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AI and VR Integration in E-Learning: Designing meaningful learning environments

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Abstract

The main idea of the educational process based on artificial intelligence and virtual reality forms a new, effective methodology of training. This article examines how AI facilitates VR environments and enriches them with immediate feedback, learner-generated learning paths and big data, resulting in personalizing the education requirements for a spectrum of learners. The literature review addresses the subject through different areas where AI and VR have been applied in a timely manner to learning and comprehension, as well in fields such as engineering, healthcare, and humanities. Also, the advantages of this integration, including enhanced activity, access to the material, and potential to get practical training, are outlined. But, it is imperative to also consider the implementation costs, technology enforcement issues, as well as the probable data privacy problems. Direction and opportunity are explored, along with such areas as further development of adaptive learning environments, more realistic VR settings, and challenges of data utilization in learning. Finally, this article underlines the valuable possibility of the AI and VR applying in the educational field and the necessity of overcoming the barriers to the educational standards.

Keywords: AI; VR; Teaching; Learning; Learning Environment; Personalised Learning; Adaptive Learning Systems

1. Introduction

Smart content is incorporated into learning with Artificial Intelligence and Virtual Reality into educational services, changing the face of traditional learning. On the one hand, AI, with many abilities, which include data analysis and individual learning, improves educational tools. On the other hand, VR creates a virtual three-dimensional environment that offers learners a situated practice in making things that let abstract concepts manifest and complicated events within the realm of the learner's reality.

As both of these technologies continue to develop, they are beneficial when adopted and combined to provide more than a consumption of information to create learning environments. AI can assess a learner's performance in real-time, provide explicit feedback on the learner's performance, and deliver content about the learner's performance level. At the same time, VR enables learners to act within a set of real-life scenarios, which means that learners practice working in scenarios that would be impossible within a physical classroom or entail a high risk of an accident.

By integrating AI into VR in education, this article aims to identify how using artificial intelligence will improve educational engagements to be more immersive and engaging. In this research, we seek to study the impact and potential of AI and VR separately and in combination to envision how they might change the future of learning. By providing a closer look into AI and VR, I discovered that the combination can improve the learning trajectory.

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2. Overview of AI and VR technologies

AI and VR are two innovative technologies that are revolutionizing most sectors based on education. Of course, each has its advantages, but in learning environments and teaching processes, AI combined with VR opens up incredible opportunities to develop human learning and interactions with content.

The principal application of AI in education is adaptive learning. It employs computation techniques to derive relevant data from the large volume of data created by learners, including their performance, their interaction, and their learning style feedback, to recommend and make the necessary changes. This makes learning flexible; students can advance in class at their rates, relying on their weaknesses. AI also drives natural language processing (NLP) systems, such as chitchatting and virtual tour tutors, that answer students' questions and offer timely assistance. Apart from customization, AI also has the potential to perform many practical assignments like grading and assessment, thus relieving faculty members from several other related chores.

Virtual Reality (VR), on the other hand, brings forth 3D arenas to the learners and allows learners to interact with virtual objects in the environment, perform real-life scenarios, and have a real-life experience learning. Unlike most 2D content, VR creates a sensation of being present in virtual reality in a way that other forms of media cannot provide. This is particularly beneficial for knowledge areas that involve demonstrations, such as technical training, nursing, engineering, fine arts, or other arts. Since VR 'creates' conditions that are unattainable, costly, or unsafe to attain in the real world, the 'practice' throughout the use of VR techniques facilitates real-world experience that is safe, repetitive/ revisionist, and comprehensive in outlook.

When incorporated, AI and VR make an educational platform most responsive to the users' needs. AI also has the ability, as a dynamic third party, to monitor learner behaviors in VR environments and make changes to ensure each learner receives their optimal experience. For example, in a virtual reality chemistry laboratory, AI can observe how children are conducting their experiments and modify the degree of challenge to correspond to this fact. The possibilities of how AI can be applied within customized VR learning environments are immense, creating opportunities for improved effectiveness, interactivity, and engagement within learning activities, all of which can be personalized according to learners' requirements.

Altogether, the synergic use of AI and VR is the new innovative approach to educational technology. In addition to positive gains in student engagement, incorporating these learning technologies in adaptive learning driven by artificial intelligence capabilities allows sophisticated, engaging, and effective simulation-based practice to master knowledge within academic subjects. Alone, the two have the potential to develop education that is more engaging, inclusive, and fit for purpose in a world that changes with the click of a button.

