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Understanding the Impact of Animation Technology in Virtual Reality: A Systematic Literature Review

Mohd Ekram Alhafis Hashim[1], Nur Safinas Albakry[1,*], Wan Azani Mustafa[2], Banung Grahita[3] Miharaini Md Ghani[4], Hafizul Fahri Hanafi[5], Suraya Md Nasir[1], Catherina Ana Ugap[1]

[1] Department of Multimedia Creative, Faculty of Arts, Sustainability and Creative Industry, Sultan Idris Educational University, Malaysia
[2] Faculty of Electrical Engineering & Technology, University Malaysia Perlis, Malaysia
[3] Faculty of Art & Design, Institute Technology Bandung, Indonesia
[4] School of Communication, University Sains Malaysia, Malaysia
[5] Department of Computer Science and Technology, Faculty of Computing and Meta-Technology, Sultan Idris Educational University, Malaysia

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ABSTRACT

This systematic literature review examines at the impact of animation technology on virtual reality (VR) environments. Using complex search techniques on the Scopus and ERIC databases, 30 articles were chosen, with an emphasis on the keywords "animation," "virtual reality," and "technology." The investigation identifies three major themes: improved user experience, educational integration, and industry innovations. The study investigates how animation innovations contribute to immersion, presence, and involvement in virtual reality contexts. Educational Integration studies the use of animation technology in training simulations, virtual classrooms, and skill development. Industry Innovations evaluates the impact of animation technology on various industries, highlighting developing trends and potential for innovation. This study, through a thorough analysis of the literature, gives significant insights into the varied relationship between animation technology and VR, shedding light on its importance for user engagement, educational applications, and industrial advancement. Keywords include animation, virtual reality, technology, enhanced user experience, educational integration, and industry innovations.

1. Introduction

In recent years, the confluence of animation technology and virtual reality (VR) has accelerated the creation of immersive and interactive experiences in a variety of areas. This systematic literature study aims to thoroughly investigate the consequences of animation technology in VR environments. This study uses advanced search algorithms on the Scopus and ERIC databases to identify and analyze 30 publications containing the keywords "animation," "virtual reality," and "technology." The literature review is organized around three major themes: enhanced user experience, educational integration, and industry innovations. Enhanced User Experience studies how animation innovations

* *Corresponding author.*
E-mail address: ekram@fskik.upsi.edu.my

improve immersion, presence, and interactivity in VR environments, ultimately changing user engagement. Educational Integration investigates the use of animation technology for educational objectives, such as training simulations, virtual classrooms, and skill development, and provides insights into its effectiveness when compared to traditional techniques[1]. Finally, Industry Innovations evaluates the impact of animation technology on various industries, identifying emerging trends and potential for innovation. This study intends to provide a thorough knowledge of the varied relationship between animation technology and VR by a systematic assessment of existing literature, explaining its significance for user experiences, educational practices, and industrial breakthroughs. This study contributes to the ongoing discussion on animation technology and its integration into virtual reality environments by conducting a thorough analysis of significant findings and critical insights.

2. Literature Review

The combination of animation technology and virtual reality (VR) has created new opportunities for immersive experiences across multiple fields[2]. This literature review will investigate the conceptual framework, ideation, and future conversations surrounding the impact of animation technologies in virtual reality environments.

2.1. Conceptual Framework: Animation Technology and Virtual Reality

Animation technology, which is based on the development of dynamic visual information, has undergone substantial evolution over time[3]. Previously limited to cinema and entertainment, advances in animation technology have cleared the door for their use into virtual reality situations. Virtual reality, on the other hand, provides immersive experiences by mimicking real-world environments or constructing wholly fictional ones using computer-generated visuals[4]. The usage of animation technology in VR goes beyond entertainment, providing prospects for improved user experiences, educational applications, and industrial breakthroughs.

2.2. Exploring the Nexus of Animation and Virtual Reality

The concept of immersion is central to the relationship between animation and virtual reality. Both animation and virtual reality rely heavily on immersive experiences that create a sense of presence and engagement[5], [6]. Animation technology enhances immersion by producing lifelike people, dynamic landscapes, and captivating storytelling[7]. When paired with VR technology, animation heightens immersion by allowing users to interact with and inhabit virtual environments. Furthermore, animation in VR enhances storytelling in novel ways, allowing for narrative exploration and user-driven experiences [8]. The ideation portion of this evaluation focuses on how animation technology enhances virtual reality's immersive qualities, changing user perceptions and experiences [9].

