Immersive Technologies for Special Students in Higher Education: A Systematic Literature Review

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In recent years, immersive technologies like Augmented Reality (AR) and Virtual Reality (VR) have garnered considerable attention for their potential to revolutionize educational practices, particularly in higher education. This study delves into the transformative capacity of AR and VR in enhancing learning experiences specifically for special students within higher education contexts. Employing a systematic literature review methodology, the research synthesizes existing studies focused on using AR and VR technologies in higher education, with a particular emphasis on special education. The findings underscore the significant potential of AR and VR to promote inclusive education and equity within higher education settings. These technologies offer tailored learning experiences that cater to the diverse needs of special students, ultimately enhancing comprehension and engagement through immersive and interactive environments. Moving forward, the study suggests several future research directions, including the need for empirical studies to assess the effectiveness of immersive technologies in supporting special students' learning outcomes.

Keywords: immersive technologies, augmented reality, virtual reality, special education

INTRODUCTION

Immersive technologies, such as augmented reality (AR) and virtual reality (VR), have been receiving significant attention in recent years because of their potential to transform teaching and learning in higher education. Their Immersive and interactive environments allow learners to engage in rich, multisensory experiences that make complex concepts more accessible and understandable. Immersive technologies have the potential to address the diverse learning needs of special education students by creating tailored learning experiences that cater to their abilities and preferences. Various studies have demonstrated that AR and VR technologies can improve literacy and engagement among special learners by providing visualizations, simulations, and interactive activities.

Educational institutions continue to explore immersive technologies to incorporate them into their teaching practices, requiring comprehensive literature reviews to synthesize existing research and identify key trends, challenges, and best practices. In higher education settings, such reviews can provide valuable insights for educators, administrators, and policymakers. This study aims to contribute to the ongoing

dialogue about inclusive education and technology integration by systematically reviewing the current state of research on immersive technologies for special students in higher education.

Purpose of the Study

Different methods have been used to assess immersive technologies' impact on students' academic performance. However, the impact of these technologies on special students, particularly in higher education, has yet to be thoroughly investigated. This paper presents a systematic literature review of immersive technologies, specifically AR and VR, and how they affect teaching and learning for special students in higher education to fill the gap in research. In this study, we review and synthesize existing research to determine how immersive technologies can support educational activities for students with disabilities and how higher education institutions can take advantage of these technologies to accomplish their inclusive goals.

By examining the current landscape of scholarly work, this study seeks to provide educators, administrators, educational researchers, and software developers with valuable knowledge of maximizing immersive technologies for students with disabilities. As a result, educational institutions can establish a competitive advantage and improve their learning outcomes.

BACKGROUND

Who Are Special Students?

Special students are identified based on various factors, including specific learning disabilities, emotional disturbances, or health impairments that can affect their educational experiences. These students may benefit from individualized learning plans, active engagement in classroom activities, and consistent communication with instructors to improve their educational outcomes. Special students require customized educational strategies due to their distinct developmental characteristics compared to their peers. Special education seeks to meet the specific needs of these students by offering specialized instruction that supports their learning and development.

In the realm of inclusive education, there is ongoing debate about whether special education should be delivered in separate settings or integrated into mainstream classrooms. Some studies argue that special schools and classes provide better support for students with special needs, while others advocate for inclusive practices to ensure equal educational access for all students. Leaders and administrators are vital in ensuring that the needs of all students, including those with disabilities, are met in line with special education policies and regulations. This responsibility includes offering evidence-based instructional practices, ensuring access to the general education curriculum, and providing sufficient resources to support the teaching and learning of students with special needs.

What Are Immersive Technologies?

Immersive technologies redefine the way users interact with digital content by creating a profound sense of immersion and presence. These technologies allow users to be transported into virtual environments or have digital elements seamlessly integrated into their real-world surroundings. This immersion enables users to engage with content in three-dimensional space, fostering a deeper level of exploration and interaction. In educational contexts, immersive technologies have shown great promise in revolutionizing learning experiences by providing students with hands-on, interactive environments that enhance comprehension and retention.

The impact of immersive technologies on education is significant, with institutions leveraging them to create dynamic learning environments that cater to diverse learning styles. By simulating real-world scenarios or providing virtual laboratories, educators can offer students opportunities for experiential learning that may not be feasible in traditional classroom settings. Furthermore, immersive technologies can potentially increase student engagement and motivation, as they provide interactive and visually stimulating experiences that capture learners' attention. As a result, students are more likely to actively

participate in their learning process, leading to improved learning outcomes and a deeper understanding of complex concepts.

