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A Systematic Literature Review: User Experience in Virtual Reality Prototyping

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ABSTRACT

This paper delves into the realm of enhancing user experiences within the domain of virtual reality (VR) prototyping. The study meticulously analyses insights derived from a comprehensive review of user experience in virtual reality prototyping, presenting a consolidated overview of current research findings. A meticulous screening process, involving the shortlisting of 350 papers from Scopus databases and subsequent application of rigorous inclusion and exclusion criteria, culminated in the selection of 7 papers that were thoroughly evaluated for quality. As a stepping stone for future research endeavours, the paper suggests the integration of conference articles and the amalgamation of data from diverse databases to garner a more exhaustive understanding of this dynamic and evolving field. This work contributes to the ongoing discourse on user experiences in VR prototyping, providing a foundation for further exploration and innovation in this transformative technological landscape.

1. Introduction

Virtual reality (VR) is a transformative technology with the potential to revolutionize our experiences. It creates artificial sensory stimulation, effectively immersing our bodies in alternate realities [1]. The development of an immersive virtual reality environment relies on specialized software. Through the use of a head-mounted display (HMD), users are transported into the VR experience, creating a distinct departure from traditional user interfaces. This technology enables users to engage with the virtual environment and characters in a manner that feels genuine and authentic. Unlike any other technology before, VR has a unique capability to immerse individuals in an alternate reality, providing them with the convincing sensation of being in a different place. This immersive quality of VR facilitates experiential learning, allowing individuals to learn from their experiences in a manner akin to real-life situations [2].

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In today's tech-centric world, people rely on various digital tools and interact with them through user interfaces, making User Experience (UX) a critical factor for success [3]. UX, in this context, encompasses users' emotions, attitudes, thoughts, behaviours and perceptions throughout their usage journey [4].

User experience in virtual reality (VR) prototyping is significantly influenced by external factors, particularly network performance. Studies indicate that variables such as traffic load, weather conditions and distance from base stations can impact mobile network performance, ultimately affecting the quality of digital interactions, especially in high-demand environments like university campuses, where reliable connectivity is essential for creating immersive VR experiences [5]. Furthermore, generative AI plays a crucial role in enhancing content creation within VR prototyping by automating the development of diverse and personalized experiences. This automation reduces manual effort and facilitates tailored interactions, leading to improved user engagement in educational and training contexts [6]. Additionally, advancements in animation technology have been shown to significantly enhance user experience in VR by improving immersion, presence and engagement within virtual environments [7].

Simultaneously, a prototype plays a role in shaping the overall feel or focus of the learning session, offering a preview or indication of what will be covered or emphasized during the session [8]. A prototypes are essential in the entire design process, not just in the end. They help us explore new ideas, understand the user's needs and communicate design concepts effectively, serving as versatile tools that empower designers and users alike [9]. Research found that the 3D virtual reality environment prototype not only successfully engaged participants but also triggered interactive experiences, holding their attention and instigating a heightened sense of interest and fascination with the simulated location [10].

The exploration of enhancing user experiences within Virtual Reality (VR) prototyping signifies a significant stride in the continuous evolution of this revolutionary technology. This endeavour involves delving into the ways VR prototypes not only engage users but also trigger interactive and immersive experiences. By understanding and harnessing the full potential of VR prototyping, there's an opportunity to shape more captivating, realistic and user-friendly virtual environments, opening doors to new possibilities and applications across various domains. This heightened focus on user experience within VR prototypes paves the way for innovations that can redefine how individuals interact with and perceive virtual spaces, contributing to the ongoing transformation of the digital landscape. As explored in this paper, the potential for elevating user experiences within VR prototyping holds promise for the continued evolution of this ground breaking technology.

2. Literature Review

The research aimed to identify studies focusing on the utilization of virtual reality prototyping in the field of user experience. Scopus served as the primary resource for sourcing relevant publications. The search terms employed, as outlined in Table 1, were:

i. "Virtual Reality"
ii. "User Experience"
iii. "Prototype."

Table 1
Number of research articles for the searched keyword

Keywords/Combination of Keyword	Number of Results (Source: Scopus)
“Virtual Reality”	168,427
“User Experience”	52,063
“Virtual Reality” AND “User Experience”	4,232
“Virtual Reality” AND “User Experience” AND “Prototype”	350

Out of the initially identified 350 articles related to the research topic (as indicated in Table 1), a total of 7 articles were selected for review (as illustrated in Figure 1). This selection was made following the application of inclusion and exclusion criteria, which involved eliminating duplicate papers.

2.1 Inclusion and Exclusion Criteria

The review encompassed a period of five years, specifically from 2019 to 2023, focusing on full-text, peer-reviewed academic papers. Non-peer-reviewed or duplicate papers were excluded from the final selection and all chosen articles adhered to the criteria of being written in English and published as articles.

