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Enhancing the Quality of Vocational Education and Training through Innovation with Virtual Reality

Summary of 48 scientific articles on Immersive Technologies in VET

Task 2.2: Adaptability of curriculum and equipment of VET schools to VR systems

16.08.2025

Immersive Technologies in Education

	Paper	Abstract summary	Summary	Main findings	Outcome measured	Summary of introduction	Summary of discussion
1	A Critical Review of the Use of Virtual Reality in Construction Engineering Education and Training Peng Wang International Journal of Environmental Research and Public Health 2018 · 589 citations	VR and AR technologies have been applied in construction engineering education and training for visualization, safety training, and operational task training.	This review critically analyzes the use of Virtual Reality in Construction Engineering Education and Training from 1997 to 2017, identifying trends in VR technologies, applications, and future directions to improve training performance.	- The review identifies the evolution of VR technologies in CEET from desktop-based to immersive and BIM-enabled VR. - VR applications in CEET are categorized into four main areas: architecture visualization, structural analysis, construction safety training, and equipment operation training. - Immersive VR, 3D game-based VR, and AR are highlighted for their potential to increase student participation and motivation.	Not mentioned (the paper is a review and does not specify primary outcomes or endpoints in terms of measurable units)	The paper reviews the rapid adoption of Virtual Reality (VR) in construction engineering education and training (CEET) due to its engaging and immersive nature, aiming to analyze VR applications from 1997 to 2017 to assist researchers and educators in integrating VR effectively into their programs.	The paper provides a comprehensive review of Virtual Reality applications in Construction Engineering Education and Training from 1997 to 2017, identifying trends, benefits, and future research directions to enhance education and training performance.
2	The Effects of Virtual Reality, Augmented Reality, and Mixed Reality as Training Enhancement Methods: A Meta-Analysis A. D. Kaplan +5 Hum. Factors 2020 · 347 citations	VR, AR, and MR are as effective as traditional training methods for enhancing performance.	The meta-analysis found that extended reality (XR)-based training is equally effective as traditional training methods in enhancing performance, offering similar outcomes across multiple	- Training in extended reality (XR) is equally effective as traditional training methods in enhancing performance. - XR is particularly suitable for training on physical	Performance	The paper aims to explore the effectiveness of virtual reality, augmented reality, and mixed reality as training tools compared to traditional methods, addressing the debate on their efficacy through a meta-	The meta-analysis concludes that XR training is equally effective as traditional training methods in enhancing performance, with its value lying in providing

			fields and providing value in situations where traditional training is not feasible due to danger or cost.	tasks, with a positive effect size (d = .36). - Overall performance following XR-based training is neither better nor worse than performance following traditional training.		analysis of existing literature.	training in situations where traditional methods are not feasible due to danger or cost, and while it may not offer superior training capacities, it is at least as effective as traditional methods.
3	Analyzing augmented reality (AR) and virtual reality (VR) recent development in education A. Al-Ansi +3 Social Sciences & Humanities Open 2023 · 325 citations	The paper analyzes the recent development and applications of AR and VR technologies in education, highlighting their growth and the need for more effective implementation and customization.	This comprehensive review analyzes the development of augmented reality (AR) and virtual reality (VR) in education over the last twelve years, highlighting their exponential growth, challenges in implementation, and future directions for educational applications.	- The adoption of AR and VR in education has shown exponential growth, with wearable devices playing a significant role. - There is a gap in implementing and customizing these technologies quickly in educational institutions. - As AR and VR technologies mature, more educational applications are emerging in the learning process.	adoption of AR and VR in education, gap in implementation and customization	The introduction highlights the revolutionary impact of AR and VR on education, notes their developmental stage and need for investment, and outlines a comprehensive review of their development over the last twelve years to evaluate their current state and future directions.	The adoption of AR and VR in education has shown exponential growth, particularly with wearable devices, but there is a gap in implementation and customization in educational institutions, necessitating further research to address these gaps and enhance adaptability.
4	Augmented, Mixed, and Virtual Reality-Based Head-Mounted Devices for Medical Education: Systematic Review Sandra Barteit +4 JMIR Serious Games 2021 ·	Augmented, mixed, and virtual reality head-mounted devices show potential benefits for medical education, especially in low-	The paper systematically reviews the effectiveness of augmented, mixed, and virtual reality-based head-mounted devices in medical education, finding them generally beneficial for	- The majority of studies (63%) found HMD-based interventions to be effective for medical education, with users showing greater enthusiasm and	Knowledge acquisition, Practical skills, Feasibility, Cost-effectiveness, Safety, Applicability	The introduction discusses the potential of AR, MR, and VR head-mounted devices (HMDs) in medical education, particularly in low-resource settings, highlighting	The majority of studies suggest that XR-based HMDs have beneficial effects for medical education, with potential applicability in LMICs, and are recommende

	321 citations	resource settings.	enhancing knowledge and skills, with potential applicability in low- and middle-income countries despite most studies being conducted in high-income settings.	enjoyment. - HMDs were effective for both skills and knowledge acquisition, although some studies suggested they were best used as supplementary tools. - The review suggests that HMDs could be beneficial in LMICs and are at least noninferior to traditional teaching methods.		their benefits and setting the stage for a systematic review to evaluate their effectiveness globally, with a focus on low- and middle-income countries (LMICs).	d as an additional tool for teaching complex spatial structures, although further rigorous evaluation is needed.
5	A Review of Extended Reality (XR) Technologies for Manufacturing Training Sanika Doolani +6 Technologies 2020 · 196 citations	The paper reviews the current state-of-the-art use of extended reality (XR) technologies, including AR, VR, and MR, for training personnel in the manufacturing industry.	The paper reviews the current state-of-the-art use of Extended Reality (XR) technologies in manufacturing training, highlighting their potential to enhance worker performance and engagement, with multiple paths for positive impact and areas for future exploration.	- The paper reviews the use of extended reality (XR) technologies in manufacturing training, focusing on their potential to improve cognitive performance. - XR technologies, including VR, AR, and MR, can positively impact manufacturing training by enhancing worker performance and engagement. - AR still lags behind and requires further development to be effective in all	performance, time taken for completion of tasks, precision, accuracy, awareness, reaction time, error rate	The paper introduces the increasing use of extended reality (XR) systems in training and education, particularly in the manufacturing industry, and aims to provide a comprehensive review of the current state-of-the-art in using XR technologies for manufacturing training due to a lack of such reviews.	Immersive XR technologies are a powerful tool for manufacturing training, enhancing worker performance and engagement, with VR and MR being more developed than AR, which still requires further development, and these technologies will augment rather than replace skilled trainers.

				manufacturing phases.			
6	Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education Mohammed A. M. Algerafi +3 Electronics 2023 · 157 citations	AR and VR have significant potential to revolutionize education by offering immersive and interactive learning experiences that can improve student motivation, learning outcomes, engagement, and overall learning experiences.	This research comprehensively evaluates the educational applications of AR and VR, emphasizing their impact on student motivation, learning outcomes, engagement, and overall learning experiences across diverse educational domains, and provides practical recommendations for educators to effectively incorporate these technologies.	- AR and VR technologies have significant potential in enhancing K-12 education by improving engagement and learning outcomes. - These technologies are transforming higher education by providing immersive and interactive learning experiences. - AR and VR have also transformed medical education by offering innovative learning experiences, but challenges such as hardware requirements and technical issues need to be addressed.	- Student motivation - Learning outcomes - Engagement - Overall learning experiences - Knowledge retention - Skill acquisition - Feasibility in educational settings - Student attitudes and perceptions towards AR and VR - Effectiveness of recommendations for educators	The study comprehensively evaluates the educational applications of Augmented Reality (AR) and Virtual Reality (VR), focusing on their impact on student motivation, learning outcomes, engagement, and overall learning experiences across various educational domains, with the aim of providing practical recommendations for educators.	The paper comprehensively evaluates the educational applications of AR and VR, highlighting their impact on student motivation, learning outcomes, and engagement, while also discussing their potential in various educational settings and addressing challenges such as cognitive load and equitable access.