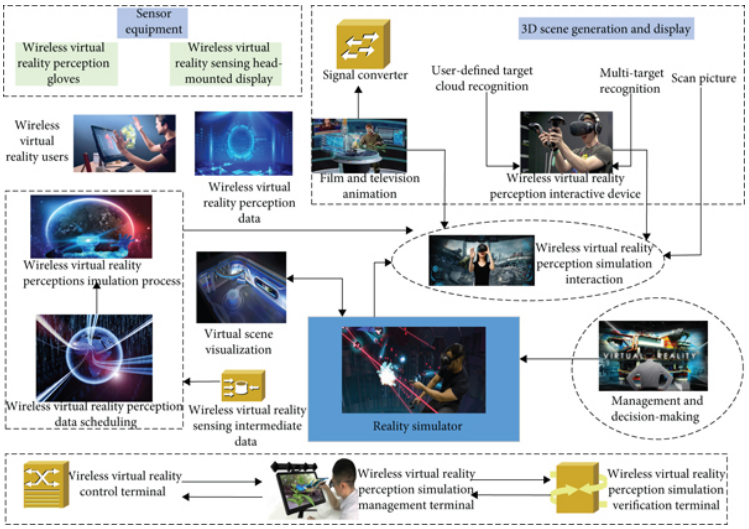

Fig. 1. Virtual reality system architecture [7]

2.3. Emerging Trends and Opportunities

Looking ahead, there are various developing trends and prospects in animation technology and virtual reality that merit additional investigation. One such trend is the democratization of content creation, which is made possible by easily accessible animation tools and VR platforms. As these technologies grow more user-friendly and inexpensive, people from all walks of life will be able to create immersive experiences [10]. Furthermore, the rise of augmented reality (AR) opens up new opportunities for combining animation with real-world surroundings, blurring the distinction between physical and digital realities [11,12]. Furthermore, the possible uses of VR animation include education, healthcare, and workplace training, in addition to enjoyment. Using animation and VR, educators can create compelling learning experiences, healthcare practitioners can replicate medical procedures, and corporations can hold virtual meetings and training sessions [10,13]. The future discussion section of this paper focuses on these upcoming trends and prospects, emphasizing animation technology's transformational potential in virtual reality environments.

3. Material and methods

3.1 Identification

In choosing several appropriate papers for this report, the systematic review process consists of three main phases. The first step is keyword recognition and the quest for linked, similar terms based on the thesaurus, dictionaries, encyclopedia, and previous studies. Accordingly, after all the relevant keywords were decided, search strings on Scopus and ERIC (see Table 1) database have been created. In the first step of the systematic review process, the present research work successfully retrieved 166 papers from both databases.

The identification phase involves searching for study materials relevant to the predetermined research issue. The keywords used are Immersive, experience and metaverse. Therefore, the first step was to detect keywords and search for similar, equivalent phrases in previous research. As a result, after determining all relevant phrases, search strings for the Scopus and ERIC databases were created (see Table 1). Thus, during the first part of the advanced searching procedure, this study effectively obtained 49 publications from the databases.

Table 1
The Scopus and ERIC databases

Scopus	TITLE-ABS-KEY ("Animation" AND "Virtual Reality" (technology AND impact)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))
ERIC	"Animation" AND "Virtual Reality" (technology AND impact)

3.2 Screening

Duplicated papers should be excluded during the first step of screening. The first phase omitted 166 articles, while the second phase screened 49 articles based on several inclusion-and- exclusion criteria developed by researchers. Literature (research articles) was the first criterion because it is the primary source of practical information. It also includes the exclusion from the current study of publications in the form of systematic review, review, meta-analysis, meta-synthesis, book series, books, chapters, and conference proceedings. Furthermore, the review concentrated exclusively on papers written in English. It is essential to note that the schedule was chosen for a four-year duration (2010–2024). In all, 117 publications based on specific parameters were excluded.