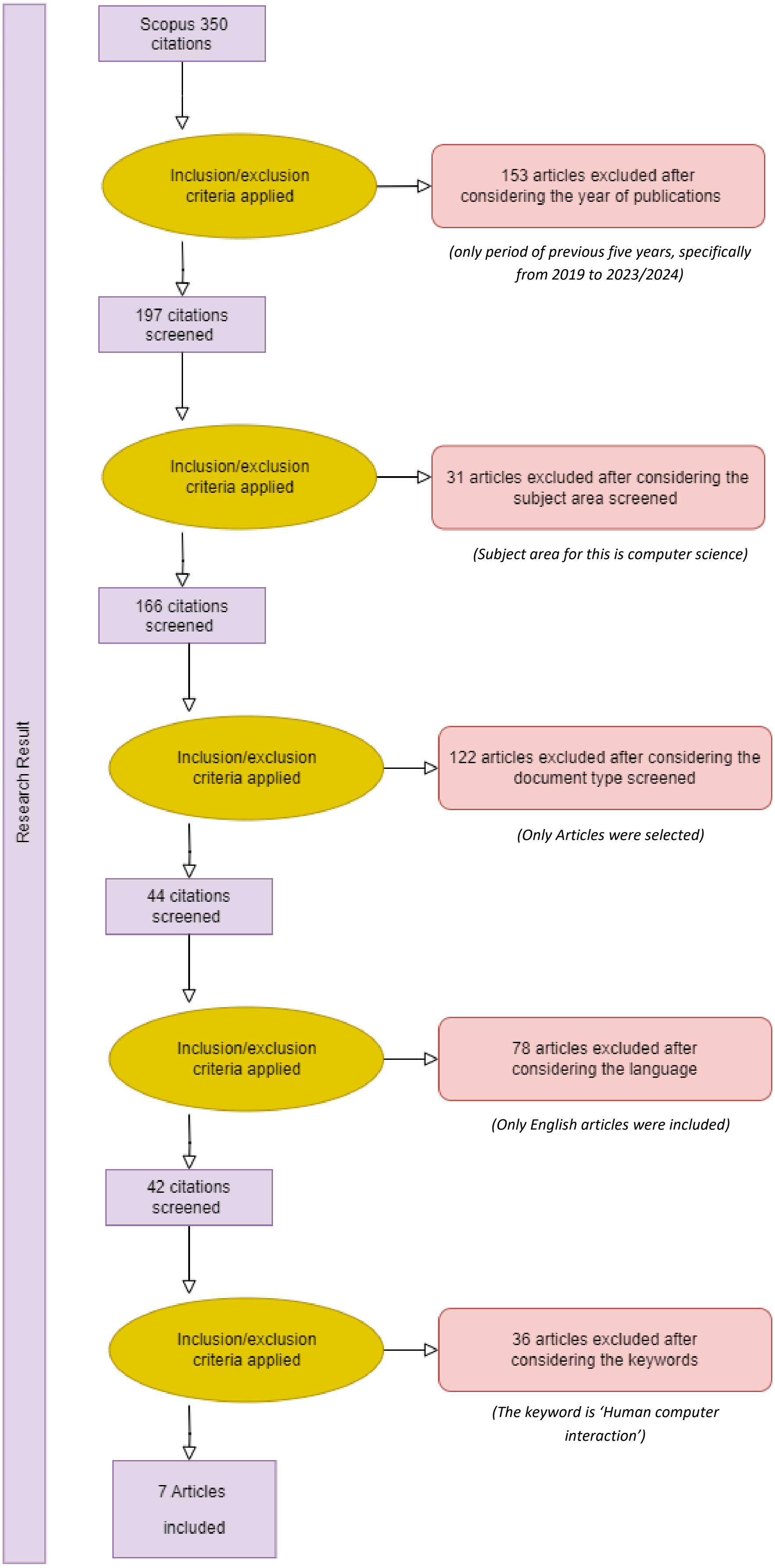


Fig. 1. PRISMA diagram detailing the study identification and selection process

Table 2
Summary of earlier research

	Author	Title of Study	Findings	Ref
1.	Luo *et al.,*	Viewpoint-Controllable Telepresence: A Robotic-Arm-Based Mixed-Reality Telecollaboration System	• This study focuses on creating a mixed-reality telecollaboration system, utilizing a robotic arm with a stereo camera for remote users to control viewpoints with head movements. • Through user studies, the research aims to enhance interaction efficiency and user satisfaction, contributing insights for the design and improvement of mixed-reality telecollaboration systems.	[11]
2.	See *et al.,*	Extended reality interactive wall: User experience design research-creation	• This article discusses the development of an extended reality (XR) interactive wall for education and exhibitions, combining augmented reality (AR) and virtual reality (VR) elements. • The XR wall, tested at a university, integrates conventional graphics with AR-based video and 3D-scanned materials, offering inclusive design for diverse users and accommodating both handheld and head-mounted devices.	[12]
3.	Lima *et al.,*	HyperCube4x: A viewport management system proposal	• The article proposes a novel management and information visualization system based on the tesseract, a 4D-hypercube, using metaphors inspired by its geometric properties. • The provided prototype garnered positive feedback, with 81.05% of participants agreeing on the system's advantages over traditional desktop metaphors.	[13]
4.	Blythe *et al.,*	Designs on Transcendence: Sketches of a TX Machine	• The monograph highlights the lack of research in Human-Computer Interaction (HCI) regarding spiritual and transcendent experiences facilitated by technology. • Drawing on diverse fields, including psychology, philosophy and neuroscience, it explores how physical, chemical and digital means, such as virtual reality and meditation apps, can induce such experiences. • The literature reveals common characteristics of transcendent experiences, emphasizing their potential benefits and concludes with a speculative design fiction envisioning a near-future conference on transcendent experience research, advocating for an interdisciplinary approach in the field.	[14]
5.	Wang *et al.,*	BeHere: a VR/SAR remote collaboration system based on virtual replicas sharing gesture and avatar in a procedural task	• This paper introduces BeHere, a Virtual Reality (VR)/Spatial Augmented Reality (SAR) system designed for remote collaboration in industry. • Utilizing 3D virtual replicas, avatars and gestures, BeHere allows a remote expert in VR to guide a local worker in real-time through procedural tasks in the real world. • The study demonstrates that the combination of visual cues such as gestures, avatars and virtual replicas enhances the user experience, especially for remote VR users, providing valuable insights for future research in VR/AR remote collaboration for industrial tasks.	[15]

