Virtual Reality for Digital Transformation in the Business Era: A Systematic Review

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Abstract— **This systematic literature review (SLR) aims to analyze real-life use cases, adoption barriers, and critical success factors, providing a comprehensive view of the role of virtual reality (VR) as a driver of technological innovation and digital transformation in the corporate world. The methodology used integrates the PICOC method, which allowed for the formulation of research questions and the development of a general search equation in Scopus. Likewise, the PRISMA protocol was applied to select, using inclusion and exclusion criteria, 71 original articles that answered the PICOC questions. In this sense, the results show VR applications in sectors such as education, healthcare, industry, and culture, highlighting benefits such as improved learning, risk reduction, process optimization, and personalization of the user experience. Barriers such as high initial costs, lack of standards, and accessibility and inclusion challenges are also identified. It is concluded that VR has transformative potential when integrated with emerging technologies, underscoring the need for inclusive, collaborative, and adaptive strategies to drive effective and sustainable digital transformation in diverse organizational environments.**

Keywords— virtual reality, digital transformation, immersive technology, technological innovation, industry 4.0

I. INTRODUCTION

In today's business era, characterized by constant digital transformation, virtual reality (VR) has emerged as a disruptive technology that has the power to redefine organizational procedures, customer experiences and business models. [1]By simulating interactive three-dimensional environments, VR facilitates new forms of training, remote collaboration, product design, and experiential marketing [2]. Companies in sectors such as manufacturing, healthcare, education, tourism, and retail are adopting these solutions to increase operational efficiency, reduce costs, and offer more personalized experiences [3].

In this sense, the growing interest in VR is based on its ability to improve decision-making, optimize the user experience, and stimulate innovation in products and services [4]. However, its adoption faces significant challenges: high initial costs, resistance to change, a lack of technological standards, and a shortage of trained personnel [5]. Furthermore, doubts persist about the scalability of implementations and their integration with other technologies that are gaining ground, such as big data, artificial intelligence, and IoT [6].

An analysis of the current landscape of virtual reality research reveals a predominance of technical and psychological approaches, while the study of its application in organizational contexts has been limited, highlighting a gap regarding its contribution to digital transformation (DT) processes in companies [7]. Likewise, the potential of VR and the metaverse to intervene in activities such as virtual meetings, professional training, and data processing is highlighted [8]. Consequently, both opportunities and challenges that condition its adoption and its impact on improving operational efficiency and organizational innovation are recognized [9]. In this context, it is pertinent to address the following question: how and under what conditions can virtual reality become an effective driver of technological innovation and digital transformation in organizations, considering real use cases, adoption barriers, and critical success factors in different business sectors?

Therefore, this SLR seeks to comprehensively analyze real-world use cases, adoption barriers, and critical success factors of VR in business contexts. It should be noted that this review article is structured into sections. The first section is linked to the methodology used in this review, including the PICOC method, which allows formulating the questions that generate the systematic search for reliable information, in this case, in the Scopus database using a general equation. Likewise, the PRISMA protocol was used for the selection of research articles using inclusion and exclusion criteria. [9]The second section describes the relevant results of this study and their respective bibliometric and thematic analysis, highlighting applications, benefits, and limitations of virtual reality in different sectors. The third section focuses on a discussion of the results, critically analyzing them in the context of digital transformation and emerging technologies. The fourth section presents conclusions that specify unresolved issues and future research. The fifth and final section describes the references used in this descriptive study.

II. METHODOLOGY

A. PICOC Method

In the following Table 1, we analyze how virtual reality (VR) is emerging as a catalyst for technological innovation and digital transformation, optimizing organizational processes through immersive environments [6]. This research analyzes its impact on efficiency, user experience, and productivity, contrasting it with traditional methods and technologies such as AI and IoT. Using the PICOC method [10], sectors that adopt VR, their applications, and results are evaluated, identifying synergies with other disruptive tools. The study seeks to quantify its contribution to digitalization, providing insights into strategic decision-making in technologically dynamic environments. To this end, structured search equations (PICOC) have been used [10], identifying key sectors, applications, and documented benefits. In this regard, the study employs a systematic literature review strategy, integrating terms such as "XR", "Industry 4.0," and "digital disruption," to quantify the role of VR in organizational competitiveness and technological convergence.

In this sense, the PICOC components were related to each other with the AND operator. Resulting as a final search equation: (TITLE-ABS-KEY (("virtual reality" OR "vr" OR "immersive technology" OR "digital transformation" OR "technological innovation" OR "technology development"))

AND TITLE-ABS-KEY ((("virtual reality" OR "VR" OR "immersive technology" OR "mixed reality" OR "augmented reality" OR "XR" OR "technological innovation" OR "digital transformation" OR "industry 4.0" OR "implementation" OR "applications" OR "adoption" OR "case studies" OR "enabler" OR "driver" OR "impact" OR "benefits")) AND TITLE-ABS-KEY ((("virtual reality" OR "VR" OR "immersive technology" OR "mixed reality" OR "augmented reality" OR "XR" OR "digital transformation" OR "industry 4.0" OR "technological innovation" OR "digital disruption" OR "technology comparison" OR "benchmarking" OR "artificial intelligence" OR "AI" OR "machine learning" OR "internet of things" OR "IoT" OR "blockchain" OR "cloud computing" OR "big data" OR "robotics" OR "5G")) AND TITLE-ABS-KEY (("immersive systems" OR "virtual environments" OR "simulated reality" OR "3D interaction" OR "innovation outcomes" OR "value creation" OR "competitive advantage" OR "business transformation" OR "measured results" OR "documented effects" OR "tangible benefits" OR "process optimization" OR "quality enhancement" OR "decision acceleration" OR "skill acquisition" OR "operational excellence")) AND TITLE-ABS-KEY (("extended reality" OR "XR" OR "immersive computing" OR "spatial computing" OR "technology convergence" OR "industry 4.0 ecosystem" OR "sectoral transformation" OR "vertical digitalization" OR "domain-specific innovation" OR "synergistic effects" OR "technology interplay" OR "health digitization" OR "smart education" OR "advanced manufacturing" OR "precision retail")))