History of Virtual Reality (VR) and Augmented Reality (AR) Technologies

The history of AR and VR can be traced back to pioneering efforts in the mid-20th century, exemplified by Morton Heilig's vision for creating immersive experiences. Heilig conceptualized the Sensorama in the 1950s, an early form of multisensory theater aimed at providing viewers with immersive experiences akin to virtual reality. However, it was only in the late 20th and early 21st centuries that significant advancements were made in the field.

In the 1980s and 1990s, VR technology began gaining momentum with the development of early VR headsets such as the Virtuality system and the Sega VR headset. While rudimentary by modern standards, these systems laid the groundwork for the immersive VR experiences we have today. Augmented reality also saw its nascent stages during this time, with research and development efforts focused on overlaying digital information onto the real world. One pivotal development was the creation of the ARToolKit in the late 1990s, which enabled real-time tracking of physical objects to superimpose computer-generated imagery.

The early 21st century marked a turning point for immersive technologies, with advancements in computing power, graphics processing, and display technologies driving progress. Companies like Oculus VR, founded in 2012, played a pivotal role in mainstreaming VR with the release of the Oculus Rift headset in 2016. Similarly, the launch of AR applications like Pokémon Go in 2016 demonstrated the potential of AR technology for gaming and entertainment, further fueling interest and innovation in the field.

Today, AR and VR technologies evolve rapidly, with applications across various industries, including entertainment, healthcare, architecture, and education. As technology advances and becomes more accessible, the potential for immersive technologies to reshape how we interact with digital content and the world around us is more significant.

LITERATURE REVIEW

The Current Impact of Immersive Technologies on Education

Literature on the current impact of immersive technologies in education provides valuable insights into the transformative potential of augmented and virtual reality in learning environments. Researchers across various studies have explored the benefits of integrating AR and VR technologies into educational settings, highlighting their ability to enhance student engagement, improve understanding of complex concepts, foster creativity and innovation, and support personalized and adaptive learning experiences.

AR and VR technologies have emerged as promising tools to revolutionize educational experiences, offering immersive and interactive learning environments. Integrating AR and VR into educational settings has enhanced student engagement, deepened understanding of complex concepts, and stimulated creativity and innovation. Comprehensive reviews of research studies have consistently demonstrated the positive impact of AR and VR interventions on various aspects of student learning outcomes, including knowledge acquisition, retention, and transfer. These technologies provide unique opportunities for experiential learning, catering to diverse learning styles and preferences.

Researchers exploring the potential benefits of AR and VR technologies in education highlight their ability to provide realistic simulations and virtual environments conducive to inquiry-based learning and the development of problem-solving skills. Educators can promote active student engagement and exploration by aligning AR and VR experiences with pedagogical goals, fostering more profound learning experiences. Moreover, AR and VR technologies offer new avenues for personalized and adaptive learning experiences, allowing educators to tailor educational content and activities to individual student needs and preferences. This customization enhances student motivation, self-efficacy, and academic achievement, contributing to more effective learning outcomes.

Recent investigations into the impact of mobile collaborative AR simulation systems have underscored significant improvements in learners' knowledge construction behaviors and learning performances

compared to traditional 2D simulation methods. These findings suggest the transformative potential of AR technologies in facilitating collaborative learning experiences and enhancing student outcomes. However, further research is needed to better understand the nuances of AR systems' learning behaviors and optimize their integration into educational contexts. Overall, integrating AR and VR technologies holds immense promise for reshaping educational practices and creating more engaging, interactive, and effective learning environments.

Challenges and Barriers in Adopting Immersive Technologies in Higher Education

Integrating immersive technologies, including AR and VR, presents significant challenges in higher education. Institutional barriers, such as limited support and inadequate infrastructure, alongside technical hurdles like the absence of training courses and technical team support, hinder the widespread adoption of AR and VR initiatives in teaching and learning practices.

Institutional barriers remain formidable hurdles in integrating augmented reality and virtual reality technologies within higher education. Despite their potential to revolutionize teaching and learning experiences, these technologies encounter resistance due to issues such as inadequate institutional support, limited infrastructure, and the reluctance of academic staff to embrace change. The implementation of AR and VR in higher educational institutions needs robust backing and a supportive environment for innovation.

A study by Alqahtani and AlNajdi sought to delve into faculty members' perceptions regarding the adoption of augmented reality as a pedagogical tool in Saudi universities, shedding light on potential impediments to its incorporation. The findings illuminated a consensus among faculty members regarding the challenges hampering the integration of AR technologies into teaching and learning practices within higher education. Among the identified obstacles, the lack of AR training courses emerged as a prominent issue, alongside constraints stemming from limited resources and insufficient technical support teams.

