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PAPER

Personalization of E-Learning: Future Trends, Opportunities, and Challenges

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ABSTRACT

Electronic learning (e-learning) has become one of the most influential trends in providing enhanced and easily accessible learning to users. However, in contrast to traditional e-learning systems that offer uniform content to all learners, personalized learning systems tailor educational materials and assessments to individual learners, ensuring a customized learning experience. Personalizing e-learning through artificial intelligence (AI) is beneficial in today's diverse environment, where beginners can tailor the learning experience to suit their preferences and requirements. This paper focuses on the personalization of e-learning, exploring future trends, opportunities, and challenges through an in-depth survey of recent literature on the personalization of e-learning technologies such as extended reality (XR), virtual reality (VR), augmented reality (AR), and mixed reality (MR). Findings identify and propose that such tools should be included in curricula that support e-learning through personalized, adaptive, and delivery models.

KEYWORDS

personalization, electronic learning (e-learning), Internet of Things (IoT), artificial intelligence (AI)

1 INTRODUCTION

Nowadays, the digitization of teaching and learning has become an integral part of the educational system [1]. The emergence of electronic learning (e-learning), with the introduction of information and communication technologies (ICTs) in the mid-1990s, has been influenced by technological advancements in education and a growing focus on creating asynchronous learning environments [2]. Therefore, the term "e-learning" has been associated with a form of education delivered exclusively through online means, with technology serving as the essential medium for facilitating the learning process. Over time, the pedagogical strategies and technological components of e-learning have undergone continuous development to enhance, support, and promote effective learning [3]. The development of e-learning has shifted

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from a teacher-centered to a learner-centered approach, where the student is more independent and responsible for their learning progress and outcomes [2]. The COVID-19 pandemic has significantly boosted e-learning models and completely transformed traditional classroom teaching approaches. This sudden shift in the learning environment has accelerated efforts to revisit existing tools and explore new trends in e-learning systems [4]. Despite its growing popularity and the significant potential for offering cost-effective and non-disruptive solutions, e-learning has faced numerous challenges on both the pedagogical and technical fronts.

Eventually, the prevalence and expansion of utilizing e-learning approaches have raised concerns and questions regarding the quality of technology, learning design, and affordances to support asynchronous learning [5]. The occurrence of these challenges has been identified in traditional e-learning services. Many researchers [6–9] have identified these challenges and suggested providing smart e-learning systems and platforms to address the growing demand for data-intensive applications and services. However, there are still a few unanswered questions that need exploration, such as why these intelligent systems (e.g., virtual reality (VR), augmented reality (AR), mixed reality (MR), etc.) are essential for e-learning and how they can enhance the e-learning experience through a personalization process.

Furthermore, the current study highlights the significance of personalized e-learning and the opportunities and advantages it offers over traditional e-learning approaches, such as one-size-fits-all or generic content delivery. While traditional e-learning can be effective in certain situations, personalized e-learning takes education and training to a higher level by tailoring the learning experience to individual learners. Therefore, in the rapidly evolving landscape of education, personalized e-learning experiences have become essential for meeting the diverse needs of learners. Tailoring the educational journey to individual preferences, abilities, and learning styles enhances engagement and significantly boosts learning outcomes. To achieve this level of personalization, the integration of the latest technologies is crucial [8]. This study explores how the latest technologies empower educators to create personalized e-learning experiences that cater to individual strengths and weaknesses, resulting in a more effective and engaging learning journey.

The present study discusses the possibilities offered by the latest technologies such as extended reality (XR), VR, AR, MR, the Internet of Things (IoT), and 5G when applied to an e-learning environment. Among these, MR, VR, and AR are observed as the life-changing technologies of the twentieth century [9, 10]. They combined software and hardware solutions, paving the way for creating three-dimensional (3D) virtual objects and worlds. This innovative technology significantly impacts educational environments and is helpful in various learning styles and pedagogical approaches [10]. By stimulating the human senses with computer-generated images, it can manipulate minds momentarily, leading them to temporarily perceive MR as an alternative version of reality and replace the physical environment with computer-generated visuals. AR is an innovation that overlays computer-generated virtual imagery on physical objects in real-time. It differs from VR, where the user is completely immersed in a virtual environment [11]. These techniques are utilized to create impactful 3D visual experiences for diverse educational and learning objectives.

