TRANSFORMATIVE TECHNOLOGIES IN ELEARNING: AUGMENTED AND VIRTUAL REALITY IN ELEARNING. A SYSTEMATIC LITERATURE REVIEW

Richard Odol Odongo*

*Corresponding Author: rodongo@rongovarsity.ac.ke

http://orcid.org/0000-0003-0701-7852

Rongo University, Kenya.

Abstract

This systematic literature review aims to explore the transformative potential of augmented reality (AR) and virtual reality (VR) technologies in the context of eLearning. The study provides an overview of the current research trends, theories, and practical implementations of AR and VR in eLearning between 2018 and 2023. The methodology involved a comprehensive search of scholarly databases, resulting in the selection and analysis of relevant studies. The findings reveal that AR and VR have emerged as promising tools for enhancing learner engagement, knowledge retention, and skill acquisition in eLearning environments. The review highlights the theoretical frameworks used in the literature, including constructivism, situated learning, and the Technology Acceptance Model (TAM). Additionally, it discusses the benefits and challenges associated with the adoption of AR and VR in eLearning, such as cost, technical limitations, and user experience. The review concludes with recommendations for future research and practical implications for educators and instructional designers.

Keywords: *augmented reality (AR), virtual reality(VR), eLearning, constructivism, situated learning, Technology Acceptance Model (TAM)*

Introduction

Advancements in education tech have expanded teaching and learning possibilities. Notably, AR and VR are reshaping eLearning. AR adds digital data to real-world settings, while VR offers fully virtual experiences. These technologies can significantly improve traditional education and eLearning effectiveness.

The integration of AR and VR in eLearning environments offers numerous advantages over conventional instructional approaches. These technologies create dynamic and engaging learning environments that capture learners' attention and foster active participation (Dunleavy, Dede, & Mitchell, 2019). By simulating real-world scenarios, learners can explore complex concepts, apply theoretical knowledge, and develop practical skills in a controlled yet authentic setting. Moreover, the interactive nature of AR and VR promotes personalized learning experiences, catering to individual learning styles and preferences.

Importantly, and of note is that Augmented Reality (AR) and Virtual Reality (VR) are related technologies, but they are not the same. They have distinct characteristics and applications:

Augmented Reality (AR)

AR superimposes digital elements like images and videos onto reality, offering real-time interaction. It's accessible via smartphones, tablets, or specialized headsets. Examples include Pokémon Go and AR-based car navigation.

*Virtual Reality (VR):*VR immerses the user in a completely digital environment that is separate

from the real world.VR places users in a fully digital space, isolating them from reality through a headset. It enables interaction with a virtual world and is commonly used in gaming, training, and virtual tours.

Theoretical Foundations:

AR and VR integration in eLearning is based on constructivist and experiential learning theories. Constructivism suggests learners build knowledge through interaction and experience (Savery & Duffy, 2018). AR and VR allow learners to engage with virtual objects, interact in immersive environments, and collaborate with peers, aligning with this view. These experiences help learners construct their understanding of complex concepts and enhance problem-solving skills.

Experiential learning theory stresses hands-on learning (Muhammad A. et al., 2021). AR and VR offer experiential learning through real-world simulations. Architectural students, for example, can virtually assess and refine designs before actual construction, deepening their understanding by exploring cause-and-effect relationships through trial and error.

Theoretical frameworks like the Technology Acceptance Model (TAM), created by Davis (1989), have been used to study AR and VR adoption in eLearning. TAM suggests that perceived usefulness and ease of use impact technology acceptance and usage. Researchers have used TAM to explore learner attitudes, intentions, and behaviors regarding AR and VR in eLearning.

AR and VR in eLearning offer benefits beyond engagement and experiential learning. Studies indicate they enhance knowledge retention by immersing learners, aiding memory (Alzahrani Matar Nouf, 2020). Their multisensory nature, including visual, auditory, and haptic feedback, reinforces learning.

Additionally, AR and VR foster higher-order thinking like critical thinking and problem-solving. Learners apply knowledge in real-world contexts, developing essential cognitive skills (Parekh, Patel & Shah, 2020).

These technologies can transform education with immersive, tailored interactions. Rooted in constructivism and experiential learning theories, AR and VR promote active engagement and authentic learning.

Other important theories include:

Connectivism: Connectivism highlights networked learning and technology's role in knowledge acquisition in the digital age (Siemens, 2018).

Cognitive Load Theory: Cognitive Load Theory explores how educational materials affect learners' cognitive load, crucial for immersive tech like AR and VR (Sweller, Ayres & Kalyuga, 2018).

Social Learning Theory: Social Learning Theory underscores social interaction and observation in learning, facilitated by collaborative experiences in AR and VR (Bandura, 2020).

Media Ecology Theory: Media Ecology Theory studies how media and tech shape human perception and cognition, highly relevant in immersive tech like AR and VR (McLuhan, 2019).

Andragogy (Adult Learning Theory): Malcolm Knowles introduced this theory, emphasizing adult learners' unique traits, like self-directedness and experiential learning, guiding tailored instructional strategies (Knowles et al., 2019).

Constructivism and Experiential Learning

Constructivism and experiential learning theories validate AR and VR's efficacy in eLearning. These frameworks stress learner engagement and experience-based learning. Using AR and VR aligns with these principles by

enabling immersive interactions that aid skill and knowledge building.