6.	Duane *et al.,*	LAD: an application design model to support the analysis of large-scale personal data collections generated by lifelogging	• This paper introduces the Lifelog Application Design (LAD) model, designed to address challenges in creating interactive systems for analysing large-scale personal collections generated by lifelogging. • The paper showcases the model's utility through case studies and an analysis of VRLE, a real-world application prototype exploring large-scale personal data retrieval in virtual reality. • The goal is to encourage future researchers to use the LAD model for designing and developing their own lifelogging application prototypes.	[16]
7	Wang *et al.,*	User-centric immersive virtual reality development framework for data visualization and decision-making in infrastructure remote inspections	• This paper addresses the need for human-centred Immersive Virtual Reality (IVR) frameworks in infrastructure inspections by proposing a new IVR development framework using agile User Experience (UX) design techniques. • The paper emphasizes the importance of integrating UX principles into IVR development for effective remote inspections and suggests potential advancements in semantic enrichment tasks.	[17]

2.2 Virtual Reality

The fascination with virtual reality (VR) has persisted since the 1990s, with continuous advancements in its evaluation. Despite some fluctuations in the graph shown in Figure 2, there has been a consistent interest in studying VR, as evidenced by the ongoing publication of articles each year.

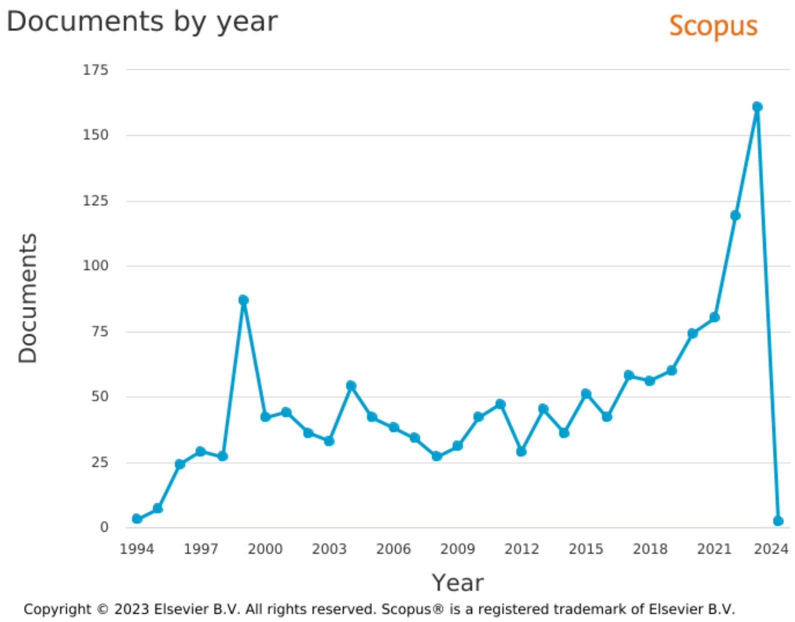


Fig. 2. Document publication trends from year 1994-2024

The systematic literature search using Scopus, particularly considering publication trends from 2018, showcases a significant and sustained rise in the quantity of articles shown in Figure 3. This trend suggests a continuous and growing interest in the field, with projections indicating sustained enthusiasm in the coming years.

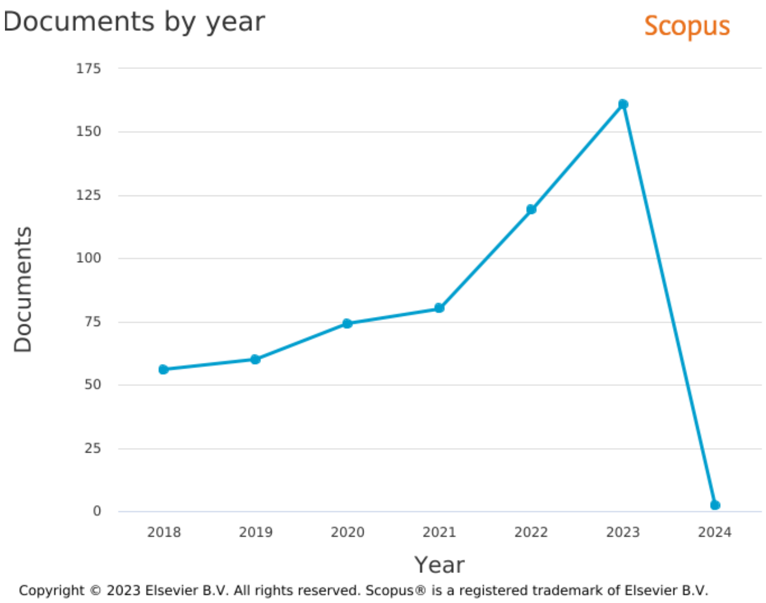


Fig. 3. Document publication trends from year 2018-2024

The documents related to the virtual reality domain primarily originated from a singular source and exhibited diverse formats. Conference papers constituted the majority at 77.7% of all published documents in the Scopus database, followed by articles at 18.9% and book chapters at 1.1%, as illustrated in Figure 4.