Moreover, such technologies support impaired students in accessing education through appropriate visual, auditory, and tactile interfaces. MR offers immersive experiences, but the setup necessitates an expensive arrangement of high-quality 360° videos, two-way interactions with zero latency and sufficient bandwidth, precise localization, and user orientation [10, 11]. XR refers to the combination of virtual and real situations, as well as human-machine interactions facilitated by computer technology. These experiences could be implemented with the help of 5G, thereby enabling various innovative e-learning scenarios. Due to 5G technology, communication between machines and between machines and people is more efficient and organized. This, in turn, provides improved connectivity and increased capacity to accommodate the demands of modern technologies [12].

Similarly, IoT in e-learning can be implemented by using smart boards and individual tablets instead of the traditional blackboard and writing desks [13]. The proposed new entities can store their content in the cloud and be accessible to a broad range of users at any time. Furthermore, this e-learning environment can be established as a cohesive unit by creating a closed-loop system where teachers and learners are interconnected via the Internet and each student's progress is readily accessible to the teacher and other relevant authorities. The use of mobile-based applications can also enhance the learning experience by incorporating a visualization to help understand the outlined concepts [4, 9]. Due to the ubiquitous nature of IoT, we can discuss anything at any time. In the case of e-learning, unlike the conventional classroom where physical space is required to conduct a class, no such space is needed for e-learning platforms. This creates a class that is open to anyone at any time based on individual availability [14]. Also, through this facility, individuals from industry, research, and development organizations can participate in the same class and contribute their valuable feedback during ongoing sessions [14]. Due to their diverse and innovative nature, IoT and the latest technologies are crucial for advancing the e-learning experience in education, particularly through personalized learning environments.

The present study has significant implications for the scope of e-learning, addressing the shift from traditional, uniform instructional methods to AI-embedded personalized e-learning experiences through emerging technologies such as mixed, augmented, extended, and virtual realities. Moreover, this study comprehensively analyzed the integration of these technologies, aided by the IoT, to offer a transformative approach to the education system. Therefore, educators and learners benefit from personalized, tailored, and customized experiences, as well as support and insights for curriculum development, user privacy and data protection, and advocacy for the incorporation of adaptive delivery models. This paper is significant because it addresses three critical questions directly. Key factors in promoting personalized e-learning. Future implications of personalized e-learning. Opportunities and challenges in adopting personalized e-learning in education systems. Authors seek answers to these questions through an extensive and in-depth analysis of the published literature. In this way, the present study contributes to the ongoing discourse on enhancing individual and collective e-learning experiences through technological advancements to shape the future of education.

2 LITERATURE REVIEW

2.1 Future trends defining personalized e-learning

Electronic learning through AR, MR, VR, and XR, including 5G and IoT, represents the future of education [15]. These emerging technologies have the potential to significantly expand the range of learning options, offering learners real-time, hands-on experiences that go beyond traditional boundaries. However, these technologies enhance engagement and offer a personalized and interactive learning environment that caters to diverse learning styles. Integrating 5G and IoT further enhances connectivity, ensuring smooth and responsive interactions within the e-learning ecosystem. As learners embrace these cutting-edge advancements, the future of personalized e-learning promises to be a dynamic fusion of innovation and accessibility, empowering learners to navigate educational landscapes with unprecedented flexibility and depth.