TABLE I. PICOC METHOD

Component	Motivation	Question	Search equation
P (Population / Problem)	Identify the problems that have been addressed in virtual reality and digital transformation.	RQ1: What types of problems have been addressed using virtual reality to optimize digital transformation in the business era?	("virtual reality" OR "vr" OR "immersive technology" OR "digital transformation" OR "technological innovation" OR "technology development")
I (Intervention)	Identifying the use of virtual reality and its components in organizational development sectors.	RQ2: What virtual reality applications are used for technological innovation or digital transformation in different development sectors?	("mixed reality" OR "augmented reality" OR "XR" OR "industry 4.0" OR "implementation" OR "applications" OR "adoption" OR "case studies" OR "enabler" OR "driver" OR "impact" OR "benefits")
C (Comparison)	Traditional methods without VR or different emerging technologies such as AI or IoT	RQ3: How does the impact of virtual reality compare to other technologies in digital transformation processes?	"digital disruption" OR "technology comparison" OR "benchmarking" OR "artificial intelligence" OR "AI" OR "machine learning" OR "internet of things" OR "IoT" OR "blockchain" OR "cloud computing" OR "big data" OR "robotics" OR "5G"
O (Result)	Identification of process improvements, efficiency, user experience, productivity, etc.	RQ4: What improvements or results have been observed after implementing virtual reality in innovation processes?	"immersive systems" OR "virtual environments" OR "simulated reality" OR "3D interaction" OR "innovation outcomes" OR "value creation" OR "competitive advantage" OR "business transformation" OR "measured results" OR "documented effects" OR "tangible benefits" OR "process optimization" OR "quality enhancement" OR "decision acceleration" OR "skill acquisition" OR "operational excellence"
C (Context)	Organizational sectors where digital transformation is driven by emerging technologies	RQ5: What impact does the implementation of virtual reality, along with other emerging technologies have on the digital transformation of organizational sectors?	"extended reality" OR "immersive computing" OR "spatial computing" OR "technology convergence" OR "industry 4.0 ecosystem" OR "sectoral transformation" OR "vertical digitalization" OR "domain-specific innovation" OR "synergistic effects" OR "technology interplay" OR "health digitization" OR "smart education" OR "advanced manufacturing" OR "precision retail"

B. *PRISMA Protocol*

According to Kitchenham and Charters, PRISMA [11]is a guideline for reporting systematic reviews, ensuring transparency, methodological quality, and reproducibility in research. In Fig. 1, this protocol is used to ensure transparency and methodological rigor in the systematic review on the impact of virtual reality (VR) on technological innovation and digital transformation [12]. This standardized framework allows for filtering, selecting, and evaluating relevant studies using inclusion/exclusion criteria, minimizing bias.

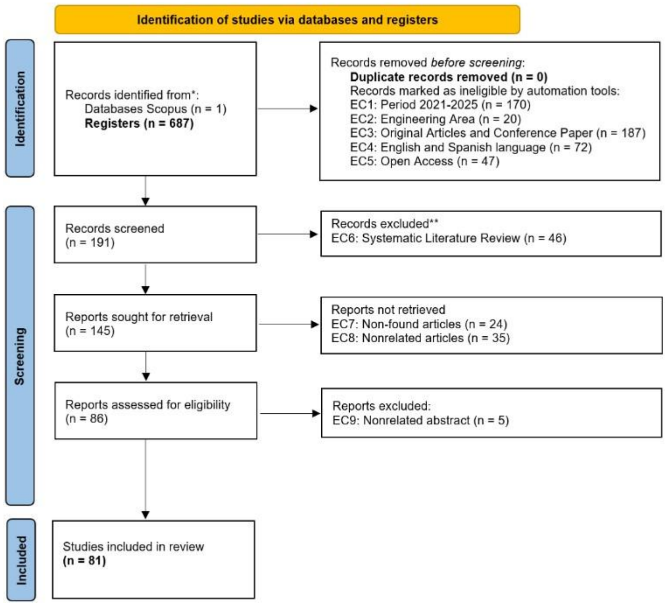

Fig. 1. PRISMA Protocol

III. ANALYSIS OF RESULTS

A. *Bibliometric analysis*

Fig. 2, illustrates the evolution of academic publications related to the use of VR in digital transformation processes within the business environment. There has been sustained growth in the volume of research since 2010, with an exponential increase between 2018 and 2025, reflecting the growing interest in integrating immersive technologies as catalysts for digital innovation. This increase coincides with the advancement of complementary technologies such as AI, the Internet of Things, and rapid industrial automation, thus consolidating virtual reality as a key enabler in the digital business era. The projected trend toward 2027 suggests greater adoption and the strategic impact of these technologies in different economic sectors.

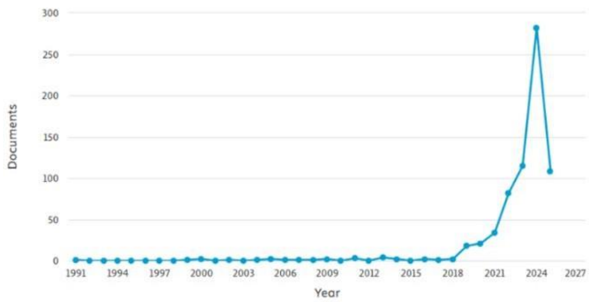

Fig. 2. Historical contribution on virtual reality for digital transformation in the business era

Fig. 3 shows the global map of scientific collaboration between countries in the field of virtual reality (VR) and its relationship with digital transformation. An active network of international co-authorship is evident, led mainly by the United States, the United Kingdom, China, Germany, and Australia, which have the highest number of collaborative ties with other nations. The most intense connections are observed between the United States and Germany, as well as between the United States and the United Kingdom, with ten joint publications each, followed by China and the United Kingdom with nine collaborations, and by Germany and France, as well as the United Kingdom and France, with six collaborations. These relationships reflect a strong trend toward joint research between technological powers, driving the development of immersive technologies through transnational networks. Furthermore, the map reveals a growing inclusion of developing countries in these networks, suggesting a global expansion in research on virtual reality applied to contexts of business innovation and digitalization.