The limited uptake of augmented and virtual reality technologies in higher education is underscored by myriad factors, including the absence of cohesive policies, inadequate infrastructural support, and the perceived complexity of utilizing AR and VR tools. Furthermore, the absence of a comprehensive adoption framework within Higher and Tertiary Education settings exacerbates these challenges, hindering the seamless integration of AR and VR technologies into educational curricula.

Addressing these barriers necessitates concerted efforts to bridge the gap in training needs, particularly in navigating emerging technologies like VR and AR, to foster a more conducive environment for incorporating immersive technologies in educational settings.

Effectiveness of Immersive Technologies for Special Education

Augmented and virtual reality technologies are increasingly recognized for their potential to revolutionize special education, providing tailored learning experiences and fostering inclusive environments. These technologies offer innovative solutions to address diverse educational needs, promoting active engagement and enhancing learning outcomes for individuals with special education needs while promoting inclusive learning environments. AR and VR are increasingly recognized for their potential to revolutionize special education, providing novel avenues for tailored learning experiences and promoting inclusive learning environments. AR environments designed to promote independence and autonomy for individuals with special education needs have shown promising results. These AR teaching materials offer real-life experiences that enhance student engagement, enthusiasm, and readiness for lessons, ultimately leading to improved learning outcomes.

The integration of AR into the curriculum has significantly enhanced academic achievement, particularly in diverse classrooms. AR technology facilitates effective content delivery and engagement, resulting in increased academic achievement and content retention, even among students with special educational needs. Immersive technologies like AR foster engagement and active participation, contributing to positive learning outcomes for all students.

Additionally, mixed reality (AR AND VR) interventions have significantly improved various aspects of special education needs settings. These interventions have enhanced students' mental well-being,

academic performance, and social skills. In a study on evaluating the use of Immersive Interactive Mixed Reality technology in Special Needs Education, teachers reported that mixed reality interventions were beneficial due to their engaging and interactive nature, fostering higher student involvement and facilitating social skills development. These findings highlight the transformative potential of immersive technologies in special education, offering innovative solutions to address diverse educational needs and promote positive learning outcomes for all students.

According to Rosli and Mohd, Assistive technology, particularly virtual reality (VR), can significantly benefit individuals with Autism Spectrum Disorder (ASD) in various aspects of their lives. VR technology has shown promise in enhancing the social performance of special students by enabling more effective interaction with others and facilitating their integration into society.

METHODOLOGY

This study employs a rigorous and transparent methodology to ensure trustworthiness, validity, and reliability. Studies are selected for inclusion in the review based on clearly defined and documented criteria to ensure they are relevant and of high quality. The study uses a comprehensive, transparent, documented search process to minimize bias risks and ensure replicability. Using a systematic literature review, the study addresses three research questions regarding AR and VR for special education by summarizing research findings. In this section, Okoli proposes a guideline to describe the systematic literature review process.

Identifying the Research Questions

A successful review process requires a well-constructed research question(s). Several research questions related to AR and VR for special education were examined in this review. The research questions were developed based on the PICO framework. They are as follows:

The research questions are as follows:

1. ***Research question 1 (RQ1):*** *What characteristics of immersive technologies are used for teaching and learning in higher education? This question aims to identify the characteristics and applications of immersive technologies in higher education.*
2. ***Research question 2 (RQ2):*** *To what extent do immersive technologies play a role in the educational experiences of special students? The purpose of this question is to understand the impact of immersive technologies on the educational experiences of special students.*
3. ***Research question 3 (RQ3):*** *What are the existing accessibility issues with Immersive technologies? This question aims to understand the accessibility challenges associated with immersive technologies in education.*

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for the selected studies in this systematic literature review are outlined in this section. The following criteria were included:

a) Higher Education: The studies had to specifically address the impact of immersive technology on higher education, ensuring relevance to the research objectives.
b) Language: Articles published only in English were included to facilitate comprehensive analysis and interpretation.
c) Peer-Reviewed: Peer-reviewed articles were considered to ensure a rigorous evaluation process and maintain study quality.
d) Publication Date: Studies published between 2019 and 2023 were included to incorporate recent research and reflect current perspectives on immersive technological impacts on special students in higher education.