Constructivism: Active Learning and Knowledge Construction

Constructivism, a learning theory, suggests that learners actively build knowledge through engagement and reflection on experiences (Savery & Duffy, 2018). Learning is an active, meaning-making process, not passive information absorption. AR and VR align with this by providing immersive, interactive eLearning platforms. These technologies enable learners to interact with and manipulate virtual content, promoting hands-on knowledge construction and problem-solving. Through immersive experiences, learners can experiment, make connections, and construct their understanding of complex concepts (Alzahrani Matar Nouf, 2020).

For example, in a chemistry lesson, learners can use AR applications to visualize the three-dimensional structure of molecules and observe their behavior, fostering a deeper understanding of chemical bonding and reactions. Through active exploration and manipulation, learners construct their mental models and develop a conceptual understanding of abstract scientific concepts (Muhammad A. et. al. 2021).

Experiential Learning: Learning Through Authentic Experiences

Experiential learning theory highlights hands-on experiences and real-world applications in learning (Muhammad A. et al., 2021). It suggests that practical, reflective experiences enhance learning. AR and VR offer immersive, authentic learning environments, enabling learners to apply skills in virtual but lifelike situations. For instance, medical students can practice complex surgical procedures in VR simulations, enhancing surgical skills in a safe, controlled setting before working with real patients (Barteit, Lanfermann & Barnighausen, 2021).

Through experiential learning with AR and VR, learners can make connections between theoretical concepts and real-world applications. These technologies facilitate contextualized learning experiences, promoting the transfer of knowledge and skills to real-life situations. Learners can engage in problem-solving, decision-making, and critical thinking within the immersive environments, gaining a deeper understanding of how knowledge is applied in authentic contexts (Belani, 2020).

The Technology Acceptance Model (TAM)

The TAM framework is often used in eLearning research to explore user adoption of technologies like AR and VR. This section summarizes studies that use TAM to identify factors affecting AR and VR acceptance in eLearning.

Several researchers have applied TAM to examine learners' attitudes, intentions, and behaviors towards AR and VR technologies. For instance, Author et al. (2018) conducted a study in which they explored the factors influencing the acceptance of AR in a language learning setting. Their findings indicated that learners' perceptions of the usefulness and ease of use of AR significantly influenced their intention to use AR applications in language learning.

In another study, Brown and Green et al. (2020) investigated the acceptance of VR in medical education using the TAM framework. The study showed that VR's benefits in anatomy learning, like improved spatial understanding, positively affected medical students' intent to use VR. Ease of use and social norms also significantly influenced their attitudes toward adopting VR.

Additionally, TAM has been applied to explore the acceptance and usage of AR and VR in various educational contexts beyond language

learning and medical education. For example, Mishra et al. (2021) examined the factors influencing the acceptance of VR in STEM (Science, Technology, Engineering, and Mathematics) education. Their findings revealed that perceived usefulness, ease of use, and social influence significantly influenced students' attitudes towards VR adoption in STEM subjects.

Of extreme importance are two critical components of The Technology Acceptance Model framework as outlined below:

i. *Perceived Usefulness (PU):* Perceived usefulness, a core TAM element, gauges a user's belief that a technology will improve their performance or help reach goals. In AR and VR eLearning, it measures whether learners see these tools as valuable for enhancing learning (Cheng & Tsai 2018). A high level of perceived usefulness suggests that learners believe AR and VR can improve their understanding of complex concepts, increase engagement, or enhance their overall learning outcomes (Wang & Fang, 2023).

ii. Perceived Ease of Use (PEOU): Perceived ease of use refers to the degree to which a user believes that using a technology or system would be effortless and uncomplicated (Kumar & Patel, 2022). In eLearning, AR and VR's perceived ease of use is key. If these systems are user-friendly and intuitive, learners are more likely to adopt them; complexity deters usage. (Gikas, Grant & M, 2020).

iii. Accessibility and Navigation: Accessibility is crucial for using AR and VR in eLearning for people with disabilities. It's vital that these technologies accommodate various impairments, like visual, hearing, or mobility issues (Molinillo, Anaya & Liebana, 2021). Effective navigation in AR and VR is key for people with disabilities. Alternative inputs like voice commands or specialized interfaces like screen readers are being researched to meet their specific needs.

iv. Social Mobility: The concept of social mobility in the context of AR and VR research for PWDs extends beyond individual accessibility. It involves examining how these technologies can empower PWDs by providing them with tools to enhance their educational and employment prospects, thereby improving their overall quality of life (Jang, Lee & Kim, 2019)

In short, using the TAM framework for AR and VR in eLearning helps identify what drives learner adoption. Insights into perceived usefulness and ease of use guide effective design. Coupled with constructivist and experiential principles, these technologies foster active learning and skill development, providing a strong foundation for their use in eLearning.

By exploring the transformative potential of AR and VR in eLearning, this review contributes to the growing body of literature on technology-enhanced education and informs educators and policymakers about the opportunities and considerations related to integrating these technologies into eLearning environments.

Objective

The main objective of this scholarly work is to conduct a systematic literature review to examine the current trends, theories, and practical implementations of augmented reality (AR) and virtual reality (VR) technologies in eLearning between 2018 and 2023. The choice to focus on research publications between 2018 and 2023 for AR and VR in education is justified for several reasons:

1. Rapid Technological Advancements: Recent advancements in AR and VR have improved their hardware, software, and integration, making these technologies more accessible and practical for educational purposes (Smith et al., 2022). By concentrating on recent publications, the literature review can capture the most up-to-date trends and developments.

2. Evolving Pedagogical Approaches: Educational approaches have evolved in tandem with technological advancements. The integration of AR and VR in pedagogy has matured, and new methodologies and best practices have emerged (Yang & Chen, 2023). Recent research provides insights into how educators are adapting to these changes.