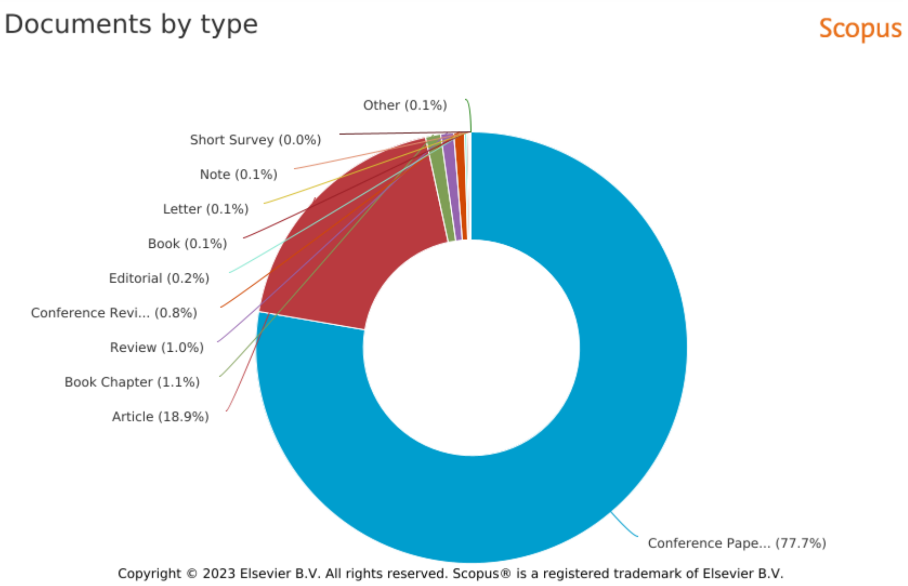


Fig. 4. Document publication trends by type of documents

Furthermore, Scopus categorizes document publications by subject, revealing that 23.7% of the subjects are associated with computer science. This indicates the dominance of computer science in the trend of publications, highlighting its significant relevance for study. Medicine ranked third with 12.3%, followed by engineering with 17.0%. Figure 5 presents a comparison of documents released by subject area.

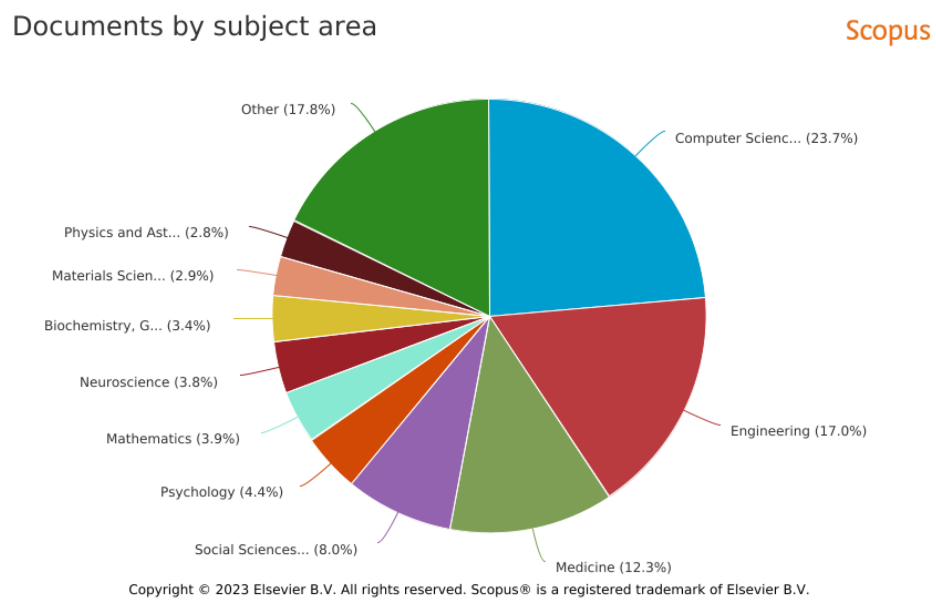


Fig. 5. Document publication trends by subject area

3. User Experience in Virtual Reality Prototyping

Virtual reality (VR) is a transformative technology that tricks our senses into accepting an artificial version of reality, holding the promise of significant life changes [1]. The application of VR technology spans across diverse industries, showcasing its versatility and impact. In medical training, engineering, entertainment and education, VR has proven to be a valuable tool. For instance, in education, VR technology enables learners to engage with real-life scenarios, providing an immersive and interactive learning experience without the need to leave the classroom [18]. For a case, the integration of virtual reality (VR) in the BeHere platform is advantageous because it provides an immersive and interactive environment, enabling natural interaction through gestures and offering a 3D virtual collaborative space that enhances user engagement and communication during remote collaborative tasks [15].

In virtual reality (VR), the real world is completely hidden from view, allowing users to immerse themselves fully in a simulated environment [19]. In the realm of user experience (UX), the concept of immersion holds particular significance. In the context of virtual reality, immersion is defined as a psychological state where individuals fully engage and interact with a continuous stream of stimuli in their environment. Virtual reality achieves this immersive experience through the integration of visual, aural and haptic feedback, leading to a profound sense of presence. This heightened sense of being present contributes directly to the overall user experience in virtual reality, creating a more immersive and engaging interaction with the virtual environment [19].