7	Augmented Reality (AR) and Virtual Reality (VR) Technology in Education: Media of Teaching and Learning: A Review Tira Nur Fitria International Journal of Computer and Information System (IJCIS) 2023 · 129 citations	AR and VR technologies offer new media for teaching and learning in various educational subjects, though they have benefits and limitations.	This study reviews the use of Augmented Reality (AR) and Virtual Reality (VR) in education, highlighting their potential as teaching and learning tools across various subjects, while also discussing their benefits, limitations, and implementation challenges.	- AR and VR are solutions for enhancing teaching and learning by adding interactive elements and creating immersive environments. - These technologies are applied across various subjects such as biology, chemistry, geography, and more. - Despite benefits, there are limitations and barriers to implementing AR and VR in educational institutions.	Not mentioned (the abstract does not specify any measured outcomes or endpoints)	The study reviews the use of Augmented Reality (AR) and Virtual Reality (VR) in education, highlighting their potential as solutions for teaching and learning, with the hope of improving education quality.	The study concludes that AR and VR are promising tools for enhancing teaching and learning, with applications across various subjects, but notes that there are challenges to their implementation that need to be addressed to fully leverage their potential in improving educational quality.
8	The Role of AR and VR Technologies in Education Developments: Opportunities and Challenges Hadi Ardiny +1 International Conference on Robotics and Mechatronics 2018 · 74 citations	AR and VR technologies have strong potential to improve education by providing attractive and effective teaching and learning experiences, though with some limitations.	This review paper explores the potential of Augmented Reality (AR) and Virtual Reality (VR) in education, discussing their capabilities and limitations in enhancing teaching and learning experiences.	- AR and VR have strong potentials for improving students' skills and knowledge. - Integrating AR/VR into education can make teaching and learning experiences more attractive and effective. - The paper analyzes the capabilities and limitations of AR/VR for learners and teachers.	Not mentioned (the abstract does not specify any outcome measures or endpoints)	The introduction to the paper provides an overview of the growing influence of technology on education, highlights the potential of AR and VR to improve student skills and knowledge, and introduces the concepts of AR/VR, their ongoing research, and their capabilities and limitations in educational contexts.	The discussion highlights the potential of AR and VR in education to improve student skills and knowledge, and examines their capabilities and limitations for enhancing teaching and learning experiences.

9	A Review of Extended Reality (XR) Technologies in the Future of Human Education: Current Trend and Future Opportunity A. Alnagrat +3 Journal of Human Centered Technology 2022 · 62 citations	XR technologies like VR, AR, and MR offer new opportunities for education by facilitating learning in virtual environments.	This narrative review describes the accelerators of XR technologies (VR, AR, MR) in education settings, discussing their potential and challenges, particularly during the COVID-19 pandemic, and provides a comprehensive review of XR technology in education, including its components, applications, and future directions.	- The review describes the accelerators of XR technologies in education settings, focusing on their potential and challenges during the COVID-19 pandemic. - VR technologies offer advantages such as providing realistic environments, enhancing problem-solving skills, and facilitating concept learning. - The use of VR is prevalent in fields like computer science, social sciences, medicine, and mathematics, indicating its broad applicability in education.	Not applicable (the paper is a narrative review and does not measure specific outcomes)	The introduction discusses the inevitable impact of technological advancements on education, focusing on Extended Reality (XR) technologies as tools to facilitate human life and transform education, with the purpose of exploring their accelerators and limitations in educational settings, especially during the COVID-19 pandemic.	The paper discusses the potential and challenges of XR technologies in education, highlighting their ability to transform learning experiences and improve problem-solving skills while identifying limitations and suggesting future work.
10	AUGMENTED AND VIRTUAL REALITY IN U.S. EDUCATION: A REVIEW: ANALYZING THE IMPACT, EFFECTIVENESS, AND FUTURE PROSPECTS OF AR/VR TOOLS IN ENHANCING LEARNING EXPERIENCES	AR and VR significantly enhance learning experiences in education, but challenges like cost and infrastructure remain barriers to widespread adoption.	This study provides an in-depth analysis of the impact, effectiveness, and future prospects of Augmented Reality (AR) and Virtual Reality (VR) in educational settings, highlighting their potential to enhance learning experiences and transform	- AR and VR significantly enhance learning experiences by offering immersive, interactive, and engaging environments. - These technologies improve student engagement, knowledge retention, and skill development.	student engagement, knowledge retention, skill development	This study provides an in-depth analysis of the impact, effectiveness, and future prospects of Augmented Reality (AR) and Virtual Reality (VR) in educational settings, exploring how these technologies are reshaping learning and teaching	The study provides a comprehensive analysis of the impact and effectiveness of Augmented Reality (AR) and Virtual Reality (VR) in educational settings, highlighting their potential to transform

	Babajide Tolulope Familoni +1 International journal of applied research in social sciences 2024 · 59 citations		the educational landscape by focusing on user experience, accessibility, and integration into curricula.	- The future trajectory of AR and VR in education will focus on enhancing user experience, improving accessibility, and integrating these technologies into educational curricula.		landscapes and predicting future evolution in user experience, accessibility, and integration into curricula.	traditional teaching methodologies, enhance engagement and knowledge retention, and provide personalized learning experiences.
11	Extended reality anatomy undergraduate teaching: a literature review on an alternative method of learning. Lucy Taylor +5 Annals of Anatomy 2021 · 58 citations	Extended reality technologies like VR and AR show potential as supplementary teaching aids for undergraduate anatomy education, with AR being more effective than VR.	This study reviews the literature on using extended reality technologies (XR) such as Virtual Reality (VR) and Augmented Reality (AR) for undergraduate anatomy teaching, finding high satisfaction and acceptability among students, with AR being more effective but VR more expensive, and suggests the need for further studies to determine long-term effectiveness and clinical relevance.	- Both AR and VR are well-received by undergraduate students as supplementary teaching aids. - AR is found to be more effective than VR. - VR is popular despite its higher cost and side effects like nausea; AR shows potential for independent study.	user satisfaction, perceived effectiveness, cost, acceptability, side effects	The COVID-19 pandemic and cadaveric shortages have necessitated a shift towards alternative methods in undergraduate anatomy learning, prompting an examination of extended reality technologies as a potential solution for medical education.	The study concludes that while both AR and VR are satisfactory and acceptable as supplementary teaching aids, with AR being more effective, larger and long-term studies are needed to determine their true effectiveness and clinical relevance in medical education.
12	Next-Generation Simulation—Integrating Extended Reality Technology Into Medical Education A. Herur-Raman +5 Frontiers in Virtual Reality 2021 ·	XR technologies like VR and AR are being integrated into medical education to enhance training in anatomy, communication, procedures,	The paper reviews the integration of Extended Reality technologies into medical education to enhance understanding of anatomy, empathetic communication, clinical	- XR technology is being adopted in medical education to enhance understanding of anatomy, practice empathetic communication, and	- Enhancement of understanding of anatomy - Improvement in empathetic communication - Rehearsal of clinical procedures - Refinement of surgical skills	The introduction discusses the advancements in XR technologies and their potential to enhance medical education by increasing interactivity, immersion, and	Medical simulation and Extended Reality technologies are being adopted by healthcare institutions and will be essential components of the post-pandemic