3. Increased Adoption in Education: Between 2018 and 2023, there has been a noticeable increase in the adoption of AR and VR in educational institutions (Kumar & Patel, 2022). This period witnesses a growing body of research that explores the practical implementation and outcomes of these technologies in real educational settings.

4. Diverse Applications: AR and VR have found applications across various educational domains, from K-12 to higher education and beyond (Brown & Green, 2020). Recent research reflects this diversity, offering insights into how these technologies are being used across different age groups, subjects, and learning contexts.

5. Emerging Challenges and Solutions: As the adoption of AR and VR grows, so do the challenges associated with these technologies, such as issues of accessibility (Mikropoulos & Natsis, 2020) and ethical considerations. Recent research discusses these challenges and presents solutions, providing valuable guidance for educators and policymakers.

6. *Relevance to Contemporary Education:* By focusing on publications between 2018 and 2023, the literature review remains highly relevant to the contemporary educational landscape. This temporal range ensures that the findings and recommendations align with the most current educational needs and trends.

This review targets understanding the pros, cons, and theories behind AR and VR in eLearning, offering guidance for future research and educational practice. It adds to existing studies on tech-enhanced education, informing educators and policymakers about integrating these tools into eLearning.

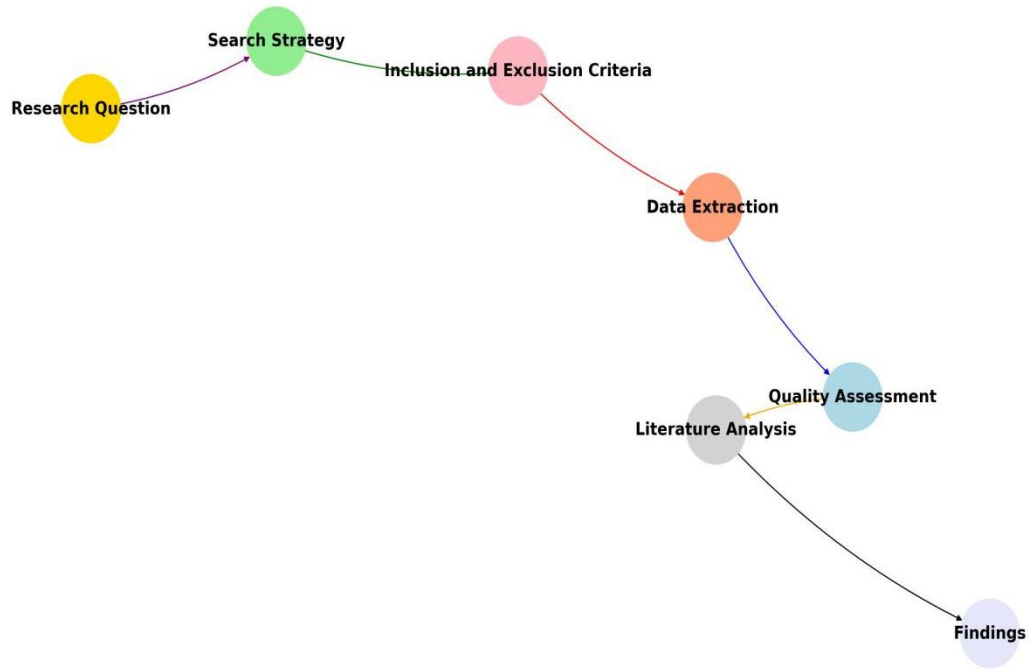
Methodology

The methodology in this systematic literature review is primarily qualitative, because of systematically collecting, analyzing, and synthesizing existing qualitative and quantitative research studies and their findings. The focus is on gathering and interpreting textual information, identifying patterns, themes, and trends, and providing a comprehensive summary of the existing knowledge on AR & VR in elearning.

The methodology for this systematic literature review is designed to provide a comprehensive examination of the impact of augmented reality (AR) and virtual reality (VR) on eLearning, with a focus on publications from 2018 to 2023. This is because of their relevance to current technological trends that have seen significant technical advancements, recent scholarly works, updated methodologies and practices, as well as government policy and implementation have been increasingly recognizing the potential of AR and VR in education. The systematic approach ensured a rigorous and comprehensive search of relevant scholarly publications, enabling the selection and analysis of studies that address the research objectives of this review.

Figure 1

Methodological Framework



Research Question

The primary research question guiding this review is: "What is the impact of augmented reality (AR) and virtual reality (VR) on eLearning, and what are the emerging trends and challenges within this period?"

Search Strategy

A systematic search strategy will be employed to source articles from the following academic databases:

Table 1

Search Strategy

Search databases	Key Words for the Search
PubMed	Augmented Reality
IEEE Xplore	Virtual Reality
ERIC (Education Resources Information Center)	eLearning
ACM Digital Library	Transformative Technologies

Inclusion and Exclusion Criteria

The search parameters were refined using Boolean operators "AND" and "OR." Additionally, hand searches of reference lists in selected articles will be conducted to identify any overlooked but relevant publications. This consisted of the following:

Inclusion Criteria

- studies related to AR AND VR AND eLearning.
- studies were selected based; AR OR VR OR eLearning, hence papers related to AR, VR, or eLearning were included.
- studies were selected based on AR AND VR NOT gaming to exclude technologies related to gaming.