Table 3
The selection criterion is searching

Criterion	**Inclusion**	**Exclusion**
Language	English	Non-English
Time line	2010– 2024	< 2010
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

3.3 Eligibility

For the third step, known as eligibility, a total of 42 articles have been prepared. All articles titles and key content were thoroughly reviewed at this stage to ensure that the inclusion requirements were fulfilled and fit into the present study with the current research aims. Therefore, 42 reports were omitted because they were Full text excluded, due to the out of field (n=4), Title not significantly (n=5), Abstract not related on the objective of the study (n=3) based on empirical evidence. Finally, 30 articles are available for review (see Table 3)

3.4 Data Abstraction and Analysis

One of the assessment procedures employed in this study was integrative analysis, which was used to investigate and synthesise a variety of research designs (quantitative, qualitative, and mixed methods). The competence study's purpose was to discover significant themes and subtopics. The stage of data collection was the first step in the theme's development. Figure 2 depicts how the writers methodically examined a collection of 166 articles for assertions or material relevant to the current study's issues. The authors next reviewed the most recent significant papers on animation technology and Virtual reality. The methods employed in all investigations, as well as the research

findings, are being looked into. Following that, the author worked with other co-authors to build themes based on the data in animation technology and virtual reality education (Mohd Ekram Hashim-expert in new media and immersive technology (Virtual reality-animation), Wan Azani Wan Mustafa-expert in Human Computer Interaction (Technology) and Nur Safinas Albakry- expert in New media design) to determine the validity problems. The expert review phase ensures the clarity, importance and suitability of each subtheme by establishing the domain.