	42 citations	and surgical skills.	procedures, and surgical skills, and discusses their potential as essential components in the future of medical education.	refine surgical skills. - XR improves understanding of complex 3D structures and increases educational enjoyment compared to traditional methods. - The COVID-19 pandemic has accelerated the adoption of XR for remote learning, and it is expected to become a key component of future medical education.		safety, addressing the need for more effective training tools due to complexity and time constraints, and considering the impact of the COVID-19 pandemic on the future of medical simulation labs.	future of medical education, enhancing learning experiences in anatomy, communication, and surgical skills.
13	Creating an Immersive XR Learning Experience: A Roadmap for Educators Maram Meccawy Electronics 2022 · 41 citations	The paper provides a roadmap for educators to create immersive XR (AR, VR, MR) learning experiences, addressing the complexity of the process.	This paper provides a roadmap for educators to create immersive learning experiences using Extended Reality (XR) technologies, addressing the challenges and complexities involved in their adoption in education.	- The paper provides a roadmap for educators to create immersive XR learning experiences, highlighting factors to consider for successful implementation. - It presents multiple options for creating XR learning environments, varying in time, effort, and cost, as summarized in Table 1. - The paper acknowledges that there is no single path for creating immersive learning environments,	Not mentioned (the paper does not specify primary outcomes related to educational effectiveness or student performance)	The paper discusses the growing interest in using extended reality (XR) technologies in education, highlighting their benefits and the complexity of creating educational tools and environments, and aims to provide a roadmap for educators to create XR experiences.	The paper provides a roadmap for educators to adopt XR technologies, offering an overview of various approaches for creating immersive learning experiences and presenting solutions to navigate technical challenges and focus on educational and social aspects.

				emphasizing the need for flexibility and choice.			
14	Extended Reality (XR) in Virtual Laboratories: A Review of Challenges and Future Training Directions A. Alnagrat +2 Journal of Physics: Conference Series 2021 · 33 citations	Virtual laboratories using extended reality technology can effectively replace physical labs, especially during the COVID-19 pandemic.	The paper discusses the role of Extended Reality (XR) technology in virtual laboratories, particularly in the context of the COVID-19 pandemic, highlighting its impact on education by providing a safe environment for experiments and improving student efficiency, while also exploring its broader applications in various industries.	- The COVID-19 pandemic has highlighted the unprecedented role of Extended Reality (XR) technology in education, addressing challenges such as limited access to physical laboratories. - XR technology offers safety benefits by providing a risk-free environment for conducting experiments with dangerous equipment and reagents. - Virtual laboratories enable students to conduct experiments remotely and repeatedly, which is particularly beneficial during the pandemic.	student efficiency, academic performance, motivation, social and collaborative skills, psychomotor and cognitive skills, learning results, acquisition of information	The introduction discusses the importance of laboratories in engineering education, the impact of the COVID-19 pandemic on laboratory access, and the role of virtual laboratories and Extended Reality (XR) technology as a cost-effective solution to enhance student efficiency.	The paper discusses the role of virtual laboratories and extended reality (XR) technology in education, particularly in the context of the COVID-19 pandemic, highlighting its benefits in providing a safe and immersive learning environment, broadening human experiences, and improving cognition, with a focus on improving student outcomes and learning results.
15	Virtual Reality and its Influence on Training and Education -	This paper provides a literature review on the	The paper provides a comprehensive review of the current state of	Not mentioned (the abstract does not provide	Not mentioned (the abstract is empty and does not	Not mentioned (the abstract is not provided)	Not mentioned (the abstract is not provided)

	Literature Review S. Martirosov +1 2017 · 32 citations	influence of virtual reality on training and education.	virtual reality technology and its applications in training and education.	specific main findings or conclusions)	provide any information on outcomes)		
16	The Opportunities and challenges in virtual reality for virtual laboratories Ahmed Jamah Alnagrat Alnagrat +2 Innovative Teaching and Learning Journal 2023 · 22 citations	VR can be a valuable tool in engineering education, including for virtual laboratories, with positive pedagogical and cognitive impacts.	The paper discusses the opportunities and challenges of using virtual reality in education, particularly in engineering, highlighting its positive pedagogical and cognitive impacts, cost reduction, and providing guidelines for researchers in this field.	- VR has a positive pedagogical and cognitive impact on engineering education, increasing students' understandin g and satisfaction. - VR can reduce university liability, infrastructure , and costs by replacing physical laboratories. - Current VR applications lack integration with learning theories and objectives in engineering education.	- Pedagogical and cognitive impact on engineering education - Increased understanding of subjects - Improved grades and performance - Overall satisfaction with education - Enhanced creativity - Teachers' skill level improvement - Easy retrieval of learned theories - Cost-effectiveness in organizing high-quality laboratory work in STEM - Improved visualization of complex concepts - Satisfaction with virtual laboratory experiments	The paper introduces the growing interest in using extended reality technologies, particularly virtual reality (VR), in education, highlighting its potential as a valuable tool in engineering education by enhancing student understanding and performance through virtual laboratories.	The paper discusses the historical development and educational use of virtual reality, concluding that it positively impacts engineering education by enhancing student understandin g and reducing costs, while also providing recommendat ions for researchers and suggesting cost-effective solutions like mobile labs.
17	Adopting extended reality? A systematic review of manufacturing training and teaching applications Andrea de Giorgio +4 Journal of manufacturing systems 2023 · 21 citations	XR technologie s can bridge the gap between theory and practice in manufacturi ng education and training.	This article presents a systematic review of extended reality technologies in manufacturing education, highlighting their applications, goals, and technology readiness levels, and serves as a guide for	- The current manufacturin g education and training methods are largely traditional and separate theoretical from practical learning. - Extended reality (XR) technologies have reached a mature level and can	Not mentioned (the abstract does not specify any particular outcome measures or endpoints)	The training of future manufacturing experts is hindered by traditional methods that separate theory and practice, but the maturity of extended reality technologies offers a potential solution to bridge this gap	The discussion concludes that extended reality technologies offer a mature solution to bridge the gap between theoretical and practical training in manufacturin g education, providing a new teaching

			experimental designs to evaluate XR interventions in bridging the gap between theoretical and practical training.	bridge the gap between theory and practice. - The review provides a state-of-the-art description of XR in manufacturing education and a comprehensive analysis of technological platforms and methodologies.		by providing simulated learning environments.	paradigm through simulated learning environments, and serves as a guide for evaluating XR interventions in manufacturing education and training.
18	The role of virtual reality in enhancing educational outcomes across disciplines Enitan Shukurat Animashaun +2 International journal of applied research in social sciences 2024 · 20 citations	Virtual Reality has the potential to enhance educational outcomes across disciplines, but challenges around accessibility and integration remain.	This review paper examines the transformative role of Virtual Reality (VR) in enhancing educational outcomes across various disciplines, grounded in key learning theories and highlighting its potential to revolutionize learning experiences and outcomes.	- Virtual Reality (VR) can significantly increase student engagement and improve learning outcomes by providing interactive and experiential learning experiences. - VR enhances accessibility in education by breaking down geographical, physical, and socio-economic barriers. - Despite its potential, VR integration faces challenges such as accessibility and technical limitations, necessitating further research and development.	Educational outcomes, knowledge retention, and development of soft skills such as problem-solving and collaboration	This review paper examines the transformative role of Virtual Reality in enhancing educational outcomes across various disciplines, grounded in key learning theories, and discusses its applications, challenges, and future directions for improved interactivity and accessibility.	The paper discusses the transformative role of Virtual Reality in enhancing educational outcomes across various disciplines, emphasizing its potential to revolutionize learning experiences and outcomes, while also highlighting the need to address challenges and limitations to fully realize its potential.