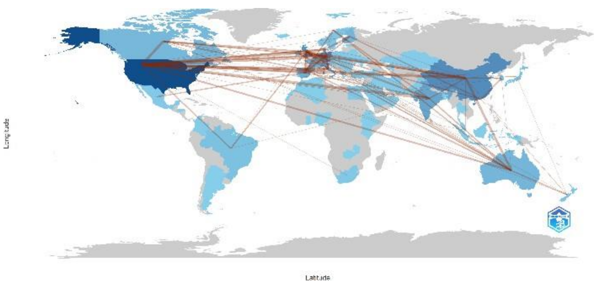

Fig. 3. Contributions by country

Fig. 4, presents the co-occurrence map of key terms extracted from the selected articles, generated using VOSviewer. This analysis reveals the thematic structure of the field of study, highlighting the most frequently occurring terms and their semantic relationships. Colored clusters are identified as representing distinct conceptual communities. For example, the green cluster, led by the term "virtual reality," groups concepts such as "virtual environments," "human-computer interaction," and "extended reality," which reflect the technological core of the research. The red cluster focuses on educational and learning applications, with terms such as "e-learning," "students," "teaching," and "immersive technology." The blue cluster encompasses terms related to user experience, such as "users' experiences," "immersion," and "simulation," while other smaller clusters address technical aspects such as "computer graphics," "augmented reality," "haptic feedback," and "federated learning." This visualization provides insight into the interconnections between technological approaches, practical applications, and associated disciplines, reflecting the diversity and interdisciplinarity of research on virtual reality and digital transformation.

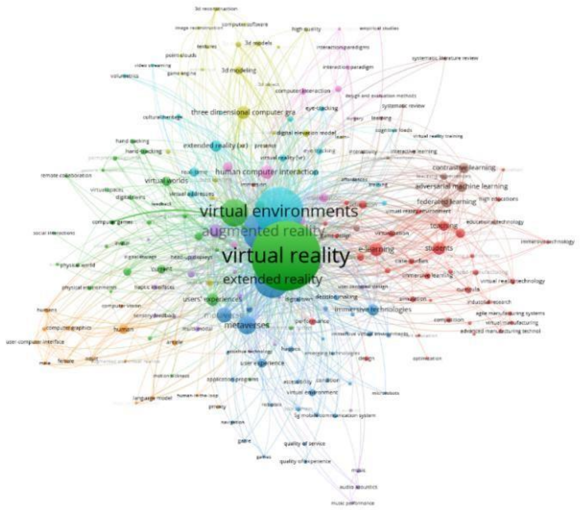

Fig. 4. Interrelation between keywords

From the analysis of the articles [13]– [14], virtual reality (VR) is described as an immersive technology that recreates interactive three-dimensional environments through devices such as HMDs, facilitating sensory and motor experiences in simulated contexts. Studies such as [15], [16], [17], [18], [19], [20], [21], [22] and [14] highlight their educational, therapeutic and industrial impact. Others such as [23], [24], [25], [26] and [27] explore their role in technical simulation and ergonomic analysis. Research such as [12], [28], [29], [30], [31], [32], [33], [34], [35], [36] and [37] present functional approaches. Overall, VR is an interactive computational system that simulates human experiences, integrating XR, AI and sensors for hybrid, personalized and collaborative environments.

On the other hand, the articles [12]– [38] agree that *digital transformation* is a systemic and structural process that redefines sectors through emerging technologies such as XR, AR, VR, AI and BIM. These tools transform processes in education [29], [30], [32], [39], healthcare [40], [38], construction [41], [42], [43] commerce [44], creativity [45] and marketing [46], promoting efficiency, inclusion and innovation. While [47], [48] and [49] highlight the autonomy and accessibility that these technologies give to teachers, other authors emphasize their role in optimizing project management, clinical treatments or user experiences. From different disciplines, all authors agree that digital transformation drives a collaborative, adaptive and sustainable multisectoral evolution that modernizes traditional practices.

P : Types of problems that have been addressed from virtual reality for the optimization of digital transformation in the business era

Multiple problems associated with the inefficiency of traditional educational methods are identified in key disciplines such as dentistry [13], medical education [16], pharmacy [30], cultural heritage [50], engineering [36], industrial design [24], dance [51] and physics [22]. These methodologies lack interactivity, immersion, scalability and motivation for the student, which limits both learning and skill acquisition. Virtual reality (VR) and similar immersive technologies have emerged as tools capable of overcoming these barriers, by offering more effective, engaging and accessible educational experiences [12], [15], [18], [52], [32], [53], [39], [54], [55], [48], [56].

There are also challenges associated with the development, implementation, and adaptation of educational content in XR. The high technical complexity of authoring tools [47], the lack of technical teaching expertise [49], the absence of standardized pedagogical design frameworks [52], [57]and the fragmentation of the XR market [58]represent significant obstacles. Furthermore, difficulties arise in clearly defining educational activities in 3D environments [59]and in maintaining the physical context in simulations [60], which limits the effectiveness, scalability, and adoption of these technologies in education and industry.

Likewise, problems related to rehabilitation and medical training are identified. There is an urgent need to personalize patient-therapist interaction and improve the effectiveness of physical and cognitive treatments [20], [45], [27]. Furthermore, traditional medical simulators present limitations in accessibility and realism, which negatively affects the quality of clinical and surgical teaching [19], [57], [61], [62], [55], [38]. In this sense, XR-based solutions allow for safe simulations, repeatable practices, and greater knowledge retention in critical clinical settings.