As virtual reality (VR) applications progress, encompassing both entertainment and therapy, ongoing research is dedicated to understanding their nuanced effects on mental health, with a pivotal emphasis on users' psychological well-being. For instance, the TRIPP meditation app exemplifies how VR can positively influence mental health. Specifically designed for mental well-being through VR headsets, TRIPP integrates insights from meditation research into immersive experiences that prioritize psychological health. The app's deliberate focus on supporting mental well-being highlights the varied impacts VR can have on individuals [14].

The assessment of user experience in virtual reality prototyping involved the development of an immersive virtual reality game as a three-dimensional environment prototype. The prototype demonstrated a high level of immersion, with noteworthy control and sensory factors and minimal distraction factors [10]. A prototype, as defined through ethnographic observations and analysis of design companies, is a physical or digital representation of essential design elements. It serves as an iterative tool to enhance communication, facilitate learning and inform decision-making at any stage of the design process. Prototypes vary widely, falling on a spectrum from high-fidelity (hi-fi) to low-fidelity (lo-fi), with fidelity indicating how closely the prototype resembles the desired product [20]. In a study, participants reported a high perception of realism and active engagement in interactive experiences, confirming the effectiveness of the 3D virtual reality environment prototype [10].

In the XR interactive wall project, the prototype serves as a vital tool, providing a tangible or digital representation of essential design elements. This aids communication, supports learning and informs decision-making throughout the design process. The prototype's adaptability, ranging from low to high fidelity, allows for comprehensive assessment. Specifically designed for engagement and inclusivity, the XR interactive wall prototype improves the user experience in VR. It facilitates easy information access in standing and wheelchair positions, is compatible with mobile devices and affordable head-mounted displays and garnered positive feedback in a pilot study. The prototype's versatility proves valuable across diverse fields, emphasizing continuous user feedback for ongoing improvements [12].

Research also introduces an advanced information management system for virtual reality (VR) prototyping, utilizing a 4D-hypercube or tesseract. It goes beyond traditional desktop approaches and introduces novel features, such as a 4D information display, modal logic for metaphor behaviour and a magic cube for spatial organization. In the realm of virtual reality prototyping, this proposal holds the potential to significantly enhance user experience by providing a more immersive and intuitive interaction with information in a virtual environment. The unique characteristics introduced aim to address the limitations of traditional desktop metaphors, contributing to a more sophisticated and user-friendly VR prototyping experience [13].

There are three categories to classify Virtual Reality systems. Non-immersive, immersive and semi-immersive systems cater to different levels of immersion, each serving various purposes and requiring different types of interactions. Non-immersive systems offer a less immersive experience and usually involve simple interactions like using a mouse and joystick. Semi-immersive systems, employing a hybrid approach, are often utilized in educational settings. On the other hand, immersive systems, which include head-mounted displays (HMDs) or fully furnished virtual reality rooms, provide the highest level of immersion [21]. The categorization of virtual reality systems into non-immersive, semi-immersive and immersive aligns with the concept of prototype fidelity in design. In the context of prototyping:

Table 3
Alignment of virtual reality system categories with prototype fidelity in design

	VR System Categories	Prototype Fidelity in Design	Description
1.	Non-Immersive	Low-fidelity (e.g. Stereo display monitor for a 3D environment or glass)	• Quick and simple representations • Limited interactivity, basic input devices
2.	Semi-Immersive	Mid-fidelity (e.g. Desktop type of virtual reality or a few physical models)	• Balanced realism and simplicity • Moderate interactivity, educational focus
3.	Immersive	High-fidelity (e.g. Head-mounted display (HMD), Tracking hardware devices, Data glove input devices)	• High realism and detail • Advanced interactivity, immersive experience

In the realm of VR prototyping, these successful VR projects exemplify the transformative potential of virtual reality in refining user experiences [22]:

i. Virtual reality training simulations: Organizations such as NASA and Boeing utilize VR for lifelike employee training. For instance, NASA uses VR to train astronauts for space missions and Boeing employs VR to train pilots on emergency procedures. This enhances the realism and immersion of the training experience, leading to more effective training programs.
ii. Virtual reality games: VR games, like "Beat Saber," demonstrate how designers use VR to create unique and engaging experiences. In this rhythm game, players use virtual swords to slash blocks in time with the music, showcasing the possibilities of VR for interactive and immersive gaming.
iii. Virtual reality museum exhibits: Museums, like the British Museum, use VR to craft immersive exhibits. For instance, a virtual tour of ancient Egypt lets visitors explore pyramids and Pharaohs' tombs. This utilization of VR enhances the educational and engaging aspects of the traditional museum experience.

The investigation into user experience in virtual reality prototyping commenced in 1996 and has consistently progressed, as depicted in Figure 6. Utilizing Scopus for a systematic literature search, the graph displays fluctuations in publication trends, yet it's evident that there has been overall improvement year by year. In 2021, there was a significant drop to less than 30 publications, but it has since rebounded, surpassing 40 and is anticipated to continue increasing in the future.