19	Designing a Technological Pathway to Empower Vocational Education and Training in the Circular Wood and Furniture Sector through Extended Reality J. Ortega-Gras +4 Electronics 2023 · 17 citations	Extended Reality (XR) technologies can empower vocational education and training in the circular wood and furniture sector.	This paper presents research and comparison of XR tools for VET in the wood and furniture sector, reviews successful examples, and analyzes opinions to design a training pathway using XR for digital and green transformation.	- The study aims to research and compare XR tools for VET in the W&F sector and design a training pathway using XR. - A technological pathway is developed to integrate XR into VET courses for the W&F sector. - Specific software and hardware recommendations are made for VR, 360° video creation, and MR training.	- Development of a training pathway using XR technologies for VET in the W&F sector - Recommendations for software and hardware tools: - Unity software - VivePro headset - gITF 3D CAD exchange format - INSTA 360 Pro 2 camera - SimLab - HTC Vive Pro - Oculus Quest - Pico Neo - Microsoft Dynamics 365 Guides platform with HoloLens	The paper introduces Extended Reality (XR) as a key technology in Industry 4.0 and the metaverse, highlighting its role in simulating workplace scenarios for training, and explores its potential for digital transformation in the woodworking and furniture sector, supported by the European Commission's Allview project.	The paper discusses the design of a technological pathway for vocational education and training in the circular wood and furniture sector using Extended Reality technologies, proposing the use of specific software and hardware tools like Unity, VivePro, and Insta360 Pro 2, while highlighting the need for further analysis to confirm efficacy and identify limitations.
20	How virtual reality, augmented reality and mixed reality facilitate teacher education: A systematic review Qin Wang +1 Journal of Computer Assisted Learning 2024 · 16 citations	VR, AR, and MR (XR) technologies have been primarily used to train teachers' procedural knowledge, especially for pre-service teachers, with positive effects reported.	This systematic review analyzes the use of extended reality technologies in teacher education, finding they are primarily used for procedural knowledge training, with positive effects on teachers, and includes a SWOT analysis for future recommendations.	- XR technologies are primarily used to train teachers' procedural knowledge, such as classroom management. - Most studies focus on pre-service teachers and use small sample sizes, with VR being the most frequently employed tool. - XR-based training has a positive effect on teachers.	procedural knowledge (e.g., classroom management), positive effects on teacher training	The use of virtual reality, augmented reality, and mixed reality in teacher education has gained recent attention, but there is a lack of review on their utilization, prompting a systematic review to explore their application and address unanswered research questions.	The systematic review found that XR technologies are primarily used to train procedural knowledge, with a focus on pre-service teachers and small sample sizes, and have a positive effect on teachers; it calls for theory-driven training design and provides a SWOT analysis to foster further discussion.

21	The Impact Analysis of Augmented Reality and Virtual Reality in Education International journal of recent technology and engineering 2019 · 15 citations	AR and VR technologies have a positive impact on education by making the learning process more engaging and effective compared to traditional textbook-based methods.	The paper studies the impact of AR/VR on education, finding that these technologies are seen as improvements over traditional methods, with a significant majority agreeing they have a positive impact, and concluding that they can revolutionize education by making it more interactive and engaging.	- The majority of participants found AR/VR applications easier to understand than traditional textbooks. - The applications were found to be user-friendly, facilitating easy adoption. - A significant percentage of participants agreed that AR/VR has a positive impact on education, with a preference for interactive learning over traditional methods.	Impact of AR/VR on education, User preference for replacing traditional learning with AR/VR	The paper introduces the disruptive impact of Augmented Reality (AR) and Virtual Reality (VR) technologies across industries, focusing on their implementation in education to enhance learning experiences and comparing their benefits to traditional teaching methods.	The paper discusses the impact of AR/VR on education, highlighting its potential to revolutionize learning by promoting practical experience and active participation, with survey results showing it is seen as an improvement over traditional methods and expected to bring significant changes to classrooms.
22	Impact of Virtual and Augmented Reality on Quality of Medical Education During the COVID-19 Pandemic: A Systematic Review. Omar Sadek +4 Journal of Graduate Medical Education 2023 · 15 citations	VR and AR have a positive impact on medical education during the COVID-19 pandemic, improving trainee confidence, skill transfer, and information retention, despite some technical and physical challenges.	The COVID-19 pandemic accelerated the introduction of virtual and augmented reality in medical education, with studies showing positive outcomes in trainee confidence, knowledge enhancement, and improved surgical procedure times, suggesting these technologies are beneficial for surgical skills teaching and can replace	- The studies reported positive outcomes in trainee confidence and self-reported knowledge enhancement. - There was a significant improvement in the time required to complete surgical procedures for those trained with VR compared to traditional methods. - Immersive technologies offer the greatest benefit in	trainee confidence, skill transfer, information retention, overall experience, time required to complete surgical procedures (mean procedure time in minutes)	The COVID-19 pandemic disrupted medical education due to social distancing, leading to an accelerated introduction of virtual and augmented reality technologies, prompting a review to summarize their impact on medical education.	The review concludes that immersive technologies like VR and AR offer significant benefits in medical education, particularly in surgical skills teaching, despite some technical challenges, and identifies areas for future research.

			traditional methods.	surgical skills teaching and as a replacement for lecture- and online-based learning.			
23	The Significant and Challenges of Extended Reality Technologies in Learning and Training during Covid-19 Pandemic Ahmed Jamah Ahmed Alnagrat +2 Journal of Human Centered Technology 2022 · 14 citations	Extended reality technologies, including virtual reality, can enhance learning and training in education during the COVID-19 pandemic.	The paper discusses the role of Extended Reality (XR) technologies, particularly Virtual Reality (VR), in enhancing learning and training during the COVID-19 pandemic by providing immersive experiences that bridge gaps caused by social distancing, improve learning quality, and offer safe vocational training environments, despite facing challenges in content development and funding.	- XR technologies enhance learning and training by equipping students with professional skills and improving learning quality. - VR provides immersive learning experiences that develop practical skills and cognitive abilities. - VR is beneficial for vocational education and simulates real-world scenarios safely, addressing challenges in implementing XR in education.	- Improvement in learning quality - Enhancement of professional skills - Simulation of real-world scenarios for training - Creation of safe learning environments - Challenges in implementing XR in education (including complexity of content development, lack of qualified human resources, and funding issues)	The paper introduces the role of Extended Reality (XR) technologies, particularly Virtual Reality (VR), in enhancing learning and training during the COVID-19 pandemic, addressing the challenges of social distancing and educational continuity.	The education industry faces significant challenges in implementing XR technologies due to the complexity of developing educational content, lack of qualified human resources, and insufficient funding for equipment and software.
24	Impact of Virtual Reality (Vr) and Augmented Reality (Ar) in Education Dr. A. Udaya Shankar +4 Tuijin Jishu/Journal of Propulsion Technology 2023 · 14 citations	VR and AR have the potential to revolutionize education by creating immersive and engaging learning experiences, though challenges remain in their adoption.	This study provides an overview of the impact of Virtual Reality (VR) and Augmented Reality (AR) in education, highlighting their potential to create immersive and engaging learning experiences, promote collaborative learning, and offer	- The study finds that VR and AR enhance student engagement, improve knowledge retention, and develop practical skills in education. - Both technologies facilitate collaborative learning and can be adapted for	- Student engagement - Development of realistic and engaging learning environments - Accessibility and comprehension of complex topics - Knowledge retention	Virtual Reality (VR) and Augmented Reality (AR) are emerging as powerful tools in education, capable of revolutionizing the field by providing immersive and collaborative learning experiences, but their adoption is challenged by factors such as cost, technical	The paper discusses the impact of Virtual Reality (VR) and Augmented Reality (AR) on education, highlighting their potential to enhance learning experiences through immersive and interactive environments