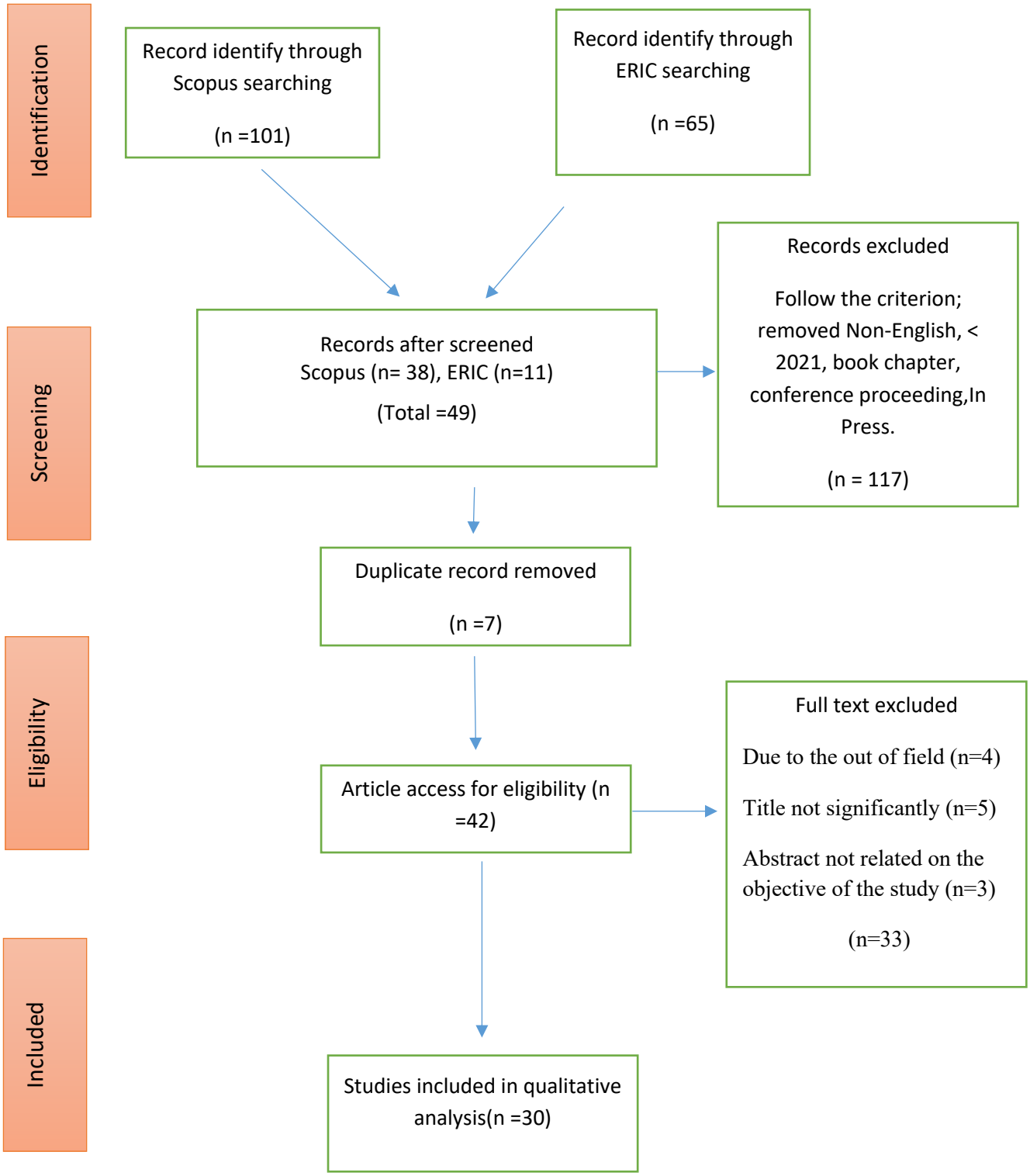

Fig. 2. Flow diagram of the proposed searching study [14]

4. Result and Finding

4.1 Synthesis Analysis Improved User Experience

The theme "Improve User Experience" is examined in a variety of studies, each focused on a particular feature and application of animation technology within virtual reality (VR) environments. A careful review and comparison of these experiments reveals crucial findings and insights, giving light on the effectiveness and obstacles of improving user experiences in VR using animation technology.

Rossoni *et al*., [2] propose integrating a virtual reality module into the product configuration and quotation process to improve industrial operations and customer interaction. The study highlights the potential of animation technology to speed up decision-making processes and increase user interactions in industrial settings by automatically generating virtual environments tailored to configured solutions. However, the study lacks empirical confirmation of user experience improvements, necessitating additional research to determine the efficacy of the suggested framework in real-world circumstances.

Wang *et al*., [8] on the other hand, tackle the problem of domain adaptation in image animation jobs by proposing a novel framework for synthesizing desired appearances and poses in still images. The proposed approach outperforms other animation tasks, such as human pose retargeting and facial expression transfer, by making use of domain-independent poses. The paper emphasizes the need of handling domain shift in animation algorithms to enable robustness and generalizability across various datasets and applications. Furthermore, the technology's potential impact on a variety of industries, including film production and online retail, highlights its relevance and scalability in real-world applications.

Lindquist *et al*., [15] contribute to the discussion by looking into the effects of multisensory simulation on environmental decision-making. The study investigates the impact of display type and acoustic circumstances on user perceptions and preferences by comparing digital animations exhibited on traditional screens and VR headsets. The findings indicate that realistic sound improves perceived biodiversity and preference, especially in VR situations. In addition, the study emphasizes the need of taking into account contextual contexts and sensory cues when building immersive experiences for decision support systems. However, the study's concentration on environmental decision-making limits its applicability to other fields, demanding additional research into user experiences in various VR applications.

Peng *et al*., [10] address the issues of dependability and real-time performance in virtual animation by providing a collision reconstruction approach that reduces virtual human unpredictability and behavior collisions. By combining behavior perception systems and collision prediction vectors, the proposed technique improves prediction accuracy and execution speed in virtual animation reconstruction. The study helps to improve the realism and dependability of virtual simulations, especially in domains like network, game, and industry applications. However, because the study is based on simulation experiments and theoretical frameworks, empirical validation and practical application are required to evaluate its usefulness in real-world circumstances.

Ho *et al*., [1] study the usage of high-immersive VR for spatial mapping in order to determine its effect on 3D software learning motivation. The study shows, using a VR painting experiment with university students, that immersive VR increases students' desire and enthusiasm in learning 3D animation. However, the study highlighted issues with hardware and space constraints, implying the need for practical solutions to promote widespread adoption of immersive VR technology in educational settings.

Shen *et al*., [9] aim to incorporate folk-art modeling into modern art design through the use of virtual reality (VR) and computer-aided design. The study's goal is to improve the human-computer interface (HCI) experience of art design through emotional and creative expressions using digital modelling approaches. However, the study does not provide empirical confirmation of the suggested framework's usefulness in improving user experiences, indicating the need for more research to measure its influence on user engagement and satisfaction.

John *et al*., [12] address privacy concerns about eye tracking in VR headsets by offering an optical defocus-based hardware solution that protects users' biometric identities. By eliminating iris patterns from eye tracking photographs, the study hopes to strike a compromise between biometric protection and user enjoyment during social VR interactions. The study's psychophysical trials and perceptual research provide useful information about users' sensitivity to changes in virtual avatar eye movements, as well as the perceived impact on eye contact and attentiveness. However, the study's emphasis on privacy protection may have overlooked other aspects of user experience, such as social presence and immersion, necessitating additional research to investigate holistic solutions that meet both privacy and user engagement.