3. How AI improves VR learning

The amalgamation of AI with VR provides value learning environments that are more than stunning but engaging, developing, and intelligent for learners. Essentially, AI's primary competence is to analyze data, acquire experience from patterns, and react logically, and when implemented in VR, it enriches virtual learning in more ways.

Thus, in line with the expectations, the breakthrough of AI in VR learning environments is the development of learning paths. Traditional education tends to adopt the only method of. At the same time, teaching and implementing AI into schooling, each virtual reality learning environment can be tailored to fit the learner's needs. AI systems can observe the students' behavior as they deal with virtual representations of scenarios or even track their progress and control the levels of ease or amount of content to use in learning processes, as observed in the case of Apple Incorporation [19]. For instance, in a VR-based lesson in history, if AI notices that the student is familiar with some early events, it can lead the student to learn more complicated data. Still, if AI sees the learner has difficulties, it can explain more details and present additional options. This makes them work within their ZPD, which needs to be a zone that a learner finds challenging but manageable; this keeps them more alert and motivated.

Another way VR is complemented with AI is that the latter can offer quick and smart comments. In conventional learning, feedback is mostly pending and generic, while in an assisted VR learning environment, learner feedback is concurrent and contextual. For instance, when medical students have a simulation of surgery using VR, AI can measure the skill of their motions, the correctness of their choices, and general efficiency to guide, encourage, or advise. Such feedback also occurs in real-time, and it retrains the learner within a short span of the type of mistakes they make. It also encourages positive behaviors to enhance learning.

The last way that AI complements VR environments is the incorporation of virtual tutors, guides, and scripts. Such artificial intelligence-based agents can provide information to learners on their progression through various virtual environments or help learners by answering questions, providing hints for particularly challenging scenarios, or assisting them in completing difficult tasks. These virtual tutors are similarly based on natural language processing (NLP). They can puss with the learners and may also be programmed to modulate the response by the type of query the learner asks [11]. For instance, in a VR language learning application, AI tutors can converse with learners, pointing out mistakes or even suggest improvements to the learner's fluency. A higher level of interactivity also enhances vigorous learning because the students feel they are being taught one-on-one.

Furthermore, true AI can enhance difficult but solving situations in the integrated VR environment by constructing versatile models that react toward various inputs and activities. For example, in a VR-based engineering lab, AI can observe how the student solves a particular task and change parameters for design – materials, conditions, money – to make the difficulty level appealing for the learner, yet forcing them to think differently. Delivering new scenarios and creating new ones from learner inputs make handling AI much more engaging [7].

Besides designing effective environments that engage users and respond to them, AI also monitors students' achievements. In the case of using AI in the VR learning environment, every learner signal, decision made, and action performed can be monitored via data analytics. It is very useful regarding how effective the learner is in grasping the content, where they may be struggling, and what the learning process may look like overall. This information may be helpful to educators when seeking to improve their approaches to teaching or when in need of useful strategies for helping learners who perform poorly.

Table 1 Comparison of Traditional Learning vs. AI-VR Integrated Learning

Aspect	**Traditional Learning**	**AI-VR Integrated Learning**
Interactivity	Low (lectures, textbooks)	High (immersive, hands-on simulations)
Personalization	Limited (standard curriculum)	Highly personalized (AI-driven, adaptive)
Immersion	Minimal	Full immersion (3D environments, haptics)
Feedback	Delayed (teacher feedback)	Real-time feedback (AI-based)
Engagement	Variable (passive)	High (interactive, game-like experiences)
Access to Real-World Scenarios	Limited	Extensive (simulated environments, safe trials)
Cost	Moderate	High (initial hardware/software investment)

4. Applications of AI and VR in different learning fields

AI, along with VR, can penetrate all fields of learning since it provides effective training, interactive learning environments, and individual approaches. Using models that effectively mimic reality and giving individual learning tracks within exciting milieus, AI and VR are revolutionizing learning in fields as diverse as medical school and professional training.