			opportunities for skill development and accessibility, while also addressing challenges such as cost, technical infrastructure, and safety concerns.	special needs education. - Challenges include high initial costs, need for technical infrastructure, content development complexities, and safety concerns.		infrastructure, content development, and safety concerns.	, while also noting challenges such as cost, technical infrastructure, and content development that need to be addressed to fully realize their potential.
25	The Application of Extended Reality Technology in Architectural Design Education: A Review Jingwen Wang +2 Buildings 2023 · 14 citations	XR technology is increasingly being integrated into architectural education, with significant impacts on teaching and learning.	This study systematically reviews the applications and outcomes of Extended Reality (XR) technology in architectural education over the past five years, highlighting its impact on teacher effectiveness, student motivation, and communication, and suggesting its potential to replace traditional teaching methods with immersive and interactive learning experiences.	- XR technology is increasingly integrated into architectural education, significantly impacting teacher effectiveness, student motivation, reflection, and communication. - XR technology improves the delivery of architectural education, motivates active learning, and enhances communication. - The use of XR technology in architectural design, theory, and practice minimizes instructional time, reduces waste, and aids in understanding complex structures.	- Teacher effectiveness - Student motivation - Reflection and improvement - Teacher-student communication - Impact on architectural design education (minimizing instructional time, reducing waste) - Impact on architectural theory (addressing heritage structures) - Impact on architectural practice (replicating real-world conditions)	The study aims to analyze the applications and outcomes of extended reality technology in construction education over the past five years, highlighting its impact on teacher effectiveness, student motivation, and communication, and suggesting its potential to replace conventional teaching techniques.	The study discusses the integration of XR technology in architectural education, highlighting its impact on teacher effectiveness, student motivation, and communication, and suggests that it will increasingly replace traditional teaching methods, providing a theoretical framework for its future use and applications in design, theory, and practice.

26	Virtual Reality, Augmented Reality, and Mixed Reality in Experiential Learning: Transforming Educational Paradigms H. Crogman +4 Education sciences 2025 · 13 citations	VR, AR, and MR technologies can transform educational paradigms by fostering critical thinking, collaboration, and practical skill development through immersive and interactive learning experiences.	The paper reviews the impact of virtual reality, augmented reality, and mixed reality on experiential learning, highlighting their benefits in enhancing engagement, comprehension, and retention, and concludes that these technologies have the potential to revolutionize educational paradigms.	- Virtual reality, augmented reality, and mixed reality have a transformative impact on experiential learning, enhancing engagement, comprehension, and retention. - Extended reality technologies foster critical thinking, collaboration, and practical skill development while addressing challenges like accessibility and cost. - Empirical findings support XR's efficacy in improving student performance, engagement, and inclusivity, with potential to revolutionize experiential learning.	student performance, engagement, and inclusivity	The introduction discusses the impact of virtual reality, augmented reality, and mixed reality on experiential learning, highlighting their potential to redefine educational paradigms by enhancing engagement, comprehension, and retention, while addressing challenges and emphasizing their transformative potential across disciplines.	The discussion likely focuses on the benefits of XR technologies in fostering critical thinking, collaboration, and practical skill development, while addressing challenges such as accessibility and cost, and concludes by emphasizing XR's potential to revolutionize experiential learning.
27	Augmented Reality, Virtual Reality and Mixed Reality in Medical Education: A Comparative Web of Science Scoping Review M. F. B. Kamarudin +1 2019 · 12 citations	The paper compares research trends of virtual reality, augmented reality, and mixed reality in medical education, finding VR and AR are used for surgical training and	This study compares the research trends of virtual reality (VR), augmented reality (AR), and mixed reality (MR) in medical education, finding increasing research in VR since 1993 and AR since 2008, with VR used in endoscopic	- There is an increasing trend in research on VR since 1990 and AR since 2008, with MR research remaining constant. - VR primarily focuses on endoscopic surgery and anatomy, while AR focuses on	- Competency "show" (surgical performance) - Competency "know" (knowledge acquisition) - Competency "know-how" (application of knowledge) - Competency "does" (reduction in influenza	The paper introduces the use of virtual reality in medical education for surgical training and anatomy teaching, notes the recent introduction of augmented reality and mixed reality, and aims to compare the research trends	The study discusses the increasing research trends in VR and AR, attributed to technological advancements and smartphone ubiquity, highlighting their strengths in counseling and practical skills,

		anatomy teaching.	surgery and anatomy, AR in anatomy and endovascular procedures, and both focusing on practical skills measured by "show" competency.	anatomy and endovascular procedures. - The competency most measured in both VR and AR is "show," indicating a focus on practical skills, particularly in surgical training.	vaccine refusal rates)	of these extended reality modalities in medical education.	respectively, with VR and AR being more prevalent than MR in medical education.
28	Virtual Transformations in Human Learning Environment: An Extended Reality Approach Ahmed Jamah Ahmed Alnagrat Journal of Human Centered Technology 2022 · 11 citations	Extended reality (XR) technologies like VR, MR, and AR are transforming virtual learning environments and have potential applications in education and training.	This paper examines the transformation of virtual learning environments through extended reality (XR) technologies, discussing their potential uses in education, particularly in enhancing safety and interaction, and suggesting future applications in virtual laboratories.	- XR is transforming virtual learning environments by providing immersive and interactive experiences. - XR is particularly useful in fields such as education, learning, and simulating emergency situations. - The benefits of XR include immersion, interaction, and participation, which enhance learning outcomes.	- Immersion - Interaction - Participation - Safety training - Educational benefits	The paper introduces the shift towards virtual learning environments, highlighting the role of VR, MR, and AR in enhancing these environments, and examines the impact of extended reality on education through a systematic literature review.	The paper discusses how extended reality (XR) technologies are transforming virtual learning environments by enhancing learning and motivation through safe, collaborative, and interactive experiences, particularly in fields like education and emergency scenario training, with potential future applications in virtual laboratories.
29	Exploring the Potential of Augmented Reality (AR) and Virtual Reality (VR) in Education Shaikh Mohammed +1 International Journal of Advanced Research in Science, Communicatio	AR and VR have transformative potential in education by enabling immersive, engaging, and personalized learning experiences.	Augmented reality (AR) and virtual reality (VR) have the potential to revolutionize education by promoting student engagement, visualization of complex concepts, experiential	- Augmented reality (AR) and virtual reality (VR) have the potential to revolutionize education by promoting student engagement, visualization of complex concepts, experiential	- Enhanced understanding - Retention - Application of knowledge - Improved critical thinking skills - Collaboration and teamwork - Addressing different learning styles -	The integration of technology into education has revolutionized traditional learning methods, and augmented reality (AR) and virtual reality (VR) are emerging technologies that have	Augmented reality (AR) and virtual reality (VR) have the potential to revolutionize education by promoting student engagement, visualization of complex concepts, experiential