2.2 Augmented reality for e-learning

Augmented reality can be used to develop contemporary comprehension by combining intuition with virtual objects that animate information [15]. By introducing AR in education, instructors can provide students with a more attentive, engaging, and interactive learning environment. The integration of AR in education through apps and textbooks enhances student-centered learning by superimposing digital information onto the physical environment [15]. In AR learning, students are immersed in educational content such as recordings, audio, or simulations. This enables them to visualize educational content within their surrounding space and engage with it by moving around and changing their perspective [10, 16]. AR supports these shared instincts that reduce the cognitive load for students. The level of information and skills needed by the user to access such content through natural interactions is minimal, resulting in a more transparent technological interface between the student and educational content.

2.3 Virtual reality for e-learning

Virtual reality technology compensates for the shortcomings of e-learning by simulating exploratory tools and providing a virtual environment for students [17]. Students can interact with the virtual environment using input devices such as a mouse, keyboard, etc. Instructors can create virtual objects through VR technology to provide an exciting and engaging learning experience for students. Three strategies for education can be specified: full-time education, part-time education (part at school, part virtual, or at a separate location), and virtual education. Full-time education is the standard and most commonly utilized approach in traditional courses at all levels, necessitating the presence of both instructors and students in the classroom. The second strategy combines education within the classroom, while the last strategy, separate education, utilizes modern innovation [16, 18]. Distance education may require direct interactions as instructors and students are physically separated in space or time, but they can still connect through communication technologies [8].

Moreover, the VR designed specifically falls into three categories. The first contains networked text-based virtual situations, which are profoundly communicative but not immersive. The moment involves desktop VR simulations, where communication is mostly limited but varies based on the program's settings, and immersion also varies but is not easily achieved. The third category involves immersive VR environments where engagement is high, but communication may be limited depending on the complexities of the virtual world [17].

2.4 Mixed reality for e-learning

Mixed reality, or hybrid reality, combines real-world and virtual content to create engaging interactive experiences [19]. It proposes immersive information that requires students to wear a head-mounted display (HMD) and a motion controller, through which they can interact with an environment created by a combination of the virtual and real worlds. Students can touch and handle objects, leading to a deeper understanding. They can also engage with data sets, complex formulas, and theoretical concepts, which may be more difficult to grasp solely through verbal instruction from a teacher [19]. Therefore, MR offers a more engaging, energizing, and effective learning experience compared to traditional learning strategies because hands-on learning is more accessible than passive listening.

Mixed reality has the potential to revolutionize the realm of e-learning in the near future [2]. As technological advancements persist, mixed reality is gradually becoming more accessible and cost-effective, making it an increasingly feasible choice for educational institutions. In the near future, mixed reality can be utilized to create personalized learning experiences, realistic simulations of real-life situations, virtual field trips, interactive course materials, and facilitate distance learning [10, 19]. By implementing data analytics and machine learning algorithms, mixed reality systems can adjust according to each student's progress, providing tailored feedback and assistance. This would result in a more captivating, interactive, and efficient learning experience, and ultimately assisting students in understanding intricate concepts more deeply [20].

2.5 Extended reality for e-learning

Extended reality includes the entire spectrum from "the complete real" to "the total virtual" within the concept of reality-essential, a continuum as described by Paul Milgram [21]. Its meaning lies within the expansion of human capabilities, especially connecting to the faculties of existence (represented by VR) and the securing of cognition (represented by AR) [22, 23]. Figure 1 illustrates the generalized view of XR as a combination of VR, AR, and MR. It may also include near-future technologies within its scope. This reality encompasses the entire spectrum of physical and virtual worlds.