On the other hand, there are challenges associated with industrial and technical training. Traditional methods used to train heavy machinery operators, industrial maintenance, and assembly are costly, inefficient, and dangerous [63]. XR technologies are positioned as key tools for simulating real-life situations without physical risks, improving workplace safety, fostering technical precision, and optimizing training times. [64], [14], [22]. They also enable more precise ergonomic practices and more effective collaborative technical documentation [21], [65], [26], [65].

Technical, accessibility, and inclusion issues in XR environments are also identified. Limitations in customization [25], the emergence of symptoms such as cybersickness [66], and cognitive overload resulting from a high sense of presence [67], hinder the user experience. Furthermore, the exclusion of certain population groups [31], [53], [25] and obstacles to widespread adoption of XR due to technical and economic factors [68], [69] highlight the need for more inclusive and accessible approaches in virtual learning environments.

In this context, connectivity difficulties [43], limited interaction between users and instructors in virtual labs [35], and the lack of personalized support limit the use of these virtual spaces. [70] Therefore , virtual reality requires a more robust educational design and strategies that ensure connectivity, inclusion, and engagement, especially in remote collaborative work situations [71], [59].

It's worth noting that, in the cultural sphere, museums and heritage education platforms face challenges in accessibility, conservation, and audience engagement, In the commercial sector [50], [28], user experiences on e-commerce platforms are still limited by a lack of realistic interaction with products [44], while traditional marketing demands new interactive experiences [46]. In these cases, Virtual Reality offers unique opportunities to optimize interaction, personalization, and understanding of the content offered.

Fig. 5, reflects the impact of virtual reality and digital transformation on addressing key challenges in systems engineering, from education and therapy to creativity and inclusion. This demonstrates a cross-cutting impact, optimizing processes (fostering remote collaboration), improving accessibility and emergency preparedness, and revolutionizing technical solutions, such as advanced simulations and immersive environments, as well as social solutions.

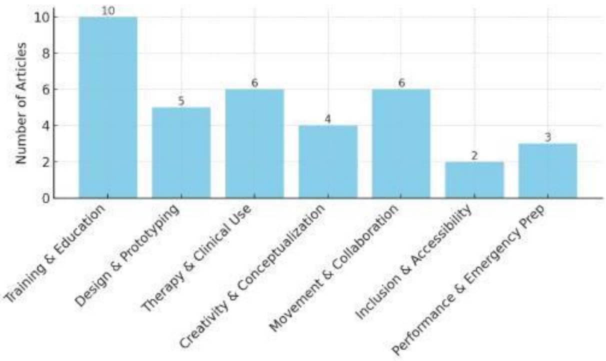

Fig. 5. Multidisciplinarity through Virtual Reality

The following Table II, summarizes key issues addressed by XR technologies in the context of digital transformation. A cross-cutting impact is evident in sectors such as education, healthcare, industry, and culture, highlighting how Virtual Reality optimizes processes through immersive, inclusive, and scalable experiences, improving efficiency, security, and accessibility in digital environments.

TABLE II. VIRTUAL REALITY AS A RESPONSE TO THE CHALLENGES OF THE DIGITAL AGE

Scope	Identified Problem	Approach from Virtual Reality (VR/XR)	IEEE References
Professional Education	Traditional methods are inefficient in key disciplines (low interactivity, immersion, motivation and scalability)	Immersive experiences that enhance learning and skill acquisition.	[13], [16], [22], [50], [30], [24], [51],[36]
Educational Design and Content	Technical complexity, lack of teaching experience, lack of pedagogical frameworks and fragmented XR market	XR tools with standardized instructional design, technical simplification, and accessible authoring.	[52], [47], [49], [57], [59], [60],[58]
Rehabilitation and Medicine	Unrealistic simulators, poorly personalized treatments, low clinical efficacy	Safe, personalized, and repeatable simulations that enhance medical education and rehabilitation.	[40], [19], [20], [38], [57], [61], [62], [55],[27]
Technical/Industrial Training	Risky and expensive training in machinery, maintenance and assembly	Simulation of real-life tasks, improved safety, ergonomics, and collaborative documentation .	[63], [21], [14], [65], [64], [26],[37]
Accessibility and Inclusion	Cybersickness, cognitive overload, user exclusion, and	User-centered XR strategies with inclusive	[31], [53], [69], [67],

	lack of personalization	and adaptive design.	[25], [66],[68]
Collaborative Virtual Environments	Limited interaction, low connectivity and poor personalized support	Collaborative XR environments with educational support and improved connectivity.	[71], [43], [59], [35],[70]
Culture and Heritage	Limited access, conservation issues, and low public participation	VR platforms that enhance educational experiences and cultural preservation.	[50], [28],[72]
Digital Commerce and Marketing	Lack of realism and interactivity in e-commerce and traditional marketing platforms	Personalized and immersive experiences to improve customer relationships.	[44],[46]
Cross-cutting Impact	Poor collaboration, limited creativity, and lack of emergency preparedness	Optimized processes through XR: advanced simulations, accessibility, and remote collaboration.	[12], [15], [18], [32], [53], [39], [48], [54], [55],[56]

I: Virtual reality applications used for technological innovation or digital transformation in different development sectors

Virtual reality has been identified as a key tool for digital transformation in various sectors, especially those where simulation, hands-on training, and immersive interaction are essential. In the educational field, applications such as laboratory simulators, XR platforms, and collaborative environments stand out, enhancing experience-based learning, knowledge retention, and digital inclusion [12]. [16], [18]. In healthcare, VR enables clinical training, surgical simulations, and personalized therapies that improve treatment effectiveness and medical education [19], [39], [55]. The industrial sector uses these technologies to train personnel in hazardous or high-cost operating environments, optimizing safety, technical precision, and collaborative documentation [21], [26], [65]. In culture and heritage, virtual museums and digital reconstructions stand out, democratizing access to historical knowledge and encouraging the participation of diverse audiences [28], [50].