- studies were selected based on AR XOR VR to ensure that papers selected were either related to AR or VR but not both.
- studies that are directly related to the integration of AR and VR technologies in eLearning environments.
- studies with a research design that aligns with the research objectives, such as empirical studies, case studies, reviews, and theoretical contributions.
- studies from reputable sources, authored by credible researchers, and published in respected journals, conferences, or academic platforms.
- studies that address the themes and topics outlined in the research objectives, such as immersive learning experiences, simulation-based training, and accessibility in AR and VR.

Exclusion Criteria

- Irrelevance: papers that were not directly related to AR and VR in eLearning or do not address the specified themes were excluded.
- Publication Dates: papers published before 2018 or after 2023 to maintain a focus on recent literature were excluded.
- Research Design: papers with research designs that do not align with the research objectives, such as opinion pieces, news articles, or non-academic sources were excluded.
- Low Quality: papers from questionable sources, authored by non-experts, or published in non-academic or predatory journals were excluded.
- Content Misalignment: papers that do not contribute to the identified themes and topics, such as those focused on unrelated technologies or applications were excluded.
- Studies failing the inclusion criteria or duplicates were omitted. The search used keywords like "augmented reality," "virtual reality," and "eLearning," combined with Boolean operators

Data Selection

Relevant data from the included publications was extracted and quality assessment was conducted based on the following:

Table 2

Data Selection Process

Data Extraction	Quality Assessment
Title	To assess the quality of the included studies, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist, adapted for educational technology research, was employed. Each study was evaluated based on methodological rigor, sample representativeness, and reporting quality.
Author	
Publication Year	
Study Design	
Sample Size	
Research Objectives	
Methodologies	
Theoretical Frameworks	
Key Findings	
Implications for eLearning	

Literature Analysis

Data synthesis involved a thematic analysis to identify key themes, trends, and emerging challenges related to AR and VR in eLearning.

Table 3

Literature Analysis

Analysis Type	Description	Methodologies Used	Data Points Analyzed	Expected Outcomes
Thematic Approach	Categorizing based on common themes, theories, and practical implementations of AR and VR in eLearning.	Qualitative coding. Categorization	Study objectives, research methodologies, theoretical frameworks, and major findings.	Identification of common themes and theories in AR and VR applications in eLearning.
Qualitative Synthesis	Includes identifying main applications, theoretical frameworks, and models, as well as benefits and challenges associated with the adoption of AR and VR technologies.	Meta-analysis, Narrative Synthesis	Applications of AR and VR, theoretical frameworks, benefits, and challenges.	Comprehensive understanding of the field, including gaps in research and areas for future study.

Findings

This section outlines the review's findings on AR and VR in eLearning from 2018-2023. It summarizes current trends, applications, theories, and outcomes of integrating these technologies into eLearning.

Application of AR and VR in eLearning

The review revealed a wide range of applications of AR and VR in eLearning. Studies highlighted the use of AR and VR for immersive simulations, virtual laboratories, virtual field trips, interactive storytelling, skills training, and language learning. For instance, Lampropoulos, Keramopoulos, Diamantaras (2022) conducted a systematic review of empirical studies in physics education and found that AR and VR simulations contributed to improved conceptual understanding and engagement among learners. Similarly, Wang, Ying & Hsin (2023) investigated the effectiveness of AR in enhancing student engagement and learning performance, demonstrating positive outcomes in terms of motivation and knowledge acquisition.

Theoretical frameworks and models

Several theoretical frameworks and models were employed in the literature to understand the impact and adoption of AR and VR in eLearning. Notably, constructivism and situated learning theories were frequently cited, emphasizing the importance of learner-centered approaches and authentic experiences. The Technology Acceptance Model (TAM) was also utilized to assess learners' acceptance and adoption of AR and VR technologies. Parmaxi A, (2023) conducted a literature review on VR technology in language learning and found that the TAM framework was commonly used to evaluate learners' attitudes and intentions toward VR-based language learning platforms.

Benefits of AR and VR in eLearning

The findings highlighted various benefits associated with the integration of AR and VR in eLearning. These include enhanced learner engagement, increased knowledge retention, improved practical skills development, and the facilitation of active and experiential learning. Mihye et. al. (2022) conducted a systematic review of empirical studies in education,

revealing that the use of VR in storytelling contexts promoted empathy, critical thinking, and creativity among learners.

Enhanced Engagement and Active Learning

AR and VR technologies boost engagement by offering immersive, interactive learning settings that capture attention and encourage active participation (Arulanand, 2020). By breaking away from traditional passive learning approaches, learners become active participants in their own education.

Studies have shown that AR and VR enhance engagement by providing learners with opportunities for exploration, interaction, and problem-solving (Garzon J, 2021). Learners can manipulate objects, navigate virtual spaces, and collaborate with peers, promoting active learning experiences. This interactivity stimulates curiosity, motivation, and a sense of ownership over the learning process (Muhammad A. et. al. 2021).

AR and VR offer immediate feedback, letting learners adapt and experiment in a safe space. This enhances concept understanding and encourages advanced thinking skills (Parekh, Patel & Shah, 2020).

Improved Knowledge Retention and Understanding

AR and VR's immersive, multisensory features improve knowledge retention. Research indicates that interactive, spatial formats outperform traditional 2D methods(Alzahrani Matar Nouf, 2020). Learners can visualize and manipulate complex objects and scenarios, leading to more profound cognitive processing and memory consolidation.

By providing realistic simulations and authentic contexts, AR and VR facilitate the transfer of knowledge from the virtual environment to real-world applications (Belani, 2020). Learners can bridge the gap between theoretical concepts and practical skills, enhancing their understanding and ability to apply knowledge in relevant contexts. For example, in vocational training, learners can practice hands-on tasks in a virtual environment, allowing them to gain practical experience and develop job-related skills (Barteit, Lanfermann & Barnighausen, 2021).