	n and Technology 2023 · 11 citations		learning, personalized instruction, and collaboration.	learning, personalized instruction, and collaboration . - The benefits of using AR and VR in education include improving students' critical thinking skills, fostering collaboration and teamwork, and addressing different learning styles. - Despite challenges, successful case studies have demonstrated the positive impact of AR and VR in education, with future research needed on scalability and long-term impact.	Personalized learning experiences - Collaboration and social learning - Support for distance education scenarios	gained significant attention for their potential to revolutionize education by providing immersive and engaging experiences that enhance students' understanding, retention, and application of knowledge.	learning, personalized instruction, and collaboration , despite challenges related to cost, accessibility, technical limitations, pedagogical integration, and ethical considerations.
30	Medical Education, Training and Treatment Using XR in Healthcare Shah Mahsoom Ali +3 International Conference on Advanced Communication Technology 2023 · 10 citations	The paper discusses the use of XR (AR, VR, MR) technologies in medical education, training, and treatment in the healthcare field.	The paper discusses the integration and impact of Augmented, Virtual, and Mixed Reality technologies in healthcare, focusing on their applications in medical education and treatment, as well as their potential future challenges and benefits.	- The use of Augmented, Virtual, and Mixed Reality technologies has dramatically increased in the healthcare sector. - These technologies enhance medical education and treatment by making them more accessible. - The paper	Not mentioned (the abstract does not specify any measurable outcomes or endpoints)	The rapid development of Augmented, Virtual, and Mixed Reality technologies is transforming the healthcare sector by enhancing medical education and treatment, improving professional-patient interactions, and offering promising opportunities despite	The paper discusses the integration of Augmented, Virtual, and Mixed Reality technologies in healthcare, highlighting their ease of use, benefits in medical education and treatment, and their potential as profitable and promising solutions

				discusses future threats and challenges related to XR technologies in healthcare.		potential challenges.	despite future challenges.
31	Extended Reality, Pedagogy, and Career Readiness: A Review of Literature Patrick Guilbaud +2 Interacción 2021 · 7 citations	XR technologies are being explored in education and training, but widespread adoption has not yet occurred.	This paper reviews the literature on the use of extended reality technologies in educational and training activities, finding that while XR applications are being used in pilot testing phases in certain disciplines, many institutions lack concrete plans for widespread adoption to support teaching and learning.	- XR applications are being used in pilot-testing levels in fields like medicine, nursing, and engineering. - Many academic institutions and training organizations lack concrete plans for widespread adoption of XR technologies.	work and career readiness, performance, and resiliency	The paper reviews the literature on extended reality (XR) technologies, noting their growing use in the digital workplace and projected growth, while highlighting the lack of robust adoption in academic and training settings, and examining their role in enhancing career readiness and performance.	The paper reviews the current literature on the use of extended reality technologies in educational and training activities, finding that while XR is being used in pilot testing in certain fields, many institutions lack concrete plans for widespread adoption to support teaching and learning.
32	Extended Reality Based Remote Learning Experience During Pandemic: Effectiveness and Barriers Prabha Susy Mathew +1 Intelligent Systems Reference Library 2022 · 5 citations	XR technologies have great potential to enhance remote learning and collaborative experiences, but face adoption challenges.	The paper discusses the impact of the COVID-19 pandemic on education and explores how Extended Reality (XR) technologies can enhance remote learning experiences, focusing on their potential, advantages, challenges, and frameworks for adoption in educational institutions.	- The COVID-19 pandemic has disrupted traditional teaching and learning processes, necessitating alternative solutions. - Extended Reality (XR) technologies can enhance collaborative learning experiences for remote learners and mitigate pandemic-related challenges. - XR technologies	Not mentioned (the abstract does not specify any specific measurable outcomes or endpoints)	The COVID-19 pandemic has disrupted traditional teaching and learning processes, but digital technologies, particularly Extended Reality (XR), offer potential solutions to enhance remote learning experiences and could revolutionize education.	The chapter discusses the impact of the COVID-19 pandemic on education, the role of digital technologies in mitigating these impacts, and how Extended Reality (XR) technologies can enhance remote learning by improving collaborative experiences, with a focus on their potential, advantages,

				have the potential to revolutionize education and training, despite being in their nascent stages.			challenges, and adoption frameworks.
33	Immersive Reality in Education: Transforming Teaching and Learning through AR, VR, and Mixed Reality Technologies Watcharaporn Jantanukul Journal of Education and Learning Reviews 2024 · 3 citations	AR, VR, and MR technologies can transform education by enabling interactive and experiential learning.	The paper explores the role of Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) in enhancing learning experiences by making complex concepts more understandable and engaging through interactive experiences, providing a comprehensive overview of their applications, benefits, and challenges in education.	- Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) improve education by making difficult concepts more accessible and engaging. - These technologies create interactive learning environments that promote critical thinking and encourage creativity. - Immersive technologies significantly increase student engagement and motivation, improve understanding of complex concepts, and support experiential learning.	- Improvement in making difficult concepts more accessible and engaging - Increase in student engagement and motivation - Better understanding of complex concepts through interactive visualizations - Promotion of experiential and active learning - Improvement in critical thinking and problem-solving abilities - Fostering of creativity and imagination	The paper aims to explore the role of AR, VR, and MR in enhancing learning experiences by understanding how these technologies can transform education through interactive and experiential learning, addressing adoption challenges, and promoting equitable access.	Immersive technologies like AR, VR, and MR improve education by making complex concepts more understandable and engaging, enhancing student engagement and motivation, and promoting experiential learning, but face challenges such as financial constraints and the need for teacher training.
34	A Review on Augmented Reality and Virtual Reality in Education Khushi Khanchandani +3 2021 ·	This paper reviews the use of augmented reality and virtual reality in education.	Not mentioned (the abstract is empty and does not provide any information)	Not mentioned (the abstract does not provide specific findings or conclusions)	Not mentioned (the abstract is empty and does not provide any information on outcomes)	Not mentioned (the abstract is empty and does not provide any information)	Not mentioned (the abstract is not provided)

	3 citations						
35	Concept Exploration of Virtual Humans in Education Mohammad Nasfikur R. Khan +5 IEEE International Symposium on Sustainable Systems and Technology 2024 · 3 citations	Virtual humans in augmented reality can enhance learning by providing personalized lessons and facilitating hands-on practice in educational contexts.	This paper explores the potential of Virtual Humans to bridge the gap between digital and physical learning settings, enhancing learning experiences through immersive AR experiences and discussing integration into educational contexts.	- Virtual Humans (VHs) offer immersive AR experiences that enhance learning. - The paper investigates the potential of VHs to bridge the gap between digital and physical learning settings for authentic and emotionally impactful learning experiences. - Ongoing research is discussed to integrate VHs into educational contexts, including instructional design, technical implementation, and ethical issues.	Not mentioned (the abstract does not specify any measurable primary outcomes or endpoints)	The paper explores the potential of Virtual Humans to enhance learning by bridging the gap between digital and physical learning settings, offering immersive AR experiences, personalized lessons, and hands-on practice, with ongoing research into their integration into educational contexts.	The paper discusses the potential of Virtual Humans to bridge the gap between digital and physical learning settings, enhancing learning experiences through immersive AR, and explores their integration into educational contexts.
36	Extended Reality Training for Business and Education: The New Generation of Learning Experiences Fabrizio Palmas +3 2022 IEEE International Symposium on Mixed and Augmented Reality	The use of Extended Reality (XR) technology is becoming increasingly important in educational and corporate training settings.	This paper discusses the integration of Extended Reality (XR) technology into real-world business and educational settings, focusing on lessons learned, real-world challenges, and problem-solving approaches for successful	- The paper discusses lessons learned from integrating Extended Reality (XR) technology into real-world business and educational settings. - It addresses the gap in literature by focusing on practical	Not mentioned (the abstract does not specify any particular outcome measures or endpoints)	The use of Extended Reality (XR) technology in educational and corporate settings is increasingly important, but there is a lack of published research on its integration into real-world applications, which this paper aims to address by	The paper discusses the lessons learned from integrating Extended Reality (XR) technology into real-world business and educational settings, including real-world challenges and problem-solving