Dzardanova *et al*., [16] look at the influence of nonverbal cues (NVCs) on user experience in immersive virtual reality (IVR), specifically in shared virtual worlds. By studying users' attention to NVCs and their impact on perceived realism, empathy, and social presence, the study offers insight on NVCs' modest but significant function in shaping user interactions and engagement in virtual worlds. However, the study's findings indicate that the effects of NVCs on user experience may be more complex than previously thought, underlining the importance of nuanced techniques to properly incorporate NVCs into VR applications.

Ma *et al*., [17] investigate multimedia-assisted new energy landscape design, which uses virtual reality (VR) and environmental analysis to produce visually appealing urban landscapes. The study's goal is to create immersive and visually appealing landscapes that resonate with consumers by combining multimedia technologies, environmental data, and artificial intelligence-driven design. The study's efficient approach provides intriguing opportunities to improve user experiences in multimedia-rich contexts. However, the study's emphasis on aesthetic design and environmental analysis may leave out other aspects of user experience, such as usability and interaction, prompting additional research to assess the overall influence of multimedia-assisted landscape design on user engagement and satisfaction.

The investigation of "Improve User Experience" throughout several studies yields numerous insights for utilizing animation technologies in virtual reality (VR) environments. From recommendations for incorporating VR modules into industrial workflows to resolving privacy problems in eye tracking, each study provides a distinct viewpoint on improving user interactions and engagement. While some research demonstrate encouraging advances, such as domain adaptation in visual animation and the favorable impact of high-immersive VR on learning motivation, others emphasize problems such as hardware limits and the difficulty of incorporating nonverbal cues into VR encounters. However, empirical validation and comprehensive techniques are required to ensure that these technologies are effective and inclusive in maximizing user engagement and happiness in VR applications.

4.2 Educational Integration

The research reviewed provide useful insights into the integration of technology in education, with each investigating the impact on learning outcomes and experiences in specific circumstances. Dong *et al*.,[11] Investigate the use of multimedia representation technology in museum contexts, as

illustrated by the China Digital Science and Technology Museum (CDSTM), which aims to improve science education and literacy through creative digital platforms. [18] Investigate the use of augmented reality (AR) and animation in engineering education, emphasizing their effectiveness in boosting student comprehension and cognitive load management, particularly in virtual product dissection exercises. Chiou and Hua [19] study examines on the usefulness of 3D virtual reality (VR)-based activities in technology university students' learning outcomes, demonstrating that it outperforms traditional lecture techniques, particularly in context-based course content. Similarly, [5] investigate the impact of virtual and augmented reality on children's learning experiences, focusing on their function in promoting emotional intelligence and creativity.

Despite the optimistic results, these research identify several limitations and problems. For example, Chiou and Hua [19] study emphasizes the significance of careful design and implementation of VR activities in order to achieve successful learning outcomes, whereas Kearney et al. emphasize the importance of empirical understanding and cognitive load management in virtual worlds. Furthermore, study's absence of random assignment, as well as probable methodological shortcomings, call into question the generalizability and validity of their findings.

The research mentioned provide light on the use of immersive technologies in education, such as virtual reality (VR) and augmented reality (AR), with each providing unique insights into their impact on learning outcomes and student engagement. [20] Investigate the use of VR simulators in medical education, demonstrating their potential to improve student motivation and learning efficacy. Using the Attention, Relevance, Confidence, and Satisfaction (ARCS) model, the study found significant gains in student engagement and comprehension, implying that VR technology has the potential to change traditional teaching practices.

Kranioti *et al*., [4] investigate the impact of mobile VR game-based learning on students' motivation and interest in a 3D operating system course. The findings show that such immersive learning experiences significantly increase students' motivation and engagement, highlighting immersive technology' transformative potential in altering educational paradigms.

In contrast to the concentration on VR, [21]provide an Augmented Reality Engineering Education Environment (AREEE) that enables interactive learning experiences. By combining AR technology with engineering equipment and tools, AREEE offers students immersive and hands-on learning experiences. The study shows that AREEE has a beneficial impact on students' interaction and learning results, emphasizing the potential of mixed reality concepts to improve STEM education methodologies.

