated into curriculum and instructional design based on learning objectives and student needs. More studies are needed to develop best practices for VR implementation and assess its impact on learning outcomes. While adoption challenges remain, VR promises to transform education by providing immersive, experiential learning at scale.

Current studies reveal virtual reality can increase motivation and enjoyment of learning when implemented appropriately. VR may be especially valuable for experiential learning in subjects involving spatial relationships, dangerous practice situations, or environments inaccessible in real life. However, technological limitations persist. Thoughtful integration with pedagogy and adequate teacher training is critical for its success. As VR capabilities grow and costs decrease, it could emerge as a powerful educational tool - but primarily alongside rather than replacing traditional classroom instruction.

Research on VR in education is still emerging, but indicates interactive 3D environments can enhance student engagement and conceptual understanding in many contexts. However, for VR to be effectively incorporated into curriculum, applications need to be designed based on learning theories and objectives. Educators require training to leverage VR optimally. While promising, VR should supplement rather than supplant conventional teaching until more definitive studies on its impact are conducted. As the technology evolves, VR has the potential to provide impactful immersive learning experiences.

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