These applications not only optimize processes and reduce risks, but also strengthen personalization, operational efficiency, and innovation, thus contributing directly to the digital transformation of the corporate environment. On the other hand, initiatives focused on the cultural, heritage, and museological fields reinforce the idea that virtual reality and related technologies are used to create virtual museums, digital reconstructions of historical environments, and interactive cultural learning experiences [28]. These solutions promote heritage conservation and facilitate access to cultural content for diverse audiences, increasing motivation and understanding of cultural knowledge [32], [50], [72].

Also, a second category of applications focuses on improving human-computer interaction through more natural and intelligent interfaces. These solutions incorporate technologies such as hand tracking, voice commands, gesture recognition, and AI-powered systems, with the aim of achieving more intuitive, accessible, and personalized experiences. Their implementation is observed in XR environments where users interact with virtual assistants, non-player characters (NPCs), adaptive tutoring systems, and collaborative design environments [68], [73], [24]. These tools enrich the quality of interaction in training, design [31] and innovation processes, consolidating the role of [48] virtual reality as a facilitator of user-centered solutions within the digital transformation [60], [44], [45].

On the other hand, industrial applications focused on the design, validation and simulation of technical processes reinforce the use of XR technologies and immersive environments, allowing the representation of three-dimensional product models, validation of complex procedures, simulation of dangerous or high-cost tasks and efficient planning of operations. This type of application is essential for sectors such as manufacturing [66], civil engineering [62] and technical maintenance [26], [64], [14], [20], [74], [43], [41], [42].

Of note are those applications in the fields of healthcare, medicine, and rehabilitation, which use immersive technologies for simulating surgical procedures [38], first aid training, clinical skills development [55], and neurorehabilitative therapies [57], [40]. These systems not only improve training effectiveness but also allow for personalized user experience through haptic feedback, , biofeedback, and controlled simulation, , [61], [13], [15], [62], [16], [19], [20], [33].

Likewise, we're grouping together immersive educational experiences supported by metaverse platforms, which offer solutions that integrate virtual reality with persistent social environments, avatars, multiplayer, and learning personalization. They aim to promote accessibility, collaborative learning, and inclusion through dynamic and engaging experiences for students of different levels .[45] [46] [49] [53] [56] [69] [74]

Fig. 6, studies evaluate the user experience in immersive environments and explore variables such as subjective presence, cognitive load, latency, natural interaction, and psychological impact. These analyses are essential for optimizing the design of XR applications, ensuring that they are effective, accessible, and tailored to the needs of the end user [43], [67], [35],. The image reflects the disruptive impact of virtual reality on systems engineering, addressing critical challenges in education, healthcare, cultural heritage, and technical training. Through immersive simulations, collaborative platforms, and interactive training, VR optimizes key processes, increasing efficiency, security, and innovation in the digital transformation, with a tangible impact on productivity and overall accessibility [68], [71], [75].

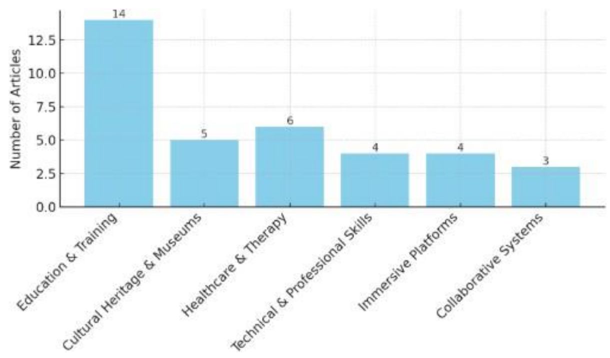

Fig. 6. XR Solutions with Virtual Reality

The following Table III outlines the key applications of Virtual Reality used to drive digital transformation in education, healthcare, industry, culture, and user experience. These solutions improve efficiency, security, inclusion, and personalization in critical processes through immersive, collaborative, and intelligent environments, with tangible impacts on multi-sector innovation and productivity.

TABLE III. DIGITAL TRANSFORMATION THROUGH VR IN KEY DEVELOPMENT AREAS

Sector	Virtual Reality Applications	Impact on Digital Transformation	IEEE References
Education and Training	Immersive simulators, XR labs, hands-on platforms, and the educational metaverse	Experiential learning, risk-free training, remote collaboration, and digital inclusion	[13]– [16], [63]–[76], [18]– [52], [53]– [42], [38]–[40], [33]– [54], [34], [59], [61]–[62], [26], [64], [72], [69], [56], [36]–[37][77]
Culture and Heritage	Virtual museums, digital reconstruction, interactive visits	Heritage preservation, mass access to cultural content, greater understanding of historical knowledge	[50], [28], [32],[72]
Human-Computer Interaction	Gesture tracking, voice, AI, natural interfaces, virtual assistants	Accessible interfaces, smart tutoring, personalized environments, intuitive collaborative design	[78], [73], [31], [45], [24], [48], [60], [58]– [68], [44], [70],[49]
Industry and Production	Process simulation, design validation, operations planning, hazardous tasks	Efficiency in manufacturing, civil engineering and technical maintenance, reduction of costs and operational risks	[41]– [43], [74], [14], [20], [66], [62], [64],[26]
Health and Rehabilitation	Surgical simulation, clinical training, first aid, immersive therapies, biofeedback	Therapeutic personalization, improved medical training, greater safety and realism in healthcare training	[13], [15], [16], [40], [33], [19], [20], [57], [61], [62], [55],[38]
Educational Metaverse	Persistent virtual environments, avatars, social and inclusive learning	Promoting accessibility, motivation, and personalized learning in shared immersive spaces	[53], [45], [49], [74], [69], [56],[46]
XR User Experience	Assessment of presence, cognitive load, latency and psychological impact	User-centered XR design optimization, improving the usability and effectiveness of immersive solutions	[75], [71], [43], [67], [35],[68]