The research reviewed provide light on the incorporation of technology in education, providing insights into how it affects learning outcomes in a variety of educational settings. For example, research into multimedia representation technology in museums, as well as the use of augmented reality (AR) and animation in engineering education, demonstrate the potential of digital platforms to promote science education and technical comprehension. Similarly, research on 3D virtual reality (VR) activities for university students, as well as studies on the impact of VR and augmented reality on children's learning experiences, show that immersive technology can help learners develop creativity and emotional intelligence.

Despite the positive results, these research highlight significant limitations, such as the need for careful design of VR activities and questions about the generalizability of findings due to methodological flaws. Nonetheless, the findings highlight immersive technology' revolutionary potential for altering educational paradigms and enhancing student engagement and learning outcomes across multiple educational areas.

Finally, the examined research give useful insights into the integration of technology in education, demonstrating its potential to improve learning outcomes and engagement across a variety of

educational situations. While highlighting the efficacy of immersive technologies such as virtual reality (VR) and augmented reality (AR) in improving comprehension and fostering creativity among learners, the studies also emphasize the importance of addressing methodological limitations and carefully designing immersive experiences. Despite these obstacles, the cumulative findings imply that immersive technologies have the potential to alter traditional teaching practices and shape the future of education by providing interactive, hands-on learning experiences that appeal to a variety of learning styles and preferences.

4.3 Industry Innovation

The works analyzed provide useful insights into industry innovation by investigating the interaction of technology, art, and science in various contexts. Kranioti *et al*., [13] take a unique technique to studying the history of violence, combining medical imaging, forensics, and virtual reality. Their initiative, which combines anatomical precision with creative art, offers viewers immersive experiences in which to ponder on the emotional, ethical, and aesthetic aspects of violence.

Similarly, Bhavana and Vijayalakshmi [22] research looks into the impact of augmented reality (AR) smartphone apps on student learning motivation in the Indian education system. Their findings emphasize the potential of AR technology to improve classroom engagement and learning results, emphasizing its importance in modern educational methods.

Wu [23] research, on the other hand, investigates the impact of visual style and creative color in bio-entrepreneurship, with a focus on how they affect consumer perception of biotechnology products. By suggesting multidisciplinary techniques that combine art and science, the study advocates for holistic design methodologies that embrace aesthetic considerations to improve product appeal and user engagement.

Sun *et al*., [3] Investigate spatial augmented reality (SAR) systems and their integration with existing extended reality (xR) technology to facilitate cooperation. Their study presents an egocentric spatial-communication taxonomy and different cues to aid spatial awareness in SAR situations. They use empirical evaluation to discover the most effective cues for improving collaboration and spatial understanding in augmented settings.

The works examined give light on different areas of industry innovation, particularly in the fields of film, television, virtual reality (VR), and judicial settings. [24] Investigate the convergence of digitized value chains in the film and game industries, emphasizing the growing integration of technology such as animation between both industries. Despite disparities in production styles and cultures, their research shows evidence of convergence, underlining the challenge of creating transmedial products that take advantage of technical breakthroughs like as Virtual Reality (VR).

In a similar line, Sun [6] research focuses into the use of 3D animation special effects in Chinese film and television productions, with a focus on visual impact and artistic expression. Using the film Avatar as an example, the study highlights the importance of three-dimensional technology in improving visual effects and contributing to the progress of Chinese cinema and television art.

Oliveira *et al*., [25] highlight the potential of Virtual Reality (VR) in different disciplines, including healthcare and rehabilitation. Their research looks at the usability of VR systems for medical therapy, highlighting the significance of adjusting interaction and avoiding problems like cybersickness. The study examines how different navigation approaches and levels of animation affect the effectiveness and user experience of VR rehabilitation applications.

Schofield's research looks at the changing landscape of courtroom surroundings, namely the increased use of visual media displays and digital evidence presentation technology. By investigating

the impact of forensic animation and virtual crime scene reconstructions on jurors, the study raises concerns about the persuasiveness of visualizations and emphasizes the importance of careful consideration when applying such technologies in courtroom contexts.

Oliveira *et al*., [26] Investigate adults' conceptions of the metaverse, revealing both a shared knowledge of the notion and some uncertainty about it. The conversations, which take place in focus groups with regular gamers, highlight the significance of wellness and social dimensions in immersive experiences, as well as the intricate relationships between the metaverse, virtual reality, animation, and gaming.