In contrast, the exclusion criteria were designed to exclude articles that did not meet these criteria, such as non-English articles, non-peer-reviewed publications, and studies published before 2019 and After 2023. A surge in virtual technologies occurred during the COVID-19 pandemic, and the educational sector

utilized them during the lockdown. This period also saw an increase in interest in immersive technologies. The review range is intended to provide current and relevant results and a glimpse into how immersive technologies were employed before the pandemic. The inclusion and exclusion criteria were developed to ensure relevant, specific, and up-to-date studies were selected, contributing to the findings' reliability. This study's inclusion and exclusion criteria are summarized in Table 1 below:

TABLE 1
INCLUSION AND EXCLUSION CRITERIA

Inclusion	Exclusion
Education	Other Fields
Articles in English	Articles not in English
Peer-reviewed	Not Peer-reviewed
Between 2019 and 2023	Before 2019 and After 2023

Finding and Cataloging Resources

This systematic literature review uses three prominent electronic databases for data collection: IEEE Xplore, ERIC, and Taylor & Francis. IEEE has established a reputation for prestigious publishing and distinguished standing within the academic community, affirming the prominence of its journals. Using this database can enhance researchers' visibility and recognition. With ERIC, one can access various scientific and technical articles, papers, and publications in education, educational technology, and related fields. Taylor & Francis is known for publishing high-quality scholarly journals across various disciplines, including humanities, social sciences, behavioral sciences, science, technology, engineering, and medicine. The content provided by these databases is regarded as reliable and peer-reviewed, resulting in an extensive and secure archive of data qualified for analysis.

Every systematic research process uses a search strategy to identify the most relevant articles for analysis. Relevant keywords are formulated into search strings to create a well-organized search strategy. The search employed keyword searches with Boolean operators (e.g., OR, AND) to enhance the specificity and relevance of the retrieved academic literature. For instance, keywords like "Virtual reality OR Augmented reality" were combined with "Disability OR Impairment" to yield a focused and comprehensive search result.

TABLE 2
SEARCH TERMS

Database	Search String	Number of Articles
IEEE	**("Virtual reality" OR "VR" OR "Augmented reality" OR "AR") AND ("disability" OR "disabled" OR "impairment") AND "Education"** **Filters Applied: Conferences, Journals, 2019 - 2023**	138
ERIC	**("Virtual reality" OR "VR" OR "Augmented reality" OR "AR") AND ("disability" OR "disabled" OR "impairment") AND "Education"** Filters: last 5 years, Journal articles, Higher education	6

Taylor Francis	&	[[All: “virtual reality”] OR [All: “vr”] OR [All: “augmented reality”] OR [All: “ar”]] AND [[All: “disability”] OR [All: “disabled”] OR [All: “impairment”]] AND [All: “education”] AND [All Subjects: Education] AND [Article Type: Review Article] AND [Publication Date: (01/01/2019 TO 12/31/2023)]	2

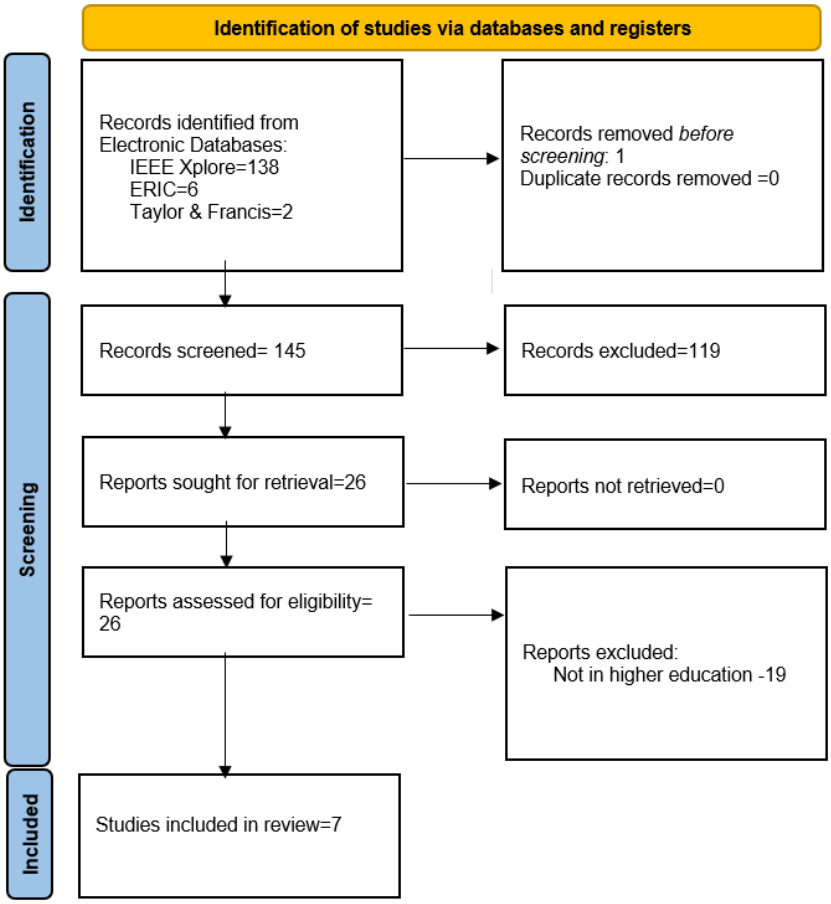
DATA ANALYSIS

The literature review used the PRISMA model (discussed in the next section). The data from each study were extracted based on factors such as the publication year, target population, study domain, and research objectives. The synthesized data were analyzed qualitatively to identify common themes, patterns, and relationships across the selected studies. The analysis involved a process of categorization and thematic synthesis.