	Adjunct (ISMAR-Adjunct) 2022 · 3 citations		implementation.	integration rather than just theoretical training. - The paper explores real-world challenges and problem-solving approaches necessary for successful XR integration.		discussing lessons learned and real-world challenges from integrating XR training into business and educational settings.	approaches necessary for success.
37	Extended Reality in Applied Sciences Education: A Systematic Review Tien-Chi Huang +1 Applied Sciences 2025 · 3 citations	XR technologies (VR, AR, MR) can enhance learning motivation, efficiency, and knowledge acquisition in applied sciences education, though challenges remain.	This systematic review examines the application of Extended Reality technologies in applied sciences education, finding that they enhance learning motivation and efficiency, while also identifying challenges that hinder their broader integration despite their transformative potential.	- VR is primarily used in higher education settings, while AR is more prevalent in primary and secondary education. - XR technologies enhance learning motivation, efficiency, and immediate knowledge acquisition, with potential long-term benefits like improved memory retention and learner confidence. - Despite challenges, XR technologies have transformative potential in applied sciences education.	learning motivation, efficiency, immediate knowledge acquisition, memory retention, learner confidence, sustained engagement	The introduction discusses the emergence of Extended Reality (XR) technologies in applied sciences education, aiming to review their application, impact on learning outcomes, and integration challenges, while highlighting their transformative potential despite existing challenges.	The systematic review concludes that XR technologies have transformative potential in applied sciences education, enhancing learning motivation and efficiency, despite challenges like high costs and limited evidence.

38	Exploring the Evolving Landscape of Extended Reality (XR) Technology Jaspreet Singh +3 2023 3rd International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON) 2023 · 3 citations	The paper provides an overview of extended reality (XR) technology, including its background, uses in education and training, and challenges.	This paper provides a comprehensive overview of Extended Reality (XR) technology, covering its emergence, applications, historical context, technological insights, and future challenges, highlighting its significant adoption and potential in various fields.	- Extended Reality (XR) technology has seen a significant increase in popularity across various applications such as training, education, and safety. - The surge in XR popularity is primarily due to advancements in augmented reality (AR), virtual reality (VR), and mixed reality (MR) technologies. - The paper provides a comprehensive overview of XR, including its background, historical context, and potential challenges.	Not mentioned (the abstract does not specify any primary outcomes or endpoints being measured)	The emergence of Extended Reality (XR) aligns with the current hyper-connected culture, and its popularity has surged due to advancements in AR, VR, and MR technologies, with significant adoption globally, especially in education during the COVID-19 pandemic, prompting a comprehensive overview of XR's background, applications, and future challenges.	The paper provides a comprehensive overview of Extended Reality (XR) technology, discussing its emergence, applications, and global adoption, particularly in education during the COVID-19 pandemic, and emphasizes understanding its foundations to address future challenges.
39	From Virtual to Reality: How VR, AR, XR, MR are Reshaping Our Lives and Work Qingtian Li International Journal of Education and Humanities 2024 · 2 citations	VR, AR, XR, and MR are transforming education, healthcare, the workplace, and entertainment through enhanced interactive experiences.	The paper explores the transformative effects of Virtual Reality, Augmented Reality, Extended Reality, and Mixed Reality on daily life and professional environments, reviewing their applications in healthcare, education, workplace, and entertainment, while also discussing challenges and	- Immersive technologies (VR, AR, XR, MR) are transforming how we live, learn, and work by offering enhanced interactive experiences. - In healthcare, VR and AR are revolutionizing patient care and medical training. - In education, these technologies	- Enhanced patient care and medical training in healthcare - Enhanced learning experiences and increased student engagement and retention in education - Improved collaboration and training in the workplace - Unprecedented immersive experiences that increase engagement	This article explores the transformative effects of Virtual Reality (VR), Augmented Reality (AR), Extended Reality (XR), and Mixed Reality (MR) on various aspects of daily life and professional environments, reviewing their applications across key sectors and discussing challenges and	The integration of VR, AR, XR, and MR is transforming traditional practices across multiple sectors, promising enhanced experiences and efficiency, but requires addressing technical, accessibility, and ethical challenges to ensure responsible innovation

			future development.	enhance learning experiences through immersive environments, improving engagement and understanding.	in entertainment	future development.	and broad accessibility.
40	Gaming, VR, and Immersive Technologies for Education/Training A. Brooks Recent Advances in Technologies for Inclusive Well-Being 2020 · 2 citations	The paper reviews the use of gaming, VR, and immersive technologies for education and training, including their potential future impact.	The paper reviews the integration of Extended Reality (XR) in education and training, discussing its potential to revolutionize interaction and learning across various fields, while also speculating on its impact on well-being.	- The future of digital lives will heavily integrate Extended Reality (XR) into education and training. - XR will be used in various educational settings, including classrooms and home environments, for diverse groups such as children, medical students, and industrial workers. - The chapter reviews the applications and potential impacts of gaming, VR, and immersive technologies on education and training, including speculation on well-being impacts.	Not mentioned (the abstract does not specify any measured outcomes or endpoints)	The introduction speculates on the impact of Extended Reality (XR) on well-being, as it integrates into daily life, revolutionizing interaction and education across various fields.	The chapter discusses the use of gaming, VR, and immersive technologies in education and their potential impact on well-being.

41	The Impact of Virtual Reality in Education: A Comprehensive Research Study Shivani Vats +1 TDIT 2022 · 2 citations	VR technologies have the potential to enhance student engagement, facilitate immersive learning experiences, and improve knowledge retention in education.	This research paper investigates the use of virtual reality in education, exploring its benefits, challenges, and implications, and concludes by highlighting its potential to enhance engagement and learning outcomes while addressing challenges for widespread adoption.	- The study found that VR technologies have the potential to enhance student engagement, facilitate immersive learning experiences, and improve knowledge retention. - VR helps foster curiosity, critical thinking, and problem-solving skills by creating an interactive learning environment. - The research highlights the future prospects of VR in education and suggests areas for further research.	student engagement, immersive learning experiences, knowledge retention, curiosity, critical thinking, and problem-solving skills	The study explores the advancements and potential applications of virtual reality technologies in education, aiming to investigate their benefits, challenges, and implications in enhancing learning experiences.	The research concludes that VR has the potential to enhance student engagement, facilitate immersive learning, and improve knowledge retention, but challenges like cost and accessibility need to be addressed, and it highlights future prospects and suggests areas for further research.
42	Methodologies and Use Cases on Extended Reality for Training and Education Anacleto Correia +7 Advances in Educational Technologies and Instructional Design 2022 · 2 citations	The paper discusses methodologies and use cases of extended reality (VR, AR, XR) for training and education.	The paper discusses the evolution of education towards incorporating technological resources and online learning opportunities, setting the stage for the integration of extended reality in training and education.	Not mentioned (the abstract does not provide specific main findings or conclusions from the study)	Not mentioned (the abstract does not specify any outcome measured)	Education is undergoing significant changes, evolving from traditional classroom settings to include technological resources and online opportunities, making learning accessible to students of all ages and locations.	Not mentioned (the abstract does not provide a summary of the discussion or conclusions)