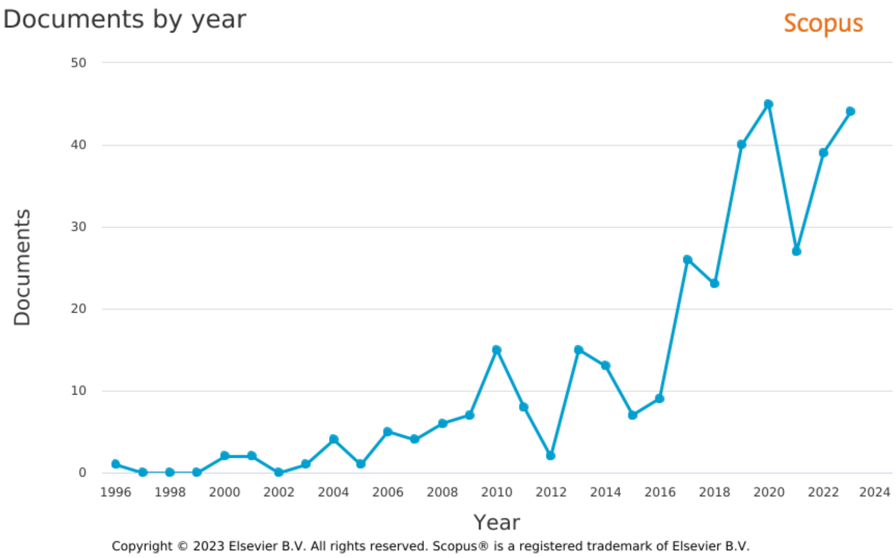


Fig. 6. Document publication trends by year from 1996 - 2024

Documents related to the domain of user experience in virtual reality prototyping came from various sources, with conference papers being the predominant form, constituting 69.4% of all published documents in the Scopus database. Articles followed closely with 23.7%, while other forms of publications, such as conference reviews, book chapters, books and erratum, made up smaller percentages, as depicted in Figure 7.

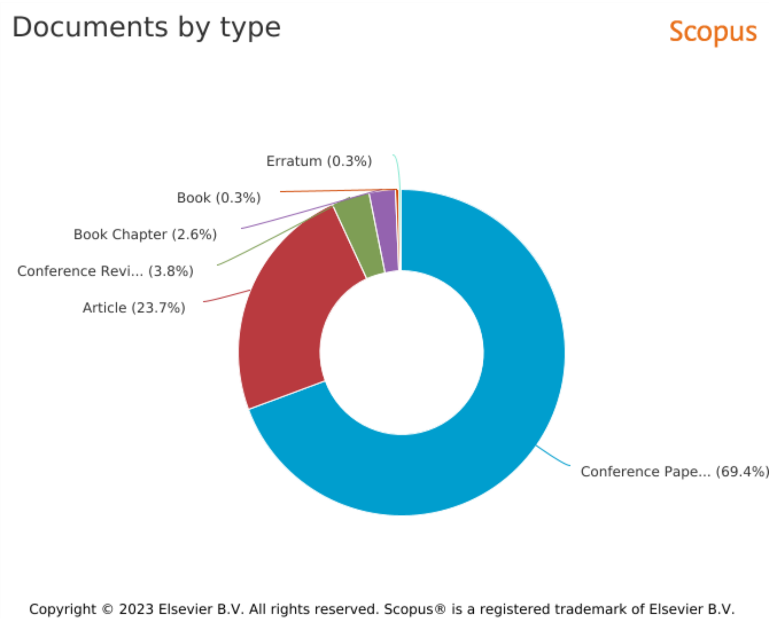


Fig. 7. Document publication trends by type of document

Furthermore, Scopus categorizes document publications by subject, revealing that 45.9% of the subjects are related to computer science. Engineering ranks second with 18.6% and mathematics follows with 13.5%. Figure 8 illustrates the comparison of documents published by subject area.

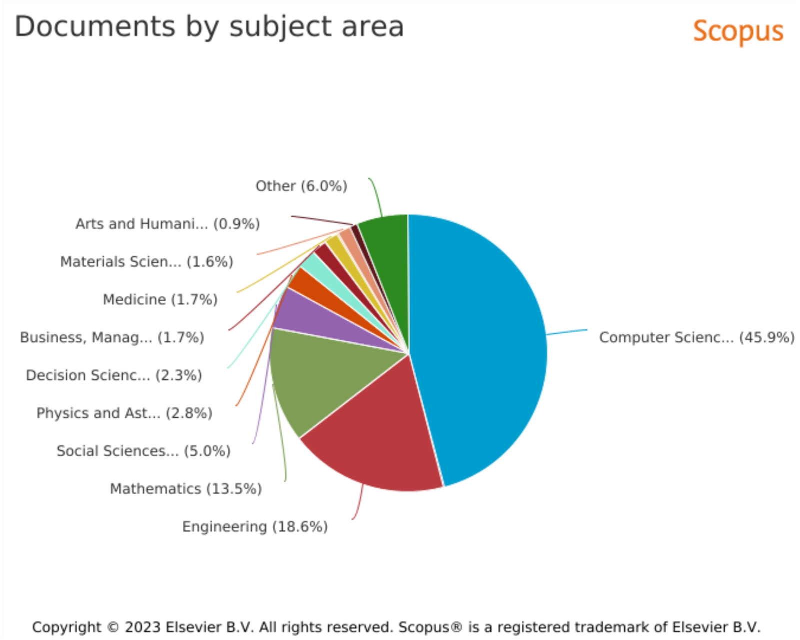


Fig. 8. Document publication trends by subject area

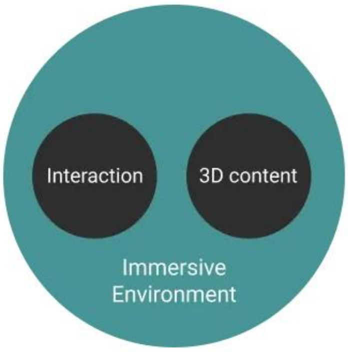
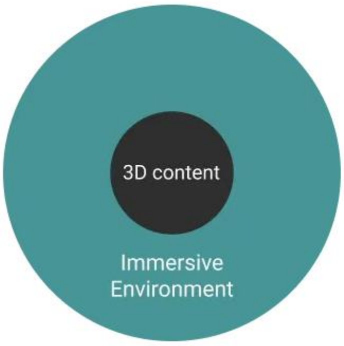
User experience is crucial in virtual reality, making prototyping essential for creating a convincing VR environment. Perfecting the VR experience is vital and interactive wireframes help achieve success by allowing quick iterations. Furthermore, A successful VR user experience relies on principles such as believability, interactivity, discoverability and immersion, ensuring users feel present, can interact seamlessly, navigate freely and enjoy a comprehensive experience from any perspective [23]. However, poor user experience is a significant obstacle to the widespread adoption of VR applications [24].