The Prisma Model

A widely recognized and utilized framework for conducting and reporting systematic reviews and meta-analyses is the PRISMA model, which stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Fig. 1. shows the PRISMA flow diagram that shows the flow of studies in the review process.

FIGURE 1
PRISMA FLOW CHART



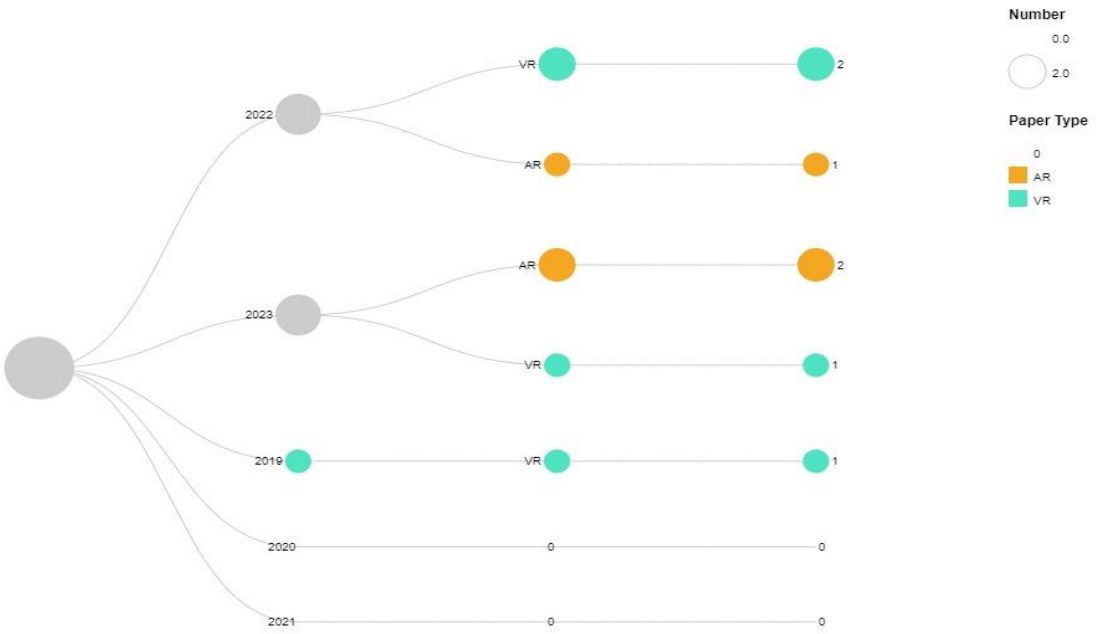
During the identification stage, 146 articles closely matching the research area of interest were retrieved from the three databases. 138 papers from IEEE, 6 from ERIC, and 2 from Taylor and Francis. The study selected articles based on their titles, containing the key search terms. A rigorous screening process followed the initial selection to ensure that only appropriate articles were included. During this stage, a total of 120 articles were excluded due to reasons such as non-matching titles, abstracts, and removal of articles from a database. A full-text reading of the articles resulted in the removal of 19 articles that were not in higher education. Finally, seven papers were deemed suitable for the literature review purely in the context of education. These articles solely focused on AR and VR for special students in higher education. The screening results found 6 relevant articles from IEEE, 1 from ERIC, and 0 from Taylor & Francis databases.

TABLE 3
SUMMARY OF ARTICLES

Citation	Study Objective	Target Audience	Domain	Database
D. Shidende et al. (2023)	The study's objective is to evaluate the usability and accessibility of an augmented reality (AR) authoring tool called MirageXR, specifically targeting users with disabilities such as blindness or deafness.	The target audience includes educators and learners in educational settings who may benefit from AR technology.	The study domain focuses on exploring the potential of AR technology in creating accessible learning experiences for individuals with disabilities.	IEEE
E. Yeguas-Bolívar et al. (2022)	The study aims to develop virtual reality software and an AI-based assistant to help students with dyslexia.	The target audience includes dyslexic students, educators, and researchers.	The study domain revolves around the intersection of technology, education, and cognitive psychology, with a specific focus on dyslexia.	IEEE
J. M. Alcalde-Llergo et al.(2023)	The main objective of the study is to propose a virtual reality (VR) serious game that increases empathy towards students with phonological dyslexia. The game aims to help teachers, students, and individuals without dyslexia understand the challenges faced by dyslexic students and the importance of offering support to them.	The target audience includes teachers, students, and individuals who do not have dyslexia. Specifically, the game is designed to increase empathy and understanding among these groups towards students with phonological dyslexia.	The study falls within the domain of educational technology and special education.	IEEE