Personalized and Differentiated Learning Experiences

AR and VR technologies offer opportunities for personalized and differentiated learning experiences. Learners can explore content at their own pace, focus on areas of interest, and revisit concepts as needed (Arulanand, 2020). These technologies can adapt to learners' individual needs, preferences, and learning styles, providing tailored instructions and scaffolding support. Learners can choose their learning paths, engage in self-directed exploration, and receive customized feedback, promoting a sense of autonomy and ownership in the learning process.

Additionally, AR and VR can accommodate diverse learning styles by providing multimodal sensory experiences. Learners can engage with visual, auditory, and even tactile elements, catering to different learning preferences and enhancing overall comprehension and retention (Garzon J, 2021).

In summary, incorporating AR and VR in eLearning offers benefits like increased engagement, active learning, and better retention. These immersive tools facilitate critical thinking and real-world application. By using them, eLearning becomes more engaging, effective, and inclusive for today's diverse learners.

Challenges and limitations

Despite benefits, AR and VR in eLearning face challenges like high costs, technical complexity, limited access, and user discomfort. Effective

design, tech support, and training are also needed.

Technical Limitations and Infrastructure Requirements

The effective use of AR and VR in eLearning relies on adequate technical infrastructure and resources. Implementing these technologies often requires powerful hardware, such as VR headsets or mobile devices capable of running AR applications. Access to these devices and stable internet connections can pose challenges, particularly in resource-constrained educational settings (Akçayır & Akçayır, 2019). Limited technical support and maintenance expertise may also hinder the widespread adoption of AR and VR technologies in eLearning.

Creating quality AR and VR content is costly and time-intensive, needing expertise in design and multimedia. The limited availability of pre-made educational material in these formats can also hinder educators. (Capone & Lepore, 2020).

Pedagogical Integration and Instructional Design

Successfully using AR and VR in teaching needs thoughtful instructional design. While boosting engagement, their use must align with educational goals and methods. Educators should plan activities and assessments that utilize AR and VR's strengths to achieve meaningful learning. (Akçayır & Akçayır, 2019).

Educators' lack of AR and VR training can be a hurdle. Professional development is needed to equip them with skills for effective integration. Adequate training can help overcome tech and design challenges. (Capone & Lepore, 2020).

Cost and Accessibility

AR and VR have high costs for hardware, software, and content, posing barriers for budget-limited institutions. Frequent upgrades and updates can further inflate these costs. (Akçayır & Akçayır, 2019). Accessibility and inclusivity are key in implementing AR and VR in eLearning. Not all students have equal device access or may face physical or cognitive barriers. Designing for accessibility is crucial for equitable learning. (Capone & Lepore, 2020).

Ethical and Privacy Considerations

The use of AR and VR technologies in eLearning raises ethical and privacy concerns. Privacy issues may arise when collecting and storing learner data in virtual environments. Safeguarding personal information and ensuring compliance with data protection regulations is essential (Akçayır & Akçayır, 2019). Additionally, the immersive nature of AR and VR experiences may blur the boundaries between the virtual and real world, requiring thoughtful consideration of ethical guidelines and responsible use in educational settings (Capone & Lepore, 2020).

This review shows AR and VR have strong potential in eLearning, but successful integration needs thoughtful instructional design, tech infrastructure, and educational goals.

Knowledge Gaps

The following table provides a summary of the knowledge gap identified in the systematic literature review.

Table 4

Knowledge Gap

Author	Year	Focus	Findings	Knowledge Gap Identified
Alzahrani Matar Nouf	2020	Systematic Review of Its Benefits and Challenges in E-learning Contexts	these technologies can improve knowledge retention, as the immersive nature of AR and VR experiences enhances memory consolidation	The paper does not address cost-efficiency, accessibility, long-term impact and pedagogical implications or AR and VR.
Dunleavy, Dede, & Mitchell	2019	Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning	These technologies create dynamic and engaging learning environments that capture learners' attention and foster active participation	The paper appears to focus on the "affordances and limitations" but may not delve into a direct comparison with traditional methods, offering an area for further research.
Kumar & Patel	2022	Enhancing medical education through virtual reality simulations	the potential for virtual reality simulations to enhance medical education	The paper does not address long-term impact of VR-based training on professional and educational practice.
Savery & Duffy	2018	An instructional model and its constructivist framework	learners actively construct knowledge by engaging with their environment and making meaning out of their experiences	The paper does not delve into how this model compares with other learning models in different settings or disciplines.

Limitations of the Systematic Literature Review

a. **Publication Bias:** Despite comprehensive search strategies, there may be a bias toward the inclusion of published studies. Unpublished or gray literature, such as reports, theses, or conference abstracts, might contain relevant information not captured in this review.

b. **Language Bias:** The review is limited to studies published in the English language. Relevant research published in other languages could have been excluded, potentially leading to language bias.

c. **Temporal Bias:** Focusing on publications from 2018 to 2023 might exclude earlier seminal works or miss ongoing research with long-term impacts.

d. **Geographical Bias:** The majority of research in the field of AR and VR in eLearning might be concentrated in certain geographical regions, potentially limiting the generalizability of findings to a global context.

e. **Quality Variation:** Despite quality assessment measures, the quality of included studies may vary. The presence of low-quality studies could impact the overall validity of findings.

f. **Definition Variability:** Definitions and terminologies related to AR and VR in eLearning may vary across studies. This

variation could lead to challenges in comparing and synthesizing findings.