Similarly Yildirim *et al*., [27] investigate the user experience of contemporary virtual reality (VR) and its relationship with the concept of presence. The discussions compare different immersive strategies, such as watching a 360° movie versus interacting with a 3D game, to evaluate the sensitivity of presence questionnaires to these differences. The findings provide useful insights into the dynamics of user perception in immersive environments, with implications for the design and evaluation of VR experiences.

In another context, Lei *et al*., [7] present a revolutionary method to wireless virtual reality that incorporates transdisciplinary technologies and aims to improve human-computer interaction and user experience. The discussions address the limits of existing VR systems by providing a dual intention perception algorithm and a navigational interactive mode, highlighting the potential for immersive technology innovation. The conversations underscore the significance of taking human intent and multimodal interaction into account when designing VR systems, opening the door for better user experiences across a wide range of situations.

Furthermore, Cairó *et al*.,[28] concentrate on electronic negotiation systems in e-Commerce applications, introducing the idea of creating intelligent agents with negotiation and interaction capabilities in virtual reality environments. The discussions focus on the potential of such systems to bridge gaps in the Latin American market and improve electronic transactions using immersive technologies. By combining graphical agents with negotiating tactics, the discussions provide a fresh approach to addressing e-Commerce issues and increasing user involvement in virtual settings.

The papers analyzed provide unique insights into industry innovation, notably the integration of technology, art, and science across sectors [29]. The study takes an innovative way to exploring the history of violence, combining medical imaging, forensics, and virtual reality, showcasing the power of interdisciplinary collaborations to produce immersive experiences that prompt reflection on important societal issues. Similarly, [30]another study investigates the transformative influence of augmented reality (AR) smartphone apps on education, focusing on AR's function in improving student engagement and learning results, stressing its importance in modern pedagogical techniques.

Furthermore, an investigation into visual style and artistic color in bio-entrepreneurship underscores the importance of aesthetics in shaping consumer perception and engagement with biotechnology products, advocating for holistic design methodologies that prioritize aesthetic considerations [31]. Additionally, an exploration of spatial augmented reality (SAR) systems provides insights into collaborative technologies, elucidating effective cues for enhancing spatial awareness and cooperation in augmented environments, thus contributing to advancements in immersive technologies across diverse domains.

Finally, the research examined contribute significantly to our understanding of industry innovation across a wide range of sectors, including film, healthcare, and e-commerce. While these findings are significant, more research is required to address growing difficulties and fully explore immersive technology' potential in fostering innovation and societal improvement.

5. Discussion and Conclusion

The systematic literature review "Understanding the Impact of Animation Technology in Virtual Reality" compiles findings from many research papers on the junction of animation, virtual reality (VR), and technology. The primary themes discovered in the analyzed research include increasing user experience, incorporating VR into education, and encouraging industrial innovation. Analyzing these studies reveals that animation technology plays an important role in improving immersion, interactivity, and engagement within virtual environments. To begin, animation technology makes a substantial contribution to improving the user experience in virtual reality applications. Research has demonstrated that well-designed animations can provide a sense of presence and realism, increasing user immersion and enjoyment. Furthermore, animations help to convey information efficiently, guide users through virtual worlds, and facilitate interactions, resulting in a more rewarding user experience. Second, incorporating animation technology into educational VR apps has enormous potential for improving learning experiences. Research has shown that animated content can improve learners' comprehension, retention, and engagement, making complicated concepts more accessible and entertaining. Using animation technology, educators can develop engaging and immersive learning environments that cater to a variety of learning styles and encourage active involvement. Finally, animation technology supports industrial innovation by allowing for the creation of appealing VR experiences in a variety of areas. From entertainment and gaming to healthcare and e-commerce, animation-enhanced VR apps provide new methods to engage audiences, sell businesses, and deliver services. Furthermore, animation technology enables the creation of transmedia content across numerous platforms, creating new opportunities for storytelling and audience involvement.

There are various intriguing possibilities for future research in the field of virtual reality animation technology. First, researchers could look at the best design concepts for introducing animations into VR settings in order to enhance user engagement and learning results. Furthermore, investigations could look into the potential of animated VR experiences for therapeutic objectives such as rehabilitation and mental health treatments. Furthermore, research concentrating on the creation of novel VR applications for various industries could shed light on emerging trends and obstacles in this fast changing industry. Overall, future research should try to fully utilize animation technology in virtual reality to produce immersive, instructive, and unique user experiences.

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