Jdaitawi & Kan'an (2022)	The study aims to examine the effect of AR on assisting special needs students in their learning outcomes in higher education settings.	The target audience is researchers, educators, and practitioners interested in the application of AR in special education, particularly in higher education settings.	The study falls within the domain of educational technology and special education.	ERIC
P. Jindal et al.(2023)	The study objective is to address inclusive challenges by developing an AR application that provides relevant information about various points of interest on the campus of Trinity Western University, thus improving accessibility and inclusivity.	The target audience is university students, faculty, staff, and visitors who may benefit from enhanced campus navigation and information accessibility.	Higher education	IEEE
T. Luzuriaga et al.(2022)	The objective of the study is to explore the use of virtual reality (VR) technology in undergraduate electrical engineering education, specifically to provide remote students and students with disabilities access to hands-on engineering labs.	The target audience includes undergraduate students in electrical engineering courses, particularly those who are unable to physically attend traditional laboratory sessions due to remote learning requirements or disabilities.	The study falls within the domain of engineering education, focusing on innovative practices to enhance the learning experience for students in electrical engineering programs.	IEEE
Y. -T. Chen et al.(2019)	The study aims to evaluate the effectiveness of an interactive note-taking interface called iVRNote in a virtual reality (VR) classroom compared to traditional pen and paper (PW) learning from viewing a lecture.	The target audience includes students in higher education or learning environments where lectures are a standard mode of instruction.	The study falls within the domain of educational technology, specifically focusing on the use of immersive technologies like VR to enhance learning experiences.	IEEE

FIGURE 2
ARTICLE PUBLICATION BY YEAR, TYPE, AND NUMBER OF RECORDS



DISCUSSION

TABLE 4
CATEGORIZATION OF SELECTED ARTICLES PER RESEARCH QUESTION

Research question	Author(s)	Article title	Category
(RQ1): What characteristics of immersive technologies are used for teaching and learning in higher education?	J. M. Alcalde-Llergo et al., (2023)	A Decade of Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education	**Characteristics and applications of AR and VR**
	P. Jindal et al., 2023	Augmented Reality Campus Exploration Application Incorporating Equity, Diversity, and Inclusion	
	E. Yeguas-Bolívar et al., 2022	Determining the Difficulties of Students With Dyslexia via Virtual Reality and Artificial Intelligence: An Exploratory Analysis	
	Y. -T. Chen et al., 2019)	iVRNote: Design, Creation, and Evaluation of an	

		Interactive Note-Taking Interface for Study and Reflection in VR Learning Environments	
	D. Shidende et al., 2023)	Towards Accessible Augmented Reality Learning Authoring Tool: A Case of MirageXR	
	T. Luzuriaga et al., 2022)	Work in Progress: Using Virtual Reality Technology for Remote Students and Students with Disabilities in an Electrical Engineering Lab	
	P. Jindal et al., 2023)	Augmented Reality Campus Exploration Application Incorporating Equity, Diversity, and Inclusion Diversity and Inclusion	
(RQ2): To what extent do immersive technologies contribute to the educational experiences of special students?	D. Shidende et al., 2023)	Towards Accessible Augmented Reality Learning Authoring Tool: A Case of MirageXR	**The impact of immersive technologies on the learning experiences of special students**
	J. M. Alcalde-Llergo et al., 2023)	A Decade of Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education	
	E. Yeguas-Bolívar et al., 2022)	Determining the Difficulties of Students With Dyslexia via Virtual Reality and Artificial Intelligence: An Exploratory Analysis	
	Y. -T. Chen et al., 2019)	iVRNote: Design, Creation, and Evaluation of an Interactive Note-Taking Interface for Study and Reflection in VR Learning Environments	
	T. Luzuriaga et al., 2022)	Work in Progress: Using Virtual Reality Technology for Remote Students and Students with Disabilities in	

		an Electrical Engineering Lab	
	P. Jindal et al., 2023	Augmented Reality Campus Exploration Application Incorporating Equity, Diversity, and Inclusion	
	E. Yeguas-Bolívar et al., 2022)	Determining the Difficulties of Students With Dyslexia via Virtual Reality and Artificial Intelligence: An Exploratory Analysis	
(RQ3): What are the existing accessibility issues with Immersive technologies?	Y. -T. Chen et al., 2019	iVRNote: Design, Creation, and Evaluation of an Interactive Note-Taking Interface for Study and Reflection in VR Learning Environments	**Accessibility Issues with Immersive Technologies**
	D. Shidende et al., 2023)	Towards Accessible Augmented Reality Learning Authoring Tool: A Case of MirageXR	
	P. Jindal et al., 2023	Augmented Reality Campus Exploration Application Incorporating Equity, Diversity, and Inclusion	
	E. Yeguas-Bolívar et al., 2022)	Determining the Difficulties of Students With Dyslexia via Virtual Reality and Artificial Intelligence: An Exploratory Analysis	