AI and VR create unimaginably realistic and plausible medical and healthcare learning and training scenarios for hospitals and other healthcare facilities. For instance, medical students can make 'virtual surgeries' where they can use models to do their operations without the complications of using real patients. AI enriches these VR simulations in a way that furnishes the students with real-time feedback, directs the students through the procedures, and evaluates the results. In this way, learners can get immediate, detailed feedback on their techniques as to what they need to eliminate from their arsenal and what they need to improve on. Furthermore, AI-controlled virtual patients within a VR environment present the symptoms of a specific disease that depends on the learner's actions. This means that medical students can sharpen their diagnosis and handle many diseases without putting the lives of actual patients in danger [16]. Moreover, with VR environments, teachers can 'activate' certain specific or emergency conditions –such as trauma cases –which students rarely meet in practice.

In STEM education, integrating AI and VR makes concepts real, brings the classroom alive, and provides the users with real life and a controlled environment for learning. In subjects such as chemistry, measurement, physics, or even

engineering, students can practice using different lab equipment and sample materials in a virtual environment and see the effects in real time. AI improves these virtual labs because the virtual environment can modify assignments based on the learner's progress and provide them with detailed feedback on their work. For instance, in a virtual physics lab, a student can 'play' physics, manipulating virtual objects to explore physics concepts such as mass, acceleration, velocity, force, etc.. AI monitors the student's physics comprehension level and sets the challenge level. Likewise, in engineering education, AI-assisted VR learners can now design buildings applying physical constraints, analyze the stabilities of designed structures, and assess the effects of various materials applied; all these processes receive full support from an integrated AI system on a real-time basis. Some deliverables allow learners to touch on certain concepts, making understanding the complicated scientific ideas under study easier.

AI and VR, therefore, find applications in corporate training and professional development to improve skills, especially those related to leadership, communication, and customer relations. One of the significant uses is soft skills training, in which employees can rehearse interpersonal communication. Virtual characters act out realistic scenarios with or without clients, civil disputes, or Jones customer complaints. These characters act as real people to the learner so that in case of a change in the learner's behavior, they also change. This makes the role plays more appropriate to real life since they help develop good decision-making processes and communication skills. For example, during sales training, people can talk to a simulated customer with an AI response to the employee's tone, gestures, and reasoned speech [18]. This positive feedback loop enables employees to undergo practice and receive feedback from their peers and coaches before facing real-life challenges. Moreover, AI can monitor the employee's performance during these interactions to suggest the best ways to enhance that performance.

Other applications of AI and VR in corporate training are safety and risk. Job roles in construction, manufacturing, or any logistics industry come with hardship and are often risky. By utilizing AI-controlled virtual reality training, businesses can maintain highly risky work facilities without the risk of personal harm. For instance, in a safety training session of the VR module that focuses on the construction area, the employees may be required to roam around the area, performing certain activities and concentrating on the hazards around them. AI improves the experience by observing the learner and getting feedback. Also, the environment can change with various safety situations. These simulations help the workers understand how best to behave in case of an incident while at the same time reducing the chances of real-life accidents happening.

In humanities and language learning, AI and VR present an opportunity for the next generation of learning by engaging the students directly in cultural and linguistic contexts. In language education, VR can take learners to an environment where they can practice what they are learning in a live context, such as ordering food or traveling around a city. AI improves these experiences by providing language translation and notes for correct pronunciation and or/usage of grammar and other appropriate vocabulary. Also, virtual characters controlled by AI involve learners in a dialogue, and their further actions depend on the learner's level. This dynamic interaction raises language learning effectiveness to a new level, making it more realistic and applicable for students to practice in a similar environment. In history and humanities, it allows students to ‘re-live' historical events and conditions. For example, students can learn about different cultures from a historical period, visit historical places, or see an event happening live. Host AI characters can assist learners undergoing the different historical simulations within the simulations or by «fictional» characters that engage the learner and offer further context and input [12].

In summary, applications of AI and VR in the different learning fields reveal general transformative possibilities. In medical training, STEM fields, business, and the humanistic disciplines, artificial intelligence supplements and improves Virtual Reality for the learner by giving performance feedback, progression-based content delivery, and relative interactions. This leads to significant learning contexts and is productive for meaningful knowledge enhancement and skill acquisition. Integrating AI and VR in learning models helps construct practical assisting tools to facilitate learners' academic and career lives.