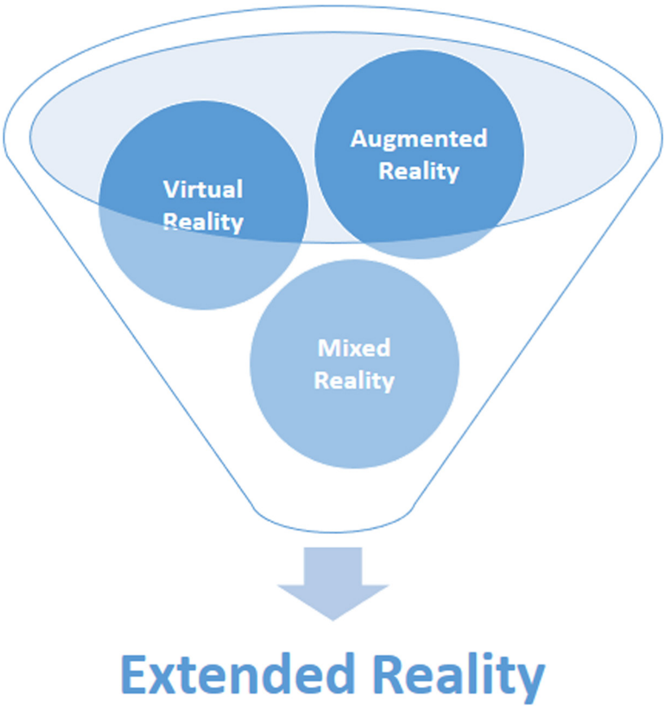

Fig. 1. Emergence of extended reality from other realities

3 METHODOLOGY

For this study, a qualitative methodology has been adopted to find answers to the research question through an in-depth analysis of the published literature. The literature published between 2018 and 2023 has been collected from major databases, including Scopus, Google Scholar, and ScienceDirect. Only studies that contributed to the development, implementation, and analysis of e-learning personalization were included. Moreover, the transformational process and the differences between personalized e-learning and conventional e-learning were discussed and evaluated in current studies. This study offers a comprehensive review of personalized e-learning models, tools, and their analysis from various stakeholders' perspectives. The aim is to enhance access to personalize e-learning for implementation in educational systems. This study will serve as a comprehensive and valid document to support future research in this field.

4 FIFTH-GENERATION (5G) TECHNOLOGY IN E-LEARNING

In the future, the modern-generation technology of wireless mobile communication known as 5G will change our lives. It presents significant developments in present-day networking technologies, offering greater bandwidth, more stable connectivity, and very low latencies. Students face various challenges and constraints when setting up interactive educational sessions, but the availability of 5G technology provides significant opportunities for the next generation [24]. The 5G documentation was accepted in the middle of 2018. The trials of 5G technology will outline the services offered to 5G users. 5G technology provides and supports more applications, such as the IoT and device-to-device communication. It will also be able to fulfill the requirements of AR and VR applications and provide up to 10 Mbps of data rate. Multi-RAT (multi-radio access technology) is a fascinating feature of 5G. Moreover, it can collaborate with various technologies such as Wi-Fi, Bluetooth, and 4G cellular telephony [4, 24].

E-learning education would be very beneficial for delivering courses online [7]. Moreover, 5G features offer numerous advanced educational benefits with low latency and high bandwidth requirements [25]. In other fields of education, AR/VR applications can be developed. AR would provide information in the fields of history and archaeology, for example, in museums, where students can use their devices to view a statue resembling an alleged sculptor. An ancient Roman tomb, reconstructed in 3D tunnels using VR technology, cannot be visited by unauthorized AR can provide images showing various variations of the same species and offer comprehensive plant classifications in the field of botany. Applications of AR/VR need 100 Mbps to a little Gbps of bitrate and latency under 5 ms with an accuracy of 99%; furthermore, 5G would reasonably support the requirements of AR/VR. 5G performance may provide ease in advanced e-learning education with the support of AR and VR [25].

4.1 IoT for personalized e-learning

The IoT is a vast network of interconnected appliances that can remotely gather and share information with each other over a secure channel [26]. It implants actuators and sensors to collect information, which can be shared with the assistance of various other devices. IoT is associated with a whitepaper that includes a significant assessment of connecting intelligently designed networks, enabling all other network connections to be linked.