RQ1: Characteristics and Applications of AR and VR Technologies Used in Higher Education

Augmented Reality overlays digital content onto the real world, allowing users to interact with virtual elements in their physical environment. This technology enhances the user's perception of reality by adding digital information such as images, videos, or 3D models to the real-world environment. Conversely, virtual reality immerses users in a completely digital environment, simulating a realistic sensory experience that can be explored and interacted with in three dimensions. VR typically requires the use of a head-mounted display (HMD) or other specialized equipment to fully immerse users in the virtual environment. These technologies provide users with interactive and immersive experiences, offering new opportunities for learning and engagement in various contexts, including education.

Augmented Reality and Virtual Reality technologies are revolutionizing higher education by offering immersive and interactive learning experiences. In research by Z. Jin & Z. Meiyu, augmented reality technologies provide unique opportunities to enhance classroom instruction and create tailored learning environments for students with disabilities. AR is applied to simulate experiences that help individuals

understand and empathize with the challenges faced by students with dyslexia, enhance campus exploration experiences, and provide relevant information to users.

The application of AR and VR technologies in higher education involves using various tools and technologies to create and operate immersive learning experiences.VR headsets, such as MirageXR, sensory gloves, interactive touchscreens, and controllers, were commonly used to engage students in virtual environments. These tools enable educators to develop interactive and accessible content tailored to the diverse learning needs of students with disabilities. Features such as voice commands, audio descriptions, and tactile feedback enhance the learning experience and support inclusive education practices.

Furthermore, immersive technologies are utilized to create interactive simulations and tailored experiences that replicate dyslexic reading difficulties, allowing teachers to gain insights into the challenges faced by students with learning disabilities. Overall, integrating AR and VR in higher education offers innovative solutions to enhance classroom instruction, promote experiential learning, and support diverse learning needs.

RQ2: The Impact of Immersive Technologies on the Learning Experiences of Special Students

Immersive technologies offer promising opportunities to enhance the educational experiences of impaired students by providing immersive and interactive learning environments tailored to their unique needs. Virtual reality technologies can positively impact students by accommodating various learning styles and disabilities and offering alternative modes of engagement and interaction. For example, VR environments can be designed to cater to different learning styles, such as visual, auditory, kinesthetic, or tactile learners, because of their graphical, auditory, and experiential abilities. In addition, students with mobility impairments can participate in educational activities from anywhere with an internet connection. By providing multisensory experiences and interactive simulations, virtual reality enables special students to explore educational content in a visually engaging and hands-on manner, which can enhance comprehension and retention of material.

Furthermore, VR can increase empathy and understanding towards students with disabilities by simulating experiences that help educators gain insights into the challenges faced by individuals with impairments. AR fosters a deeper understanding of complex concepts through immersive simulations and interactive learning environments and promotes inclusivity in education. For example, in a science class, students could use AR to explore the human body in three dimensions, allowing them to visualize organs and physiological processes more intuitively than traditional textbooks or diagrams. By immersing students in these simulations, AR facilitates a deeper understanding of abstract or challenging concepts by providing a hands-on learning experience that stimulates multiple senses. AR fosters inclusivity in education by ensuring that all students can engage with course materials in a way that resonates with them. AR and VR technologies offer customizable experiences that cater to individual learning needs, allowing students to engage with educational content that suits their preferences and abilities.

Overall, integrating AR and VR in special education holds significant potential to transform educational experiences for impaired students. By providing access to interactive virtual environments and alternative modes of engagement, AR and VR can enhance engagement, comprehension, and retention of educational content, ultimately promoting inclusive and accessible learning environments for all students.