C: Comparison of the impact of virtual reality versus other technologies in digital transformation processes

Studies comparing virtual reality (VR) with traditional teaching, training, and simulation methods such as face-to-face classes, physical models, manuals, or instructional videos—consistently report significant improvements in learning outcomes, skill retention, motivation, and safety. Research including [12], [15], [63], [18], [52], [23], [39], [20], [51], [21], [74], [55], and [64] highlights VR's effectiveness in reducing training costs and risks while enhancing engagement in immersive learning environments. This positions VR as a superior alternative that drives digital transformation in sectors like education, healthcare, and industry [18], [21], [38].

Comparative analyses also evaluate VR against other immersive technologies, including Augmented Reality (AR), Mixed Reality (MR), and Extended Reality (XR). Studies such as [50], [17], [75], [43], [67], [35], [72], and [37] assess metrics like cognitive load, emotional engagement, presence, and collaborative effectiveness. While all these technologies offer transformative potential, VR stands out for its immersive depth and flexibility in high-interaction contexts. MR, however, excels in environments requiring integration between physical and digital elements, such as museums [50] and industrial applications [72].

Further comparisons include VR versus older non-immersive digital tools like 2D software, non-interactive platforms, email, PDFs, or static video-based systems. Research by [73], [41], [42], [74], [48], [65], [59], and [70] demonstrates that immersive technologies significantly enhance collaboration, spatial understanding, design efficiency, and user personalization. These benefits not only improve existing processes but also enable their complete digital reinvention.

Together, this body of research confirms that VR is a robust, multifaceted enabler of digital transformation, outperforming both traditional and digital predecessors. Its influence is particularly evident in enhancing operational efficiency, training accessibility, and user experience. As Fig. 7 illustrates, VR is revolutionizing systems engineering by solving critical challenges from industrial process design to clinical and therapeutic training delivering measurable gains in productivity, precision, and scalability.

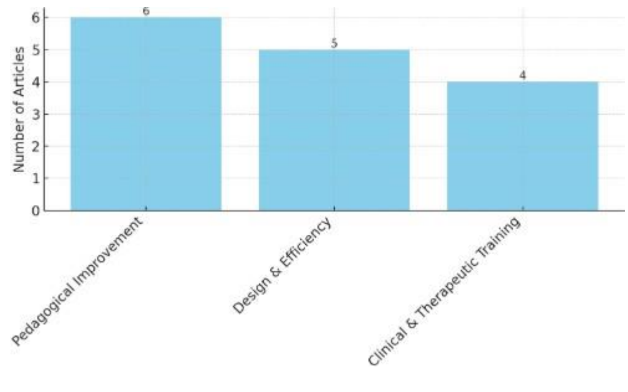

Fig. 7. Real impact and efficiency of VR solutions

The following Table IV summarizes comparative research that positions Virtual Reality as the most impactful immersive technology compared to traditional methods, other XR technologies, and conventional digital tools. VR stands out for its immersive capacity, training effectiveness, experience customization, and process optimization, consolidating it as a key driver of multi-sector digital transformation.

TABLE IV. ADVANTAGES OF VR OVER OTHER TECHNOLOGIES AND METHODS

Compilation	Criteria Evaluated	Advantages of VR	IEEE References
Vs. Traditional methods	Retention, motivation, risk, costs	Greater educational effectiveness, greater commitment, risk reduction and savings in training	[12], [15], [63], [18], [52], [23], [39], [20], [51], [21], [61], [55], [64],[38]
Vs. Other immersive technologies (AR, MR, XR)	Cognitive load, presence, emotionality, collaboration	VR stands out for its immersion; MR is useful for physical-digital integration; VR is more versatile for technical training.	[50], [17], [37], [75], [43], [67], [35],[72]
Vs. Non-immersive digital technologies	Spatial interaction, understanding, collaboration, personalization	Improves three-dimensional understanding, efficient design, and richer, more intuitive experiences	[73], [41], [70], [42], [74], [48], [65],[59]

O: Improvements or results that have been observed after implementing virtual reality in innovative processes

First, one of the most notable contributions of virtual reality is its positive impact on learning, motivation, and knowledge retention. Several studies agree that immersive environments foster a deeper understanding of concepts and increase user engagement through active and sensory experiences. These platforms allow for the development of practical and cognitive skills in realistic and safe contexts, promoting experience-based learning. Furthermore, by focusing on the user, VR enables more inclusive, sustainable, and adaptive educational environments, which enhances participation and improves the effectiveness of the training process [12], [62], [53], [74], [18]. These findings reinforce the strategic value of VR as an enabling technology for a digital transformation focused on active and personalized learning [50], [28], [69].

Subsequently, it has focused on developing practical skills, performance, and training in real-life contexts. These immersive experiences allow complex situations to be simulated in a safe and controlled manner, facilitating the acquisition of specialized skills, reducing risks during the training process, and evaluating performance through objective metrics. Virtual environments offer an effective transfer of learning to real-life scenarios, particularly benefiting sectors such as construction [13], [77], [41], [42] healthcare [38], [57], industry [26], [14] and agriculture [21], [15], [23].

Clinical and therapeutic applications have also been identified, demonstrating improvements in physical and cognitive rehabilitation processes. The personalization of therapeutic environments, continuous improvement in patient well-being, and effective medical training through immersive simulation have been some of the most significant results. Furthermore, benefits have been reported for both patients and healthcare professionals in terms of treatment efficacy and [40] reduced [55] emotional burden [62], [20].