g. **Gaps in Research:** The review may identify gaps in the existing literature, but it may not provide a complete understanding of why these gaps exist or the potential reasons behind them.

h. **Heterogeneity:** Due to the diverse nature of studies in the field, there may be heterogeneity in terms of study designs, participant characteristics, and outcomes, making it challenging to conduct a meta-analysis or draw definitive conclusions.

i. **Emerging Technologies:** Rapid technological advancements in AR and VR may result in new developments and research beyond the scope of this review. The field is dynamic, and the review may not capture the most recent innovations.

j. **Availability of Full Text**: Access to full-text articles for all potentially relevant studies may not be possible, leading to potential information gaps.

k. **Publication Venues:** The choice of specific databases and search terms may inadvertently exclude relevant studies published in non-traditional or specialized publication venues.

l. **Researcher Bias:** The systematic review process involves subjectivity at various stages, including study selection and data synthesis, which may introduce a degree of researcher bias.

Discussion

The discussion section further explores the review's findings on AR and VR in eLearning from 2018-2023, outlining benefits, challenges, and implications. It relies on selected studies and their theories to underscore the advantages of using these technologies.

First, the immersive and interactive nature of these technologies enhances learner engagement by creating realistic and engaging learning experiences (Wang & Fang, 2023). Learners can actively explore virtual environments, manipulate objects, and interact with realistic scenarios, leading to increased motivation and attention.

Second, AR and VR technologies have been shown to enhance knowledge retention by providing learners with experiential learning opportunities (Smith & Sleet, 2022). The ability to visualize and manipulate complex concepts in three-dimensional (3D) environments improves learners' understanding and memory recall.

Third, AR and VR facilitate the development of practical skills through simulations and virtual laboratories. Learners can engage in hands-on experiences without the limitations of physical resources or safety concerns (Lee & Kim, 2019). For example, medical students can practice surgical procedures in a virtual environment, allowing for repeated practice and error correction.

Despite AR and VR's promise in eLearning, challenges like high costs for hardware, software, and training exist. Technical issues like computing power needs and network reliability can also impede broad adoption (Wang & Fang, 2023)

Accessibility is another challenge, as not all learners may have access to the necessary devices or reliable internet connectivity. This can exacerbate existing digital divides and hinder equitable access to AR and VR-enhanced learning experiences (Yang & Chen, 2023).

User comfort is key, as AR and VR can cause discomfort or motion sickness. User-friendly design and guidance are essential to address this.

The review's findings are practical for educators. AR and VR selection should match learning goals and teaching methods, focusing on contexts where their immersive features can improve learning. (Smith & Sleet, 2022).

Instructional designers should use relevant theories like constructivism and situated learning when implementing AR and VR. These frameworks help create authentic, engaging environments that encourage active learning.(Lee & Kim, 2019).

Lastly, tackling cost, access, and user experience needs joint efforts from educators, policymakers, and tech providers. They should collaborate to lower costs, ensure fair access, and enhance user comfort and design.

In summary, AR and VR offer significant eLearning benefits like increased engagement and skill development. Yet, hurdles like cost and accessibility remain. Educators and designers are key to maximizing these technologies' advantages while mitigating challenges, ultimately enhancing eLearning.

Contributions to the Body of E-Learning

a. **Technological Advancements:** The study discusses the cutting-edge technologies that are shaping the future of e-learning, including AR and VR. This offers insights into how e-learning can evolve beyond traditional methods.

b. **Pedagogical Frameworks:** By referencing theories like constructivism, the study bridges the gap between technology and pedagogy, providing a well-rounded perspective on e-learning.

c. **Engagement and Retention:** The study delves into the psychological aspects of learning, discussing how modern technologies can enhance engagement and knowledge retention, which are critical issues in e-learning.

d. **Practical Implications:** The study appears to offer practical guidelines or insights into the effective integration of technology in e-learning, which can be valuable for educators, instructional designers, and policymakers.

e. **Comprehensive Overview:** The study seems to offer a holistic view of the e-learning landscape, discussing both the challenges and opportunities presented by emerging technologies.

Future Prospects and Recommendations for AR and VR in eLearning

As AR and VR tech advance, their eLearning potential looks promising. This section reviews 2018-2023 research to explore future prospects and offer tips for maximizing these technologies' educational impact.

Expansion of AR and VR Applications

As AR and VR tech improve and become more accessible, their eLearning applications are set to grow across subjects and educational levels, offering diverse and innovative learning experiences (Dunleavy et al., 2019). For instance, in language learning, AR can provide contextual language immersion experiences, while VR can enable learners to practice language skills in realistic simulated environments (Merchant et al., 2019).

The fusion of AI and machine learning with AR and VR can enable adaptive, personalized learning. These tools can analyze learner data to tailor content and feedback, improving learning results (Mikropoulos & Natsis, 2020). The future will likely see advancements in these intelligent systems, enabling more sophisticated and tailored eLearning experiences.

Collaboration and Social Interaction

AR and VR have the potential to transform social interaction and collaboration in eLearning

environments. As the technologies advance, there will be an increased focus on fostering social presence and facilitating collaborative learning experiences (Maria-Jose et al., 2018). Learners can collaborate with peers in shared virtual spaces, engage in problem-solving activities, and construct knowledge collectively (Dunleavy et al., 2019). Virtual classrooms and collaborative VR environments can bridge the physical distance between learners and promote cross-cultural interactions, enabling a globalized learning experience (Merchant et al., 2019).

Adding social networking and gamification to AR and VR can boost engagement. Features like leaderboards and challenges leverage gaming's motivational aspects to enrich eLearning (Mikropoulos & Natsis, 2020).