43	Virtual Reality in Education Melany Rosencwaig International Journal of Scientific Research in Science Engineering and Technology 2025 · 1 citation	VR, AR, and XR technologies have significant potential to transform education by offering highly engaging and interactive learning experiences.	The paper reviews the impact of Virtual Reality on education, highlighting its potential to enhance engagement, understanding, and performance, while also discussing challenges and future integration recommendations.	- Implementing VR enhances student engagement, understanding, and academic performance by providing interactive learning experiences. - VR improves learning environments across various fields, such as sports training and chemical engineering simulations. - VR safely replicates complex situations, offering a cost-effective alternative to physical experiments, with encouraging results in India.	enhanced understanding, improved academic performance, increased student involvement, improved learning environments, transformation of practical education, student engagement	The rapid development of Virtual Reality (VR) and Augmented Reality (AR) technologies has significantly impacted the education sector, offering highly engaging and interactive learning experiences, with benefits including enhanced understanding and increased student involvement, despite challenges such as high implementation costs and technological barriers.	The discussion concludes that Virtual Reality (VR) will play a key role in the future of education, enhancing learning experiences and outcomes, despite challenges such as high implementation costs and technological barriers, and offers recommendations for its future integration across various educational domains.
44	A Review of Opportunities, Applications, and Challenges of XR in Education Yash Doshi +5 2021 · 1 citation	XR technologies have significant potential in education but also raise ethical concerns around data privacy and misuse.	This paper reviews the applications, advantages, disadvantages, and ethical considerations of Extended Reality (XR) in education, highlighting its potential impact on knowledge development and addressing challenges such as data privacy and misuse.	- XR has a significant positive impact on students' knowledge development. - Ethical concerns such as data privacy and misuse are associated with the use of XR in education. - The paper provides a comprehensive review of XR applications, advantages, disadvantage	students' knowledge development	The paper introduces Extended Reality (XR) as a pathbreaking technology in education with significant positive impacts on knowledge development, but also raises ethical concerns such as data privacy and misuse, aiming to review its applications, advantages, disadvantages, and ethical considerations.	The paper discusses the use of Extended Reality in education, its positive impact on knowledge development, and addresses ethical concerns such as data privacy and misuse, reviewing research on its applications, advantages, and challenges.

				s, and ethical considerations in education.			
45	Revolutionizing Education Through Augmented Reality (AR) and Virtual Reality (VR): Innovations, Challenges and Future Prospects Sathya Thangavel +2 Asian Journal of Interdisciplinary Research 2025 · 1 citation	AR and VR have disruptive potential in education by providing immersive, interactive learning experiences, but adoption is limited by technical and ethical challenges.	The paper discusses how Augmented Reality (AR) and Virtual Reality (VR) are revolutionizing education by providing immersive learning experiences, explores their potential in experiential and personalized learning, emphasizes the need for industry-academia collaboration, and addresses future advancements and research issues to make education more accessible and effective.	- AR and VR are revolutionizing education by providing immersive, interactive learning experiences. - Effective deployment requires collaboration among educators, policymakers, and business leaders. - Future advancements in AI, 5G, and cloud computing will enhance AR/VR applications, making them more adaptive and scalable.	- Knowledge retention - Skill development - Long-term impact on student performance - Comparison with traditional teaching methods	Augmented Reality (AR) and Virtual Reality (VR) are revolutionizing education by providing immersive learning experiences, but their adoption is limited by high costs, technical constraints, and ethical concerns, necessitating collaboration and investment to overcome these barriers and make education more accessible and effective.	The discussion concludes that AR and VR can revolutionize education by providing immersive learning experiences, but their effective deployment requires collaboration, investment in R&D, and addressing ethical concerns to make education more accessible and effective for all students.
46	Advanced Applications of AR/VR in Immersive Education and Experiential Training S. Kawsar Journal of Mathematical & Computer Applications 2023 · 0 citations	AR and VR are considered evolutive tools for enhancing education and training.	The paper discusses the advanced applications of Augmented Reality (AR) and Virtual Reality (VR) in enhancing immersive education and experiential training by improving progressive, multimedia, and activity-based learning programs.	Not mentioned (the abstract does not provide specific findings or conclusions from a study)	Not mentioned (the abstract does not specify any outcome measures)	Augmented Reality (AR) and Virtual Reality (VR) are considered evolving tools in education and training, enhancing progressive, multimedia, and activity-based learning programs.	The discussion likely focuses on the advanced applications and benefits of AR/VR in enhancing educational experiences through progressive, multimedia, and activity-based learning programs.
47	The Use Of Augmented Reality (AR) And Virtual	AR and VR technologies offer immersive	The integration of Augmented Reality (AR) and Virtual	- AR and VR contribute to enhanced experiential	enhanced experiential learning, increased	The integration of Augmented Reality (AR) and Virtual	The integration of AR and VR in education

	Reality (VR) In Modern Education Ahmad Sa'adi Journal of Education and Learning Sciences 2024 · 0 citations	and interactive learning experiences in modern education, but challenges like cost and technical limitations remain barriers to widespread adoption.	Reality (VR) in education transforms traditional learning methods by offering immersive experiences, enhancing experiential learning, motivation, and comprehension, but faces challenges such as high costs and technical limitations that require affordable solutions and improved teacher preparedness to maximize impact.	learning, increased motivation, and better comprehension of complex concepts. - High costs, technical limitations, and the need for teacher training are significant barriers to widespread adoption. - Affordable solutions, improved teacher preparedness, and better infrastructure are essential for maximizing the impact of AR and VR in education.	motivation, and better comprehension of complex concepts	Reality (VR) in education has transformed traditional learning methods by offering immersive and interactive learning experiences, with benefits including enhanced experiential learning and increased motivation, but challenges such as high costs and technical limitations need to be addressed for widespread adoption.	transforms traditional learning by offering immersive experiences, enhancing experiential learning, motivation, and comprehension, but faces challenges like high costs and technical limitations, which can be addressed by affordable solutions, teacher preparedness, and better infrastructure .
48	Virtual and Augmented Reality in Education Based on CogInfoCom and cVR Conference Insights Borbála Berki +1 IEEE International Conference on Cognitive Infocommunications 2024 · 0 citations	The paper examines the use of VR and AR in education, highlighting the rise of VR-based research and the application of different VR devices in educational and training scenarios.	This paper investigates educational virtual and augmented realities within the Cognitive Infocommunications and Cognitive Aspects of Virtual Reality conference series, analyzing trends from 2016 to 2023 to identify key themes, technological differences, and applications in higher education, professional training, and safety training, aiming to provide insights into the evolving	- The study identifies a significant rise in VR-based educational research, particularly in higher education and professional training. - The prevalence of different VR devices, such as desktop VRs and head-mounted displays, is examined in various educational scenarios. - The study aims to provide insights into the evolving landscape of	- Key themes in VR and AR use for educational purposes - Technological differences in VR and AR use for educational purposes - Rise in VR-based educational research - Prevalence of different VR devices - Application of VR devices in safety training and other educational scenarios	This paper investigates educational virtual and augmented realities within the Cognitive Infocommunications and Cognitive Aspects of Virtual Reality conference series, analyzing trends from 2016 to 2023 to identify key themes and technological differences in VR and AR use for educational purposes, with a focus on enhancing learning experiences.	The study discusses the evolving landscape of virtual and augmented reality in education, highlighting a significant rise in VR-based research in higher education and professional training, and examines the use of different VR devices and their applications in enhancing learning experiences.

			landscape of VR and AR in education.	VR and AR in education and their potential to enhance learning experiences.			