The Lifelog Application Design (LAD) model is intricately linked to user experience in virtual reality (VR), aligning with the critical importance of crafting compelling VR environments. User experience is paramount in VR and prototyping becomes indispensable for refining and perfecting this experience. The LAD model contributes to this refinement by providing a versatile framework for developing lifelog applications within VR, ensuring that users can seamlessly interact, navigate and enjoy a comprehensive lifelogging experience. Just as interactive wireframes aid in quick iterations for a convincing VR environment, the LAD model supports the principles of believability, interactivity, discoverability and immersion, all vital for successful VR experiences. Recognizing that poor user experience poses a significant challenge to VR adoption, the LAD model strives to address these challenges and enhance the overall user experience in the lifelogging domain within the virtual reality landscape [16].

User experience with wearables, particularly VR headsets, encompasses two primary aspects. Firstly, it involves the physical comfort during usage, considering factors like the ergonomic design of the headset and controllers. Secondly, it addresses intangible elements in digital experiences, such as the design and architecture of applications. VR experiences are categorized based on three elements: immersion, interaction and content origin. Immersion, debated in definition, is viewed as both a psychological and technological concept, emphasizing the computer's ability to create a vivid illusion of reality. Interaction, incorporating elements like gaze, hand gestures, touch controllers or voice commands, significantly influences the user experience. Lastly, content origin is classified into fully computer-generated 3D objects or captured from the real environment, shaping the overall nature of the VR experience [25].

Furthermore, VR experiences can be classified into three types: Interactive Immersive 3D Environments, Immersive 3D Environments and Immersive Captured Environments as shown in Table 4 [25]. A research indicated that the key strength of virtual reality lies in its immersive nature, projecting stimuli extensively onto users' sensory receptors in an interactive and vivid manner. Previous studies also suggested that actively engaging more human sensory and motor skills enhances understanding and learning, with immersion significantly improving user recall. The overarching belief was that virtual reality technology could pave the way for more natural and effective human-computer interfaces. In the project, the emphasis naturally shifted towards optimizing the virtual reality platform, recognizing its compelling impact on user interaction [13]. This aligns with the classification of VR experiences into interactive immersive 3D environments, immersive 3D environments and immersive captured environments, emphasizing VR's immersive and varied nature.

Table 4
Classification of VR experiences

	VR Experience Type	Key Characteristics	Examples
1.	Interactive Immersive 3D Environments 	Varied interactivity levels, from low to highly interactive, for games, serious games and social communication.	AltspaceVR: Communication, meetings, conferences, games.
2.	Immersive 3D Environments 	Presents 3D content with limited interaction, often through 2D UI.	Immersive animations, live concerts.
3.	Immersive Captured Environments 	Least interactive, 360 videos or photos.	Felix and Paul Studio's 360 videos, YouTube VR.

Nevertheless, the discussed research projects share common threads regarding limitations, each presenting unique challenges within the scope of their investigations. In the viewpoint-controllable telepresence system, constraints in view-sharing technology, specifically abandoning solutions involving a robotic arm carrying a 360 camera and issues with 3D video matching the 3D model impacted the user experience [11]. The LAD model for lifelog application design faced challenges in interfacing with virtual environments due to the absence of familiar input devices like physical mice and keyboards, hindering effective user interaction [16]. The HyperCube4x project acknowledged the need for in-depth usability tests, reinforcing the qualitative results obtained and paving the way for continuous improvements [13]. The extended reality interactive wall project recognized initial design limitations for young users and aimed for inclusivity through diverse content and hardware configurations [12]. BeHere highlighted data limitations in its user study and the loss of depth in real-time video for certain tasks during remote collaboration [15]. Lastly, the immersive VR development framework for infrastructure inspections indicated potential limitations that may arise during the integration of UX principles and semantic enrichment tasks [17]. Despite these challenges, the collective pursuit of innovation in immersive technologies remains resilient, guided by the shared goal of overcoming limitations and enhancing user experiences in diverse applications.

4. Discussion

This investigation explores the impact of virtual reality (VR) prototyping on user experience. The synthesis of diverse literature suggests that VR prototypes, especially 3D virtual reality environment prototypes, significantly engage users and provide an immersive experience. Studies consistently highlight the effectiveness of VR prototypes in eliciting a heightened sense of realism and engaging participants. Prototypes, ranging from low to high fidelity, are essential tools in shaping the overall feel and focus of learning sessions. They are adaptable, allowing exploration of new ideas, understanding user needs and effectively communicating design concepts. This aligns with the dynamic nature of user experience in VR prototyping, where iterative design and testing are crucial.