E-learning, a digitally facilitated instructional approach primarily dependent on Internet technologies, is a pivotal catalyst in the modern educational landscape [2, 7]. It optimizes the learning experience, offering increased efficacy for students and educators. Traditionally encompassing virtual classrooms, video lectures, animations, online tutorials, and study materials, e-learning has emerged as a focal point in contemporary educational discourse [9]. The advent of the IoT introduces a transformative dimension to educational methodologies. This nuanced exploration critically examines the potential impacts of IoT on the educational milieu, systematically unraveling key facets that illuminate how the integration of IoT can dynamically reshape and elevate the educational environment [13].

There are certain IoT devices available on the market that can have a significant impact on e-learning, including:

i) Smartboards enable learners and teachers to interact with screens using digital highlighters, converting text into audio, which facilitates a quick and easy learning experience.
ii) RFID chips can track various physical objects, including plants and animals, collecting information that can be stored in the cloud. Later, researchers can analyze this information to draw meaningful conclusions, providing valuable support for their investigation.
iii) QR codes used on various mobile devices can be linked to any online document. By scanning the code with a mobile camera, students can easily access the specific document.
iv) IoT gadgets are the pathway to innovation. Students utilize this remarkable opportunity to comprehend, manage, and construct such frameworks. With the rise of cloud-based innovations, data mining, and big data analytics, the future of IoT seems promising, along with the applications it will enable.

In this way, the abovementioned represent a potential benefit of IoT outcomes in e-learning; advancements combined with creativity imagination are the limitations [9, 13].

5 OPPORTUNITIES

This built-in personalized e-learning environment presents both opportunities and obstacles. If users embrace the suggested protocols, the resulting pedagogy will be intelligent, interactive, enhanced, and adaptive. Further, specific challenges need to be addressed: acceptance by societies, cost-effectiveness, understanding general usage, and network competence to provide sufficient bandwidth, which can be achieved by utilizing fifth-generation mobile network technology. Privacy and security issues will also be significantly affected [15]. In the future, education will typically depend on e-learning and will be a substitute for the traditional teaching method in the form of AR, VR, MR, and extended reality. For example, following Table 1 provides comprehensive details on how VR can benefit future education.

Table 1. The focus on extended reality (XR) and its benefits in education

Focus of XR	Benefits
Global Teleportation	It breaks down geographical limitations. This could be priceless for a school because it implies that students can visit places beyond their means within the real world.
Remote Presence	VR helps students connect with other students and join lectures and lessons given by teachers worldwide. Multi-user, social VR stages like Engage, AltSpace, and more will end up flourishing Centre points for educational content as the complete concept of what a school is and can start to transform into something genuinely modern.
Focused Immersion	VR being surrounded by a headset means that the learners can focus on learning and encounter fewer distractions.
Contextualized Learning	It permits students to see what cannot be seen within the real world (objects of smaller scale and large scale, objects of the past and the future).
Multi-Sensory Experiences	Being able to move inside a virtual environment and be involved with components, handle different objects, and involve learners like never before.
Extraordinary Abilities	It allows students to do what they cannot do in the real world, like breaking the laws of physics.
Empathy Agent	VR can be used to raise self-respect, remind empathy, and influence emotions.
Virtual Rehearsal	Using VR technology, the students can practice skills without fear of failure, like practising public speaking, etc.

Moreover, e-learning provides the opportunity for education, which can be very helpful for students in the educational model, offering location and time independence [23, 27]. Utilizing AR/VR technology, learners can engage in visualization and hands-on practice in technical and medical fields.

5.1 Identify e-learning costs

E-learning is more cost-effective than classroom-based learning because it does not require students to travel daily to the same place or invest in specific hardware, software, and learning materials for each module of their courses [1, 4]. Instead, learners can log into a portal from anywhere, thus naturally reducing travel costs. As modules can be viewed on the screen, it also reduces the time individuals need to spend on reading material [28, 29].