Additionally, it highlights innovation in design, development and prototyping, where the use of XR technologies has allowed complex ideas to be visualized, reducing design errors and facilitating remote collaboration. These works show how virtual reality can accelerate innovation by enabling early testing, real-time interaction and evaluation of proposals before their physical implementation, thereby improving efficiency in design and production cycles [78], [73], [29], [31], [71], [43], [45], [24], , [67], [65], [59], [58], [79], [72], [49], [37].

On the other hand, some studies focus on improving the user experience and personalizing learning. In these cases, XR solutions have managed to increase emotional immersion, reduce cognitive load, and offer adaptive and inclusive environments [16], [27], [66] . High levels of satisfaction, intention to use in the future, and overcoming of technical barriers are reported, which reinforces the competence of these technologies to adapt to the demands of a diverse population and promote equitable access to learning [68], [75], [72], [17], [25], [33], [35], [34], [44], [37], [46], [54], [60], [61].

It has also focused on organizational digital transformation and operational efficiency. The integration of virtual reality has allowed for streamlining communication processes, reducing interpretation errors, and accelerating design and technical documentation. This has contributed to better coordination between multinational teams, more informed decision-making, and the adoption of sustainable digital solutions, particularly in sectors such as architecture [15], [80], manufacturing [65], [42] and commerce [44], [14], [41].

The analysis in Fig. 8 demonstrates the transformative role of virtual reality in systems engineering. VR is solving critical problems such as industrial process optimization, immersive technical training, and complex systems design, driving digital transformation with innovative and scalable solutions.

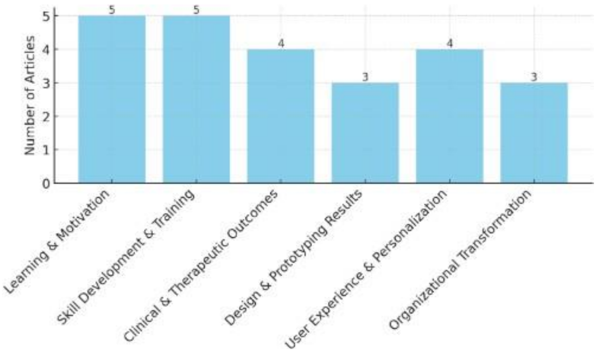

Fig. 8. Engineering 4.0 and the VR revolution

The following Table V summarizes significant improvements associated with the use of Virtual Reality in innovation. Research reveals benefits in learning, design, health, user experience, and organizational efficiency. VR drives effective digital transformation by facilitating immersive, safe, and tailored experiences that optimize key processes across multiple industries.

TABLE V. TRANSFORMATIVE EFFECTS OF VR IN EDUCATION, HEALTHCARE, AND INDUSTRY

Area of Improvement	Observed Results	IEEE References
Learning and motivation	Greater understanding, retention, engagement, learning personalization, educational accessibility	[12], [50], [63], [76], [28], [18], [52], [30], [23], [81], [32], [53], [39], [74], [33], [19], [48], [8], [51], [62], [55], [64], [69], [56], [36], [70], [22],[80]

Skills and training	Simulation of real-life scenarios, safe practice, performance measurement, effective transfer of skills	[13], [15], [23], [41], [42], [21], [57], [77], [26], [14],[38]
Health and rehabilitation	Improvement in physical/cognitive therapies, personalization, medical simulation, clinical effectiveness, and reduction of emotional burden	[40], [20], [62],[55]
Design and prototyping	Accelerated innovation, rapid prototyping, error reduction, remote collaboration, early validation	[78], [73], [29], [31], [71], [43], [45], [24], [67], [65], [59], [58], [79], [72], [49],[37]
User experience	Emotional immersion, adaptation, inclusion, satisfaction, cognitive load reduction, accessibility for diverse audiences	[16], [17], [25], [47], [25], [54], [34], [60], [61], [66], [35], [68], [72], [44], [46], [27],[37]
Organizational digital transformation	Communication optimization, remote coordination, informed decision-making, error reduction, technical sustainability	[15], [41], [80], [42], [65], [44],[14]

C: Impact that the implementation of virtual reality, along with other emerging technologies, has on the digital transformation of organizational sectors

The implementation of Virtual Reality (VR) in combination with emerging technologies such as artificial intelligence, mixed reality, XR immersive systems, 3D modeling, the Internet of Things (IoT), the Metaverse, and Language Learning Models (LLM), has generated a significant impact on the digital transformation of various organizational sectors. Firstly, its effect on the corporate and industrial sectors stands out, where the convergence of these technologies has enhanced specialized training processes, remote collaboration, infrastructure design, operational efficiency, and secure and personalized technical training. This change has been especially noticeable within the framework of Industry 4.0 and 5.0 [12], in areas such as manufacturing [73], port logistics [33], [43], architecture [52], [42], and food services [41], [29], [63], [15].

On the other hand, in the education and vocational training fields, the integration of VR with technologies such as XR and iVR has transformed teaching in disciplines such as engineering, science, medicine, and advanced manufacturing. These technologies make it possible to simulate complex environments, facilitate conceptual understanding, increase accessibility, and promote training without the need for physical infrastructure [76], [16], expanding the pedagogical capabilities of educational institutions [47], [18], [30], [39], [81], [74], [17].

Likewise, a significant impact is observed in the cultural and heritage sector, where virtual reality and its variants have fostered the digitalization of museums, artistic education [32], heritage conservation, and the democratization of access to cultural knowledge. This transformation has expanded educational opportunities and preserved traditional knowledge, offering new forms of interaction to diverse audiences [50], [23], [28].

In addition, innovative applications are identified that explore the convergence of VR and emerging technologies such as the Metaverse and LLMs, transforming human-computer interaction and enabling more personalized and immersive multi-sector experiences [31], [45], [53]. These experiences foster inclusion, accessibility, and connectivity in educational, social, and work contexts, facilitating a holistic and distributed digital transformation [43], [78], [71], [75].