5. Benefits of AI and VR in learning

This use of AI and VR in learning is rich in gains that improve the learning landscape by making learning environments more interactive, student-centered, and impactful. This one is also among the major advantages; immersion reached by their combination is significantly higher. It is argued that VR makes learning engaging as learners are exposed to virtual OPEN environments where they can touch, manipulate, or even talk to objects or people [14]. This level makes the learner more focused and alert since the virtual environment looks like the real world. AI makes this immersion even more effective since it can change the context of the learning process in real time so that the flexible approach will work well for the learner. Implementing changes in the scenarios, giving feedback, and dictating what the learner has to do next all ensure that the learner remains active and consequently retains what they have been taught.

Another advantage is that such learning can be personalized. AI can process large volumes of data produced by learners in the context of education and can apply this information while learning. In a VR environment, such a development implies that AI can manage difficulty levels, change the types of tasks, or provide different instructional approaches based on abilities, areas of emergency, and learner preferences. It enables the learner to move forward at their own pace within and out-of-class activities so they are energized and energized. For instance, where a student is finding it difficult to grasp a given content in a virtual science lab, this can be highlighted with additional help or simpler words can be used to explain the same content, or on the other extremity, more difficult content can be provided for a relatively fast learner. This is a major advantage in generating better learning results since the learners are always challenged according to their capacity.

AI and VR also excelled at providing hands-on practice, and experiential learning is one of the major benefits. Systems, especially applications such as medicine, engineering, or science, are most easily explained and understood not through theoretical or conceptual frameworks. For instance, VR enables learners to practice in an environment that mimics reality and in the comfort of the classroom without using human patients. AI improves upon this practice through the ability to immediately give feedback on a learner's performance, suggest alterations, and change the simulated environment in response to the learner's decisions. For instance, if a student wants to practice surgery in a VR medical simulation environment, AI can assess the student's work, and if learning occurs, then correct the student and explain how to improve on a particular task. It engages the learners in instant performance feedback to enhance learning and skill development since they can practice hard skills without suffering the consequences of mistakes and errors when handling real-life situations [2]. In addition, repeated action and experiments in a virtual environment bring additional possibilities for mastering the material.

Lastly, the interest created by AI and VR enhanced learning and motivation, which helps make learning more fun and appealing. Organizing learning through AI-simulated virtual reality makes learning interactive rather than just receiving knowledge from the source; learners actively become involved in the process. With the help of AI and VR, learning is becoming more game-like/fun; students are motivated to learn and explore more content since they are intrinsically motivated. In addition, AI is adaptive, so the learner's skill level is constantly challenged but not overwhelmed in the 'flow' theory sense. This balance in kinds of practice thus leads to a positive attitude towards learning, including curiosity and sustained learning behavior.

Therefore, extending AI and VR in learning effectively delivers numerous benefits, including multiplication of the learning environment's details, education customization, practice sessions, exposure to real-life situations, and activity engagements. These technologies make the learning environment more comprehensive, stimulating, and sensitive to learners' needs, making education more effective and meaningful. In creating real, active concepts and turning them into tangible and adaptable forms, AI and VR assist students in learning inputs in various forms and fields.