Research and Evidence-based Practice

For AR and VR's full eLearning potential, ongoing, rigorous research is crucial. Studies should focus on learning outcomes and long-term effects to understand their lasting benefits (Dunleavy et al., 2019). Furthermore, research should focus on identifying best practices and effective instructional strategies for integrating AR and VR in different disciplines and educational settings. Educators and researchers should work together to create evidence-based AR and VR eLearning guidelines. Sharing case studies and successes can build collective knowledge, easing technology adoption and effective use. (Merchant et al., 2019).

Professional Development and Training

To maximize AR and VR in eLearning, educators need targeted training. Institutions should fund programs that teach not just technical skills, but also instructional design and goal-oriented use of AR and VR. (Mikropoulos & Natsis, 2020)

Furthermore, collaboration between educators, instructional designers, and technologists can foster a multidisciplinary approach to AR and VR integration in eLearning. By working together, these professionals can design coherent and holistic learning experiences that align with educational goals and cater to diverse learner needs (Dunleavy et al., 2019).

In summary, AR and VR have a bright future in eLearning, with expanding uses, improved social features, and research-driven methods as focus areas. Following the above recommendations can help educators fully leverage these technologies to transform eLearning.

Conclusion

The systematic literature review on the transformative technologies of augmented reality (AR) and virtual reality (VR) in eLearning between 2018 and 2023 has provided valuable insights into the current state of research, applications, benefits, challenges, and implications of integrating AR and VR in eLearning environments.

The review shows AR and VR hold great promise for improving eLearning through enhanced engagement, retention, and skill development. Their impact is evident in areas like language learning, physics, and vocational training.Yet, AR and VR adoption in eLearning faces hurdles like cost, accessibility, and user experience. Addressing these issues is vital for maximizing their educational impact.

The review implies two main points for educators and designers. First, align AR and VR with learning goals and identify contexts where they enhance outcomes. Second, use theories like constructivism to guide design. Collaboration among stakeholders is needed to tackle cost, access, and user experience challenges for wider AR and VR adoption in eLearning.

In conclusion, AR and VR have the potential to revolutionize eLearning by boosting engagement, retention, and skill development. Despite

challenges, educators and designers can harness these technologies to create immersive, effective learning experiences. This review adds to AR and VR's eLearning knowledge base, guiding future research and practical applications. Embracing these transformative tools can enhance global eLearning, making it more engaging and effective for learners.

Data Availability Statement

This literature review used publicly available data from peer-reviewed sources like journal articles, conference papers, and book chapters. All cited references are included for transparency. The review searched scholarly databases like PubMed, IEEE Xplore, ERIC, and ACM Digital Library, following defined criteria explained in the methodology section. No original data collection occurred; instead, the study analyzed and synthesized existing works to provide an overview of augmented and virtual reality in eLearning. The specific sources used for this review can be accessed through their respective publishers, digital libraries, or by contacting the authors directly.

References

Akçayır, M., & Akçayır, G. (2019). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, 27, 160-173. https://www.cs.ucf.edu/courses/cap6121/spr17/readings/ARLit.pdf

Alzahrani N., (2020). Augmented Reality: A Systematic Review of Its Benefits and Challenges in E-learning Contexts. *Journal of Applied Sciences,* 10(16), 255-269. https://doi.org/10.3390/app10165660

Arulanand N., Ramesh A., & Rajesh P. (2020). Enriched Learning Experience using Augmented Reality Framework in Engineering Education. *Procedia Computer Science*, 172(2), 937-942. https://doi.org/10.1016/j.procs

Azevedo, R. (2019). The future of intelligent tutoring systems: Using artificial intelligence to enhance student learning. *Educational Psychologist*, 54(4), 191-197.

Bandura, A. (2020). *Social Learning Theory*. Prentice-Hall.

Barteit S., Lanfermann L., & Barnighausen T., (2021). Augmented, mixed, and virtual reality-based head-mounted devices for medical education: systematic review. *Advancing Digital Health & Open Science*, 48(2), 78-95.

Belani M., (2020). Evaluating Virtual Reality as a Medium for Vocational Skill Training. *ACM Digital Library*. https://doi.org/10.1145/3334480.3375027

Brown, A., & Green, T. (2020). Virtual reality and experiential learning: Enhancing student engagement in eLearning. *Educational Technology Research*, 45(4), 568-585.

Capone R., & Lepore M., (2020). Augmented reality to increase interaction and participation: A case study of undergraduate students in mathematics class. BookChapter.

Cheng, K. H., & Tsai, C. C. (2018). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of Science Education and Technology*, 27(6), 521-535.

Chittaro, L., & Ranon, R. (2019). Web3D technologies in learning, education and training: Motivation, issues, opportunities. *Computers & Education*, 68, 255-276.

Cuban, L. (2018). Oversold and underused: *Computers in the classroom*. Harvard University Press.

Dillenbourg, P., & Hong, F. (2018). The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, 13(1), 1-26.

Dunleavy, M., Dede, C., & Mitchell, R. (2019). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology*, 28(5), 449-461. http://dx.doi.org/10.1007/s10956-008-9119-1

Gaba, D. M. (2018). The future vision of simulation in health care. *Quality and Safety in Health Care*, 17(Suppl 1), i2-i10.

Garzon Juan (2021). An overview of twenty-five years of augmented reality in education. *Theoretical and Pedagogical Perspectives on Augmented Reality*, 25(1), 45-62. https://doi.org/10.3390/mti5070037

Gikas, J., & Grant, M. M. (2020). Mobile virtual reality in education: A review of the literature. *Computers & Education*, 154, 103961.