RQ3: Accessibility Issues With Immersive Technologies

Accessibility issues pose significant challenges to effectively integrating immersive technologies in teaching and learning environments. These challenges include inadequate support for individuals with sensory impairments, input responsiveness, complicated user interfaces, the absence of standardized accessibility guidelines, hardware limitations, such as bulky headsets and controllers, which may be difficult for some users to operate, particularly those with mobility impairments or dexterity limitations. According to Jindal et al., the lack of standardized accessibility features in AR and VR applications further compounds these issues, making it challenging for users with disabilities to access and interact with educational content. For example, features such as screen readers, voice commands, alternative input methods, and adjustable text size may need to be included or adequately implemented. These features are

necessary for users with visual, hearing, or mobility limitations to navigate and interact with the content effectively. Many developers may not fully understand the diverse needs of users with disabilities or may prioritize other design considerations over accessibility.

According to Yeguas-Bolívar et al., concerns regarding the cost and availability of hardware and potential discomfort or motion sickness associated with prolonged use of VR devices present additional barriers to accessibility. These factors may disproportionately affect individuals with limited financial resources or those who experience physical discomfort when using immersive technologies. They emphasize the need for specialized training for educators to integrate VR effectively into teaching practices, adding another layer of complexity to addressing accessibility issues in educational settings. Shidende et al. Highlights input responsiveness, navigation difficulties, and inconsistent user interfaces associated with immersive technologies. According to the study, these challenges particularly affect users with disabilities, such as those who depend on assistive technologies or alternative interaction methods.

To mitigate these challenges and promote inclusivity in AR and VR-based learning environments, it is essential to prioritize inclusive design principles and provide alternative modalities for accessing educational content. Inclusive designs may involve developing accessible user interfaces, implementing support for assistive technologies, and ensuring that educational materials are presented in multiple formats to accommodate diverse learning needs. Additionally, raising awareness among educators about accessibility considerations and providing training on creating inclusive AR and VR experiences can help ensure that these technologies are accessible to all learners, regardless of their abilities or limitations.

CONCLUSION

In conclusion, the comprehensive exploration of immersive technologies for special students in higher education through this systematic literature review underscores the transformative potential of AR and VR. By synthesizing existing research, it becomes evident that AR and VR offer tailored learning experiences that cater to the diverse needs of special students, enhancing comprehension and engagement through immersive and interactive environments.

This study illuminates the critical role of immersive technologies in promoting inclusive education and fostering equity in higher education settings. By providing valuable insights for educators, administrators, policymakers, and software developers, this review paves the way for maximizing the benefits of AR and VR in supporting students with disabilities.

Looking ahead, educational institutions must embrace the opportunities presented by immersive technologies while addressing challenges related to accessibility and standardization. Through ongoing research and practical implementations, educators can leverage AR and VR to create dynamic and inclusive learning environments that empower all students to succeed.

IMPLICATIONS

A. **Educational Practice:** The findings suggest that educators and institutions can leverage immersive technologies, particularly AR and VR, to enhance teaching and learning experiences, especially for special students. By embracing these technologies, educators can create inclusive learning environments that cater to diverse learning needs and preferences.
B. **Technology Integration*:*** Institutions need to seriously consider integrating immersive technologies into their educational practices. This involves investing in infrastructure, training faculty, and developing appropriate content to maximize the benefits of AR and VR in higher education settings.
C. **Equity and Accessibility:** Immersive technologies have the potential to promote equity and accessibility in education by providing tailored learning experiences for students with disabilities. However, continued research and development are needed to ensure that these technologies are inclusive and accessible to all learners.

D. Accessibility Features*:* Developers should prioritize integrating accessibility features into AR and VR applications to ensure that they are inclusive and usable by all learners, including those with disabilities. This may involve incorporating features such as customizable interfaces, voice commands, and compatibility with assistive technologies. Collaboration between developers and educators is essential to ensure that AR and VR applications meet the needs of educational settings.

E. Future Research Directions: The study highlights the need for further research to explore the effectiveness of immersive technologies in supporting special students' learning outcomes. Future studies could focus on specific educational contexts, pedagogical approaches, and technological innovations to deepen our understanding of how best to utilize AR and VR in higher education.

LIMITATIONS

It is essential to recognize that the study may have specific limitations that could impact its findings.

A. Specific time frame: One limitation of the study is the restriction to a specific time frame in the coverage of literature. By focusing on a particular span of years, the study may overlook recent developments or disregard insights from earlier studies, potentially missing out on historical perspectives and trends in immersive technologies for teaching and learning.

B. Scope and Coverage: The study's scope is limited to specific types of immersive technologies, such as AR and VR, potentially excluding other emerging technologies or alternative approaches that could also benefit special students.

C. Accessibility: The accessibility of the reviewed literature, including language barriers, could limit the inclusivity of the study and the comprehensiveness of the synthesized findings.

D. Generalizability*:* Findings from the literature review may only be universally applicable across some higher education institutions or special student populations due to variations in educational contexts, technological infrastructure, and student demographics.

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