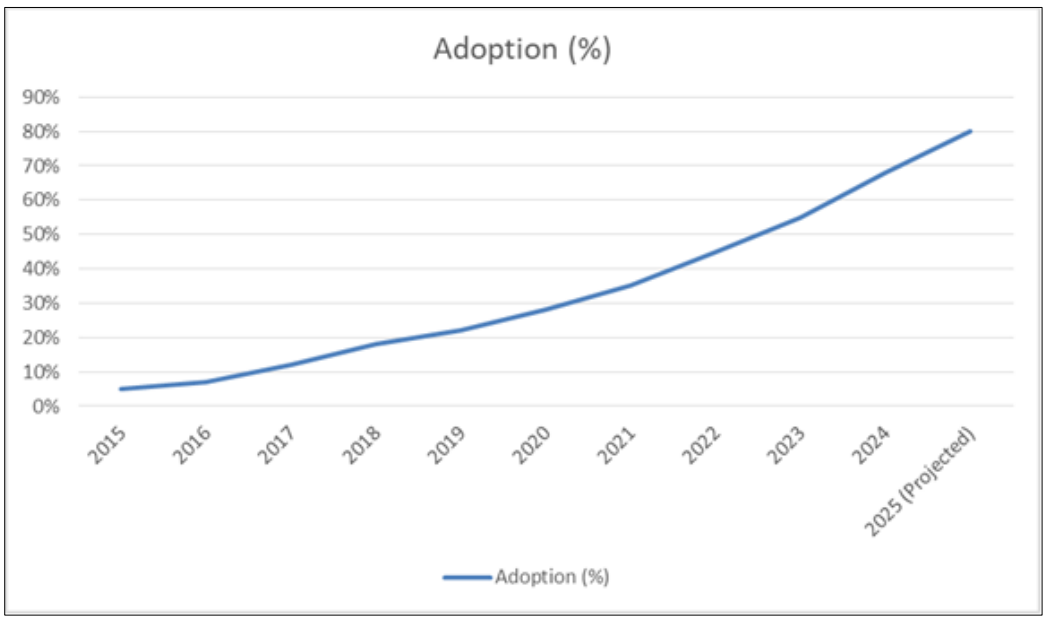

Figure 1 Growth of AI and VR Adoption in Education (2015-2025)

6. Challenges of AI and VR integration in learning

The combination of AI and VR for learning, as we showed, has some limitations that need to be addressed to enhance the efficiency of these technologies. The key restriction is an implementation issue, as the assessed approach requires much funding. Updating and sustaining AI-based VR systems entails significant capital investments in software and hardware. The equipment needed for VR, such as headsets, controllers, and other paraphernalia, is costly, even for a single headset and controller, when several entities, such as institutions or schools, wish to implement VR. Besides, developing high-quality VR environments and AI that suit the needs of the learner requires advanced programming, design, and data analysis, which are costly. This poses a problem for many educators, especially those in underprivileged areas, since their institutions must invest more capital to purchase and apply these technologies at scale.

The main weakness includes the technological support system of AI and VR applications and integration. These technologies require a lot of computing, fast internet, and advanced devices that simultaneously run complex VR applications and AI algorithms. Due to low internet connection, the use of old technologies, or a total lack of technologies, the complete utilization of AI and VR to enhance learning is a challenge in areas where learners have inadequate or outdated technologies [10]. This produces a digital or technological apartheid by which learners in technologically deprived areas may effectively be denied access to state-of-the-art tools of learning. Also, the requirement to constantly upgrade models and fix the hardware and fall-back software challenges institutions that need to be better endowed with information technology support.

There is the challenge of content development, where it is equally arduous to develop functional AI-driven VR content, and pedagogy and instructional design knowledge and skills are equally needed. These learning experiences must be designed meticulously to integrate the features of good learning experiences and embrace the objective of education and the required improvements in learning styles. It is essential to understand that interactions between educators and their counterparts in software development and design can take a long time and may be expensive. Moreover, generating topic-specific, area-oriented, intelligent, and immersive content can be time-consuming and require significant human effort. This may reduce the plethora and range of content authored and shared across and about contrasting subject matters and training settings.

One of the major challenges is also inherent in understanding the specifics of using artificial intelligence and virtual reality. Many of these tools may require long training for educators and learners before they can master them. However, educators, especially educators, need to understand how to incorporate AI and VR into the teaching-learning process, develop suitable activities, and analyze the data provided by AI systems. Technology plays a critical role in facilitating learning. For learners not conversant with technology, using VR and AI in learning can cause a focus shift from learning. The interest here lies in that, unlike the education content, a student can spend the first several minutes simply learning how to move around the VR environment or engage with AI-based systems, which could be distracting during the educational process [5].

Lastly, the danger of implementing these options is that they become overly automated. However, AI and VR have their advantages: The problem arises in that educators and institutions might rely heavily on AI, VR, and other similar technologies more than using muscles and brains to construct CBTs and relying heavily on what has been seen as effective in delivering educational content. The problem with over-reliance and usage of IT is that it erodes interaction and relationships between the trainee and the teacher, which is a very important factor in the learning process. Geared-up tutors or virtual navigators lack the human touch, emotional intelligence, and ability to penetrate the student and motivate or console them appropriately as an intelligent tutor can. Hence, working with AI and VR as supplements in the learning platforms and only partially replacing teachers will be safe.