Furthermore, widespread, though not sector-specific, educational applications show that virtual reality significantly contributes to overcoming logistical barriers, facilitating access to learning, and supporting teachers and students at various levels of training, even in technologically limited environments [18], [39], [47], [76], [81].

Finally, in the healthcare field, VR has transformed both medical training and clinical rehabilitation, facilitating personalized treatments, pharmaceutical process simulations, and new methodologies for neurorehabilitation. These advances not only optimize the user experience but also restructure care and learning models in the healthcare sector [16], [30], [40]. The distribution in Fig. 9 shows how virtual reality is transforming systems engineering through key processes such as initialization, data extraction, and converging applications. These areas reflect its impact on solving complex problems, optimizing workflows, and improving technical solutions in healthcare and other critical sectors .

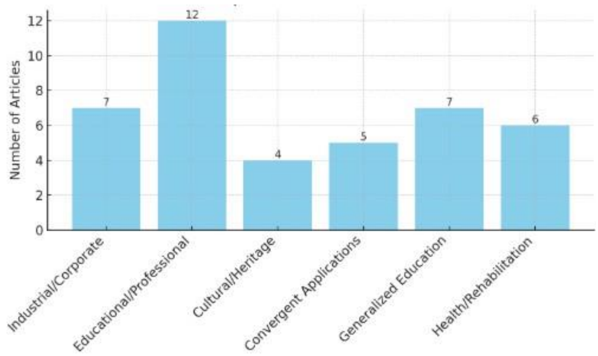

Fig. 9. Systematic solutions and innovation with VR

The following Table VI explains how the integration of Virtual Reality with emerging technologies has driven the digital transformation of key sectors. From manufacturing to healthcare, improvements have been observed in training, design, accessibility, and inclusion. These technological synergies enable advanced, personalized, and multi-sector digitalization, adapted to complex and diverse environments .

TABLE VI. SYNERGIES OF VR AND EMERGING TECHNOLOGIES IN ORGANIZATIONAL SECTORS

Sector or Domain	Combined Technologies	Main Impact on Digital Transformation	IEEE References
Industry and corporations	VR + IoT + AI + XR + 3D Modeling + Industry 4.0/5.0	Design optimization, technical training, operational simulation, remote collaboration, and efficiency in logistics, architectural, and manufacturing processes.	[12], [15], [63], [73], [29], [52], [41], [42], [43],[33]
Education and training	VR + XR + iVR + Immersive Models	Accessible, infrastructure-free teaching, simulation of complex environments, promotion of digital pedagogies, and increased conceptual understanding in engineering, medicine, manufacturing, and science.	[16], [17], [76], [47], [18], [30], [81], [39],[74]

Culture and heritage	VR + Mixed Reality + XR + Digital Modeling	Digitization of museums, heritage preservation, artistic education, and the democratization of cultural knowledge through immersive and accessible experiences for diverse audiences.	[50], [28], [23],[32]
Multisectoral experiences	VR + Metaverse + Language Models (LLM) + AI	Personalization and inclusion in human-machine interaction, distributed connectivity, and social and educational integration through immersive and intelligent environments.	[78], [75], [45], [31], [71], [43],[53]
General educational applications	VR + XR Platforms + Inclusive Digital Tools	Overcoming logistical barriers, equitable access to learning, and teacher and student support even in contexts with limited infrastructure.	[76], [18], [81], [39],[47]
Health and medicine	VR + Immersive Simulations + Therapeutic Technologies	Advanced medical training, neurorehabilitation, personalized therapies, pharmacological simulation, and improved clinical care models with a focus on the patient experience.	[16], [30],[40]

IV. DISCUSSION OF RESULTS

The main findings of this study show that Virtual Reality (VR), especially in combination with emerging technologies such as XR, AI, IoT and LLMs, has generated substantial impacts on innovation and multi-sector digital transformation. Improvements in knowledge retention, practical skills development, learning personalization and operational efficiency are highlighted, particularly in contexts such as healthcare, manufacturing, education and industrial design [10], [13], [28], [38], [50]. This synergy has enabled adaptive immersive environments that not only enhance technical training but also restructure traditional organizational processes towards more sustainable and collaborative models.

These findings confirm and extend previous research analyzing VR integration in industrial, educational, and clinical settings, such as those conducted by Hagl and Duane [1] or Pessot et al. [2]. However, this study incorporates a more transversal perspective, aligned with current approaches such as Industry 5.0 and the systematic virtualization of services [3], [4], [6]. The review also allows us to infer that VR implementation is mediated by contextual factors (technological, cultural, and economic), which still represent limitations. These include the lack of standardization of tools, the digital divide into less developed regions, and the high initial costs of technological adoption [26], [62].

Some unexpected results include the significant appropriation of VR in cultural and heritage sectors [21], [30], which suggests future lines of research in unconventional contexts. Furthermore, it is recommended to delve into longitudinal studies that evaluate the real impact of these technologies on organizational productivity, as well as the development of inclusive pedagogical models and regulated educational metaverses [14], [16], [76]. Finally, exploring the ethics and security in the use of VR alongside AI and LLM (Large Language Models) represents a key emerging agenda in systems engineering and computer science.

V. CONCLUSIONS

The findings of this systematic review consolidate virtual reality as a strategic technology for multisectoral digital transformation, with effective applications in education, healthcare, industry, and cultural heritage. It demonstrates its ability to overcome barriers posed by traditional methods through greater immersion, personalization, accessibility, and risk reduction. The critical integration of previously disparate studies allows us to outline key success factors such as inclusive instructional design, interoperability, and user-centeredness. Furthermore, the emerging role of convergence with technologies such as artificial intelligence, IoT, and the metaverse, which enhance its transformative value, is highlighted. However, research gaps persist regarding standardized metrics, longitudinal assessments, and inclusive approaches.

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