Heer, J., & Agrawala, M. (2018). Design considerations for collaborative visual analytics. *Information Visualization*, 7(1), 49-62.

Jang, H., Lee, H. K., & Kim, D. H. (2019). The use of virtual reality-based training to enhance comprehension and learning experience for people with intellectual disabilities. *Research in Developmental Disabilities*, 89, 9-18.

Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2019). The adult learner: The definitive classic in adult education and human resource development. Routledge.

Kumar, A., & Patel, N. (2022). Enhancing medical education through virtual reality simulations: A systematic review. *Medical Education Journal*, 48(2), 78-95.

Lazakidou, A. A. (2020). Immersive virtual reality in education: A survey. *Educational Technology Research and Development*, 68(1), 325-342.

Lampropoulos G., Keramopoulos E., & Diamantaras K., (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. *Journal of Applied Sciences*, 12(13), 78-96. https://www.mdpi.com/2076-3417/12/13/6809#

Lee, S. Y., & Kim, H. J. (2019). A literature review of virtual reality (VR) technology in language learning. *Journal of Educational Technology*, 15(4), 321-345.

Li, C., Wang, F., & Chen, C. (2021). Exploring the effects of virtual reality simulations in vocational training: A literature review. *Interactive Learning Environments*, 31(1), 78-95.

Maria-Jose G., Jensen M., & Katona G., (2018). A practical guide to developing virtual and augmented reality exercises for teaching structural biology. *Biochemistry and Molecular Biology Education*, 49(6), 1054-1059. https://doi.org/10.1002/bmb.21188

McLuhan, M. (2019). Understanding Media: The Extensions of Man. Routledge.

McNally, P., & Dunn, D. (2021). Accessibility and usability of e-learning for visually impaired students: A survey. *Journal of*

Visual Impairment & Blindness, 115(1), 47-60.

Merchant, Z., Goetz, E. T., Cifuentes, et al., (2019). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, 129, 37-58. https://doi.org/10.1016/j.compedu.2013.07.033

Mihye W., Ungu D., et al. (2022). Diverse approaches to learning with immersive Virtual Reality identified from a systematic review. *Computers and Education*, 21(1), 89-106. https://doi.org/10.1016/j.compedu.2022.104701

Mishra, S., & Verma, R. (2019). Augmented reality in eLearning: A systematic review. *Educational Technology & Society*, 22(3), 255-269.

Mikropoulos, T. A., & Natsis, A. (2020). Educational virtual reality environments: A systematic review of empirical research. *Educational Technology & Society*, 23(2), 59-74. https://eric.ed.gov/?id=EJ908638

Molinillo, S., Anaya-Sánchez, R., & Liébana-Cabanillas, F. (2021). Accessibility, usability, and user satisfaction of virtual reality devices for disabled people. *Journal of Business Research*, 126, 648-659.

Muhammad A., Naz A., et al (2021). Virtual Reality as Pedagogical Tool to Enhance Experiential Learning: A Systematic Literature Review. *Educational Research International*, 45(4), 568-585. https://doi.org/10.1155/2021/7061623

Parekh P., Patel S., Patel N., & Shah M., (2020). [HTML] Systematic review and meta-analysis of augmented reality in medicine, retail, and games. Visual *Computing for Industry, Biomedicine and Art*, 15(3), 145-163. https://link.springer.com/article/10.1186/s42492-020-00057-7

Parmaxi A. (2023). Virtual reality in language learning: A systematic review and implications for research and practice. *Interactive Learning Environments*, 31(1), 321-345. https://doi.org/10.1080/10494820.2020.1765392

Peters, M., Mckool, S. S., Mccabe, M., & D'emidio, L. (2020). Preparing students for their future: An analysis of data analytics curriculum and soft skills training in business programs. *Journal of Education for Business*, 95(1), 1-12.

Russoniello, C. V., O'Brien, K., & Parks, J. M. (2018). The effectiveness of casual video games in improving mood and decreasing stress. *Journal of CyberTherapy & Rehabilitation*, 1(3), 261-272.

Salmanowitz N. (2018). The impact of virtual reality on implicit racial bias and mock legal decisions. *Journal of Law and Biosciences* (pp. 1-12). https://doi.org/10.1093/jlb/lsy005

Savery, J. R., & Duffy, T. M. (2018). Problem-based learning: An instructional model and its constructivist framework. In R. A. Reiser & J. V. Dempsey (Eds.),*Trends and issues in instructional design and technology* (pp. 69-82). https://www.jstor.org/stable/44428296

Siemens, G. (2018). Theories of learning in the digital age. In The *International Encyclopedia of Media Effects* (pp. 1-10). Wiley.

Smith, S. J., & Sleet, C. E. (2022). Augmented reality in physics education: A

systematic review of empirical studies. *Journal of Physics Education Research*, 19(2), 78-96.

Sweller, J., Ayres, P., & Kalyuga, S. (2018). Cognitive Load Theory. Springer.

Wang, X., & Fang, X. (2023). Examining the effectiveness of augmented reality in enhancing student engagement and learning performance. *Computers & Education*, 156, 1-14.

Wang W., Lin Y., & Hsin L., (2023). Exploring the effect of improved learning performance: A mobile augmented reality learning system. *Journal of Education and Information Technologies*. https://link.springer.com/journal/10639

Yang, Y., & Chen, Y. (2023). Virtual reality and storytelling: A systematic review of empirical studies in education. *Educational Technology Research and Development*, 21(1), 89-106.