Consequently, despite the amazing possibilities of implementing AI and VR in learning, both methods are introduced being faced with several crucial and not-straightforward-to-solve challenges of high costs, infrastructure constraints, content creation issues, need for higher readiness, data privacy, accessibility, potential overdependency on technology. Solving these issues will take significant efforts, funding, and multiparty cooperation among teachers, technology developers, and the government to make the promises of AI and VR possible in various learning settings.

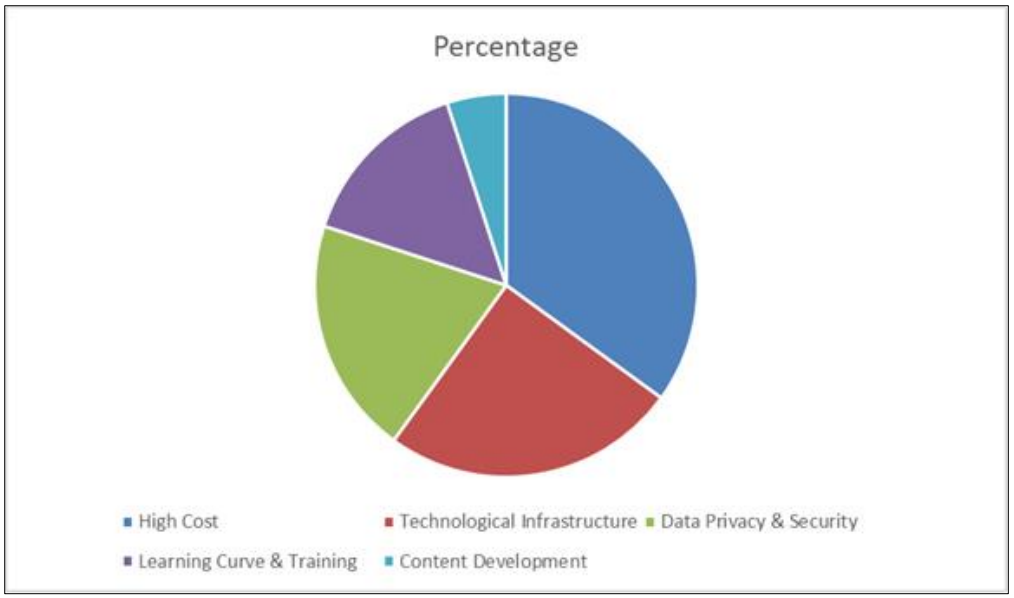

Figure 2 Challenges in AI and VR Integration

7. Future trends and possibilities

The future of impersonal intelligent systems and virtual reality in learning has a higher prospect as trends and developments have further improved the learning environment. The most emerging trend identified is enhancing the artificial intelligence adaptive learning system. With advancing technology, even more complex algorithms can be developed that can adapt to the data obtained from learners and provide learning solutions within moments. It will be possible to have these systems that will be capable of following learner progress, forecasting learning effectiveness, determining knowledge and learning content gaps and adapting content in reaction to these elements to enhance learning routes. This will result in greater student satisfaction because each who needs help will be directed to the best help that suits their best learning style.

Another development in the future is the trend of AI & VR to be adopted together with other advanced technologies such as AR and IoT. AR, which superimposes information on objects in real life, can work in conjunction with VR by providing an environment in which learners may handle both physical and virtual objects. The IoT can also be integrated into learning environments to make smart classrooms, to which artificial intelligence can also take into account not only the interactions of learners through electronic devices but also their physical actions and inactions, including sitting, turning the head, and so on to have a better picture of the learners' engagement and outcome. Such hybrid systems can effectively combine digital and physical learning, enriching the learning process even more.

Other trends include integrated and social learning in a virtual setting, as seen in the LMS and virtual learning environments. By incorporating AI into VR platforms, education will promote more social kinds of learning, in which students get involved with others from different parts of the globe in virtual classrooms or engage in problem-solving exercises in common VR environments. Self-controlled avatars and virtual agents will improve these interactions through their role as moderators, helping users and moderating the debates. Social learning and immersive environments actively enhance student engagement, foster collaboration, and let students embrace the worldview [4].