By utilizing technologies such as AR, VR, MR, and XR, students can engage in practical work to enhance their skills with various expensive tools or machines (See Table 1). This approach not only enhances students' skills but also proves to be cost-effective for educational institutions. Colleges seeking guidelines on e-learning costs or comparative information from other institutions should proceed with caution and consider that e-learning costs may vary based on institutional goals and methodologies [15, 30]. According to the studies [29, 30], these savings are attributed to a significant reduction in the time required to develop new features and increased learner engagement resulting from the adaptability of a platform that customizes itself to the learner's style or professional role. Figure 2 is adapted from Huynh et al.'s proposed cost-effective curve model. They argue that e-learning is more cost-effective than other models, such as traditional classroom learning [29].

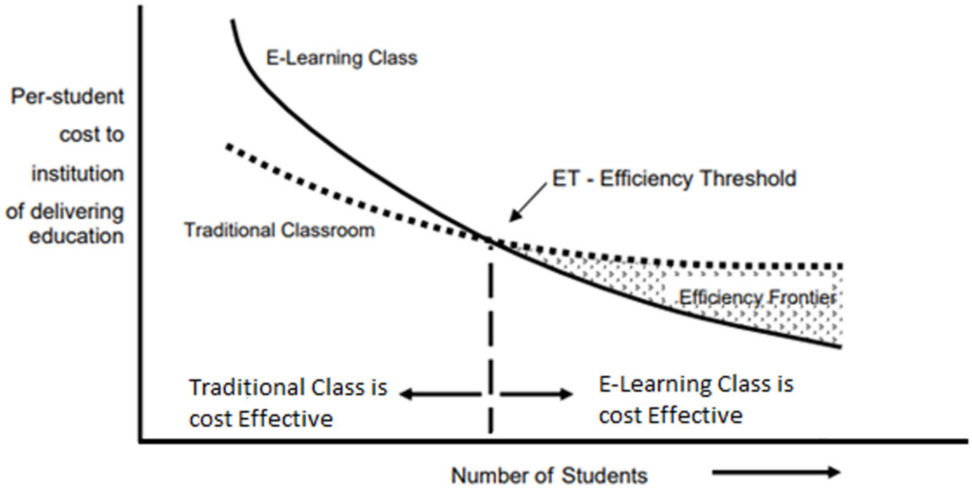

Fig. 2. Single class – e-learning and traditional classroom assumptions on the cost curves – single class [29]

5.2 Cryptography

This method involves protecting information using codes to ensure that only authorized individuals can access it [13, 31]. Encryption and decryption techniques are used to convert data to ensure its confidentiality and integrity [31]. Figure 3 illustrates the encryption process, whereby plaintext, which refers to legible and non-encrypted data, is transformed into ciphertext, which is non-readable and encrypted, through a secret key or algorithm. The decryption process involves reversing encryption, wherein cipher text is converted back into plaintext using either the same or a different key or algorithm [31].

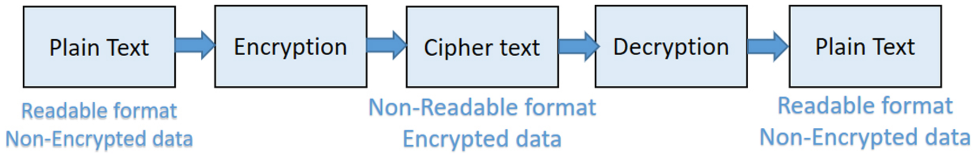

Fig. 3. Block diagram of cryptography

5.3 Distributed firewall solution

A firewall functions as a protective system by enforcing specific security rules to control access between two networks, safeguarding the internal network from external threats [32]. It can exist as a software program operating on a secure host computer. In any scenario, it is necessary to have a minimum of two network interfaces—one for the network it aims to safeguard and another for the external network it is exposed to. This dual-network functionality ensures comprehensive security measures for internal and external network interactions [31]. Figure 4 illustrates the firewall system, which blocks or allows traffic based on predefined rules. It also monitors and controls the incoming and outgoing traffic between an untrusted network and a trusted network.