The classification of VR systems into non-immersive, semi-immersive and immersive categories introduces a framework for understanding varying levels of immersion and interaction. This classification resonates with the fidelity spectrum of prototypes, emphasizing the need to align fidelity levels with specific design goals and user requirements. The versatility of VR applications, from educational settings to fully immersive experiences, underscores the impact of thoughtful design choices in creating effective and impactful VR prototypes. The following discussion delves into key findings and insights derived from the literature review and the identified research studies.

The immersive potential of VR prototyping emerges as a central theme throughout the paper. Virtual reality, as a transformative technology, enables the creation of artificial sensory experiences that can significantly impact user engagement. The unique ability of VR to immerse users in alternate realities, as highlighted in the introduction, sets the stage for understanding how prototypes within this environment can enhance user experiences. The discussion emphasizes the role of prototypes not only in engaging users but also in triggering interactive and immersive experiences.

The literature review focuses on seven selected studies that investigate the intersection of virtual reality, user experience and prototyping. Each study contributes unique insights into the diverse applications of VR prototyping. Luo *et al.,* [11] introduce a mixed-reality telecollaboration system, emphasizing the role of user studies in enhancing interaction efficiency and user satisfaction. See *et al.,* [12] discuss the development of an extended reality interactive wall, combining augmented and virtual reality elements for educational and exhibition purposes. Lima *et al.,* [13] propose a novel viewport management system based on a 4D-hypercube, showcasing positive feedback and advantages over traditional desktop metaphors. Blythe *et al.,* [14] explore the lack of research in Human-Computer Interaction (HCI) regarding spiritual and transcendent experiences facilitated by technology, advocating for an interdisciplinary approach. Wang *et al.,* [15] introduce BeHere, a VR/SAR system for remote collaboration in industry, highlighting the effectiveness of visual cues in enhancing user experience. Duane *et al.,* [16] present the LAD model to address challenges in creating interactive systems for analysing large-scale personal data collections generated by lifelogging. Wang *et al.,* [17] propose an immersive VR development framework for data visualization and decision-making in infrastructure remote inspections, emphasizing the integration of UX principles.

In today's exploration of immersive technologies, several research topics shed light on the evolving landscape of virtual reality (VR) and related fields. The research on viewpoint-controllable telepresence introduced an innovative system using a robotic arm, emphasizing the ongoing need to enhance user experiences in remote collaboration. The proposed Lifelog Application Design (LAD) model highlighted the challenges in lifelogging interactive system design, stressing the importance of integrating user experience (UX) principles for effective user interaction. The HyperCube4x project brought attention to viewport management, recognizing the potential of a new interaction metaphor to improve user experiences, while acknowledging the need for extensive usability tests. The investigation into extended reality interactive walls emphasized inclusive design for AR and VR experiences, targeting improvements through diverse content and hardware configurations. BeHere, focusing on VR/SAR remote collaboration, identified data limitations and depth loss in live video, underlining the challenges in maintaining rich information exchange during remote collaboration. Lastly, the proposal for a user-centric immersive VR development framework for infrastructure inspections highlighted the need for human-centred approaches, aiming to enhance user experiences in the specific context of infrastructure inspections. Collectively, these research endeavours showcase the multifaceted nature of immersive technologies, grappling with challenges, embracing user-centric design principles and pushing the boundaries to create more intuitive, efficient and inclusive user experiences across diverse applications and industries.

The analysis of publication trends in virtual reality research reveals a sustained and growing interest in the field. Despite fluctuations, the overall trajectory suggests continued enthusiasm. The dominance of computer science in the subject area aligns with the significance of VR in technological advancements. The assessment of user experience in virtual reality prototyping involves the development of immersive environments, exemplified by a 3D virtual reality game prototype. The fidelity of prototypes, ranging from low to high, aligns with the classification of VR systems into non-immersive, semi-immersive and immersive categories. The paper categorizes VR experiences into three types: Interactive Immersive 3D Environments, Immersive 3D Environments and Immersive Captured Environments. Each type reflects varying levels of interactivity, from highly interactive environments for games and social communication to fewer interactive environments presenting 3D content with limited interaction.

While the potential for elevating user experiences within VR prototyping is evident, challenges such as poor user experience and the physical comfort of VR wearables remain. The discussion emphasizes the importance of principles such as believability, interactivity, discoverability and immersion in ensuring successful VR user experiences. The paper concludes by highlighting the promise of continued evolution in VR technology through a heightened focus on user experience within prototyping. It suggests future research directions, including the incorporation of conference articles and data from various databases to gather more thorough insights.

5. Conclusion

In conclusion, the exploration into virtual reality (VR) prototyping and its impact on user experience unfolds as a rich and nuanced narrative. The historical trajectory of VR, characterized by sustained scholarly interest dating back to the 1990s, reinforces its enduring significance as a transformative technology. The systematic analysis of user experience in VR prototyping unveils a discernible upward trend in scholarly contributions, with a notable surge in 2021, signalling an intensified focus on refining user interactions within virtual environments. The prominence of computer science as a dominant subject area attests to its pivotal role in shaping the discourse surrounding virtual reality.

The classification of VR experiences into Interactive Immersive 3D Environments, Immersive 3D Environments and Immersive Captured Environments contributes a nuanced understanding of the spectrum of interaction and content presentation within the virtual realm. This investigation underscores the central role played by VR prototypes, specifically 3D virtual reality environment prototypes, in not only captivating users but also crafting immersive experiences that go beyond the conventional boundaries of user engagement. As a result, this study significantly enriches the ongoing dialogue on virtual reality and user experience, offering valuable insights that contribute to the continual evolution of this ground-breaking field.

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