One of the other two future trends is the integration of AI and VR into lifelong learning and workforce training. Increased demand for upskilling or reskilling due to the dynamism in the job market; hence, AI and VR will be useful in professional training. I anticipate that shortly, organizations will have AI-aided VR training programs targeted at the needs of diverse sectors, which provide feedback and act as virtual practice places for hands-on training. Such programs will enable workers to rehearse complex actions in simulated settings and learn from experts' feedback once they commit a mistake or complete an activity. It will also be very useful, especially in the health sector, manufacturing, and technological fields, where the organization is expected to learn and change constantly.

The application of AI in generating content necessary for constructing VR environments is yet another unexplored avenue. In the future, AI could dynamically create individual and learning goal-typed VR content while considering the learner profile and performance records. This would dramatically cut down the time and energy spent on generating

massive amounts of material in education, thus making it possible to offer the right content on learning preferences. Another implication of using a generated virtual environment is flexibility in terms of updating or refreshing the content presented to those to be taught to share button or the 'skip button' could automatically take the user/learner to the right section without delay, in line with the most frequently used or most updated content Depending on the application of the virtual environment, content in such an environment could be updated in real-time only to present the relevant information or change the display as frequently.

The future may also provide the power for adaptive and continued advancement in bringing new, improved, and more affordable types of AI or VR. As VR hardware costs continue to drop and AI algorithms become even more refined, these technologies will reach out to even more schools, colleges, universities, and training establishments, including those not readily located in technologically advanced regions. AI and Virtual Reality technologies may be released as open platforms, narrowing the gap for educators to develop their pilot avatars of the 3D learning environment at a significantly reduced cost. Further, by enabling cloud computing and 5G advances, it will be fine for institutions to introduce AI and VR in large-scale scenarios and obtain quick and stable access to the technologies, especially in countries/regions with relatively underdeveloped information technology.

Altogether, the perspective of applying AI and VR in the learning process will expand the opportunities for providing even further more engaging, personalized, and interactive experiences. The rather effective approaches of adaptive learning, mixed reality, collaborative virtual environments, workforce training, ethical issues, content created by AI, and improved accessibility are some of the trends and opportunities of the next-generation learning technology. These technologies shall continue to develop while making learning environments for students at all learning levels and disabilities more interactive, efficient, and productive.

8. Conclusion

Using AI and VR in learning is a new paradigm shift in understanding that provides unthought-out social, interactive, and individualized learning experiences. Thus, thanks to the adaptability of AI integrated with the interactive environment of VR, educators will be able to design knowledge spaces that are maximally interesting for learners, individualized, with capabilities to provide feedback, conduct simulations, and recommend individual learning pathways. These technologies create new opportunities for practical activities based on elaborated learning tasks to solve non-trivial problems in safe conditions while providing individual feedback depending on the results achieved by students.

AI and VR are not only improving previously traditional areas of learning such as medicine, engineering, and the sciences. Still, they are also transforming professional development, organizational training, and the liberal arts. In the same way, virtual surgeries, experimental laboratories, language practice, soft skill training, and even risky-for-life simulations are achieved by using AI to assist in a VR environment that might be too costly or dangerous. Not only does this enhance their learning of the subject content, but it also challenges them with realistic, real-life scenarios.

However, it is also important to view the challenges that are still present even after such points seem clear. Some of the challenges that the adoption of mobile learning faces include high costs, the need for infrastructure development, and content development, which may be complicated, among other technical issues regarding data ownership and sharing. It is therefore important to ensure that these technologies reach the various learners regardless of their history, geographic location, or economic background to avoid the development of a digital divide in learning. However, educators must find how to make AI and VR complementary tools to learning and teach the students the usefulness of the technologies and the value of being understood, cared for, and guided by a human being.

The future of AI and VR in education has great prospects and promises to change how students study. That is why, with the development of technologies, we will witness deeper and more improved adaptive learning systems, better VR settings, and increased frequency of AI content. Besides, the use of AI and VR in other developing technologies like AR and IoT will cause the development of new learning experiences that combine virtual and physical environments seamlessly. The advancements mentioned above will increase interest and ensure real growth in the effectiveness of educational processes needed by students.

Therefore, applying AI and VR in learning, though still under development, has a future that may redefine the effectiveness of learning. Since these technologies are in the development process, the follow-up tendencies of their application contribute to creating a more vivid, open, and individualized learning environment, which will define the educational process in the future.

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