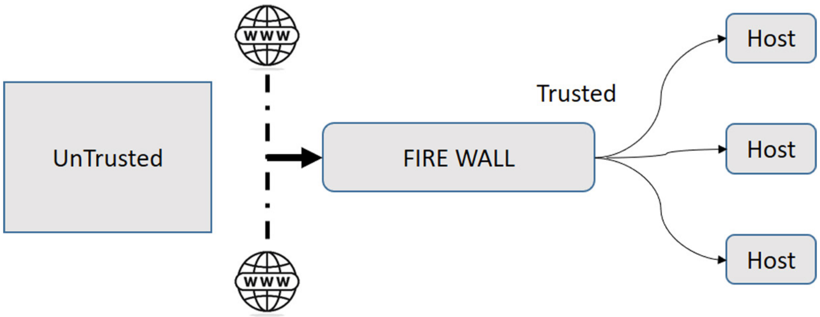

Fig. 4. Block diagram of distributed firewall

5.4 Biometric authentication

Passwords can be misused for assignment submissions or exams, whereas biometric authentication would provide more security for students [33].

5.5 Digital watermarking

Digital watermarking embeds a message related to a digital signal (such as pictures, documents, etc.) within the signal itself. It may be a concept closely related to steganography in that both conceal a message within a computerized signal [34, 35].

6 CHALLENGES

The challenges inherent in the realm of personalized e-learning, as depicted in Figures 5 and 6, particularly within the framework of advanced technologies such as AR, VR, MR, and XR, demand a rigorous examination in the context of academic research. Several intricate challenges are discernible, requiring in-depth analysis and resolution. Developing and deploying a personalized content delivery system poses many complex challenges within the e-learning domain.

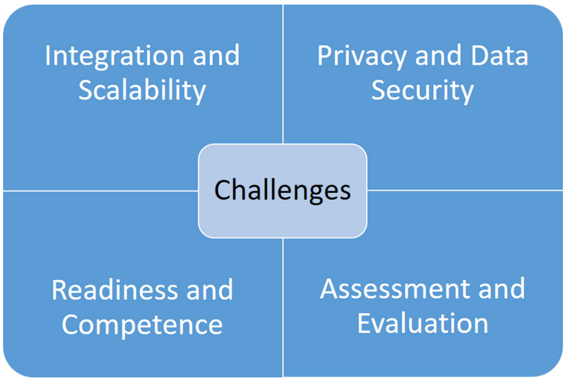

Fig. 5. Future challenges in the field of e-learning domain

A fundamental requirement for the effective functioning of such a system is to establish a coherent and capable mechanism that can ensure the continuous evaluation of learners while precisely determining their level of comprehension [27, 32]. This necessitates a sophisticated approach to adapting the educational content to each individual's needs. In this context, integrating advanced computational techniques, specifically machine learning (ML) and deep learning (DL) models, emerges as a promising avenue to address these challenges. By leveraging ML and DL algorithms, the system can potentially assess learners' cognitive and educational progress and discern their unique aptitudes. This, in turn, allows for the seamless adaptation of content to match the appropriate cognitive level and learning pace of each student, thereby enhancing the overall effectiveness of the personalized content delivery system [35, 36].

6.1 Integration and scalability

First and foremost, the integration and scalability of immersive technologies pose significant challenges. Deploying AR, VR, MR, and XR tools within educational environments requires significant investments in hardware and software infrastructure. There are various challenges.

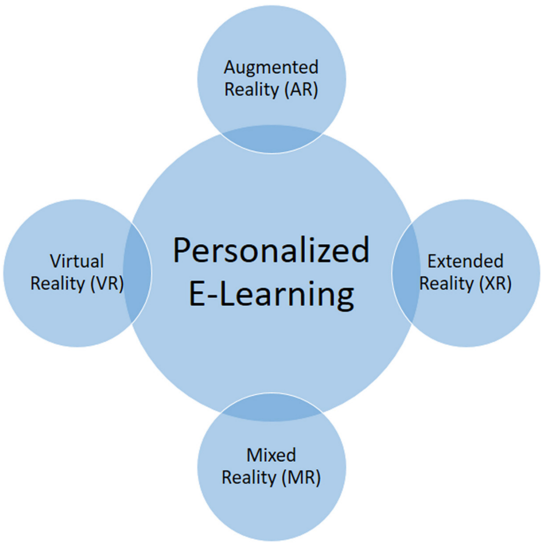

Fig. 6. Framework of advanced technologies within the boundary of e-learning

For instance, MR application data sharing for 5G requires data transfer speeds of around 100 Mbps for smooth streaming [25]. In this situation, no more than nine users access the MR content and may experience a delay in data sharing. In response to escalating threats, analysts have developed various countermeasures and protocols to enhance security in e-learning. E-learning has become more user-centered and secure with the assistance of modern technologies [2, 4, 36, 37]. However, the accessibility of these resources is not uniform, creating disparities in the educational landscape. Addressing issues of equitable access, particularly in underprivileged regions or among students with limited resources, represents a critical concern that necessitates systematic study and solutions [38].

6.2 Readiness and competence

Another pivotal challenge pertains to the readiness and competence of educators and instructional designers in effectively incorporating these immersive technologies into e-learning curricula [15, 17, 18]. Ensuring that educators possess the necessary skills and knowledge to fully utilize AR, VR, MR, and XR in personalized learning is crucial for successfully implementing these technologies.

6.3 Privacy and data security

Privacy and data security are crucial aspects of personalizing e-learning through AI and immersive technologies [14, 18]. As gathering and analyzing extensive learner data becomes indispensable for customizing educational experiences, safeguarding this data and adhering to data protection regulations present substantial challenges that warrant scholarly exploration. Furthermore, content creation and adaptation in the context of personalized e-learning are not without complexities. Developing immersive and interactive content that effectively supports personalized learning experiences can be resource-intensive and time-consuming. The dynamic nature of digital content, which may require frequent updates to remain current and compelling, accentuates this challenge [39, 40].

6.4 Assessment and evaluation

Establishing robust assessment and evaluation methods for personalized e-learning is a significant research area [38, 39]. Traditional assessment methodologies may not align seamlessly with fluid and individualized learning experiences [1, 26]. Hence, the design and implementation of innovative assessment techniques that accurately evaluate learner progress and ascertain the attainment of educational objectives in personalized e-learning environments warrant scholarly exploration. In addressing these academic challenges, researchers, educators, and policymakers must collaborate synergistically to develop innovative solutions that promote inclusivity, uphold learners' privacy, and provide the necessary support and resources to maximize the benefits of personalization in e-learning through emerging technologies [40, 41]. Rigorous academic inquiry is indispensable to meet these challenges and advance the field of personalized e-learning.

7 CONCLUSION

Electronic learning is not only a technological innovation but also a means through which humans can transmit information, skills, and values to future generations in educational institutions and industries. This research anticipates the continued evolution of e-learning and its diverse capabilities. Envisaged developments include learners engaging with numerous information modules, ranging from simple web pages with text and graphics to more complex multimedia simulations. E-learning has increasingly become the predominant training and instructional delivery method across various domains. The essence of successful e-learning is encapsulated in four fundamental principles. Firstly, it aims to educate learners on what they need to learn in a manner aligned with their natural learning tendencies. Secondly, a crucial element involves clearly defining learning objectives. The third principle builds upon the initial two by focusing on the relevant and appropriate educational targets. The ultimate secret lies in the control of testing. In short, integrating AI-driven personalized e-learning, augmented by immersive technologies, presents an exciting frontier in education. While challenges exist, they present opportunities for innovation and growth. As we navigate this evolving landscape, it is imperative to collaborate, address these challenges, and maximize the potential of personalized e-learning to transform education into a dynamic, inclusive, and learner-centered experience for the future.

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