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Review

Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade

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Abstract: In the field of education, virtual reality (VR) offers learners an immersive and interactive learning experience, allowing them to comprehend challenging concepts and ideas more efficiently and effectively. VR technology has enabled educators to develop a wide range of learning experiences, from virtual field trips to complex simulations, that may be utilized to engage students and help them learn. Learning theories and approaches are essential for understanding how students learn and how to design effective learning experiences. This study examines the most recent published findings in educational theories and approaches connected to the use of VR systems for educational and tutoring purposes. Seventeen research studies that meet the search criteria have been found in the database, and each of them focuses on at least one learning theory or learning approach related to educational systems using VR. These studies yielded five educational approaches, one methodology, five learning theories and one theoretical framework, which are presented in the context of virtual reality in education. These include constructivism learning, experiential learning, gamification of learning, John Dewey's theory of learning by doing, flow theory, Cognitive Theory of Multimedia Learning, design thinking, learning through problem solving, scientific discovery learning, social constructivism, cognitive load theory and the Technology Pedagogical Content Knowledge Framework (TPACK). A major finding of this study is that constructivism learning is the most often utilized learning theory/method, Experiential Learning is most appropriate for VR and the gamification of learning has the greatest future potential.

Keywords: virtual reality in education; learning theories; constructivism learning; experiential learning; gamification of learning; John Dewey's theory of learning by doing; flow theory; cognitive theory of multimedia learning; design thinking; learning through problem solving; scientific discovery learning; social constructivism; cognitive load theory; Technology Pedagogical Content Knowledge Framework (TPACK); literature review

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1. Introduction

Virtual reality is an emerging technology that delivers a computer-generated simulation of an environment that may be interacted with in an apparent real-time manner. VR technology has been employed in a variety of industries, including medical training [1], engineering [2] and entertainment [3], but it also has significant educational potential. VR technology in education allows learners to interact with real-life scenarios without leaving the classroom.

One of the primary advantages of implementing VR in education is that it provides a more immersive and engaging learning experience. VR can transport learners to difficult-to-access places, such as historical monuments, outer space or even within the human body. Students are able to better understand the subject and engage with the learning material when they are given a unique perspective.

Furthermore, VR in education can enhance collaborative learning [4]. Learners can interact with their peers and the virtual environment, making the experience more active.

It can additionally offer students a personalized learning experience by allowing them to explore the virtual world at their own pace and in the way they prefer. Students can improve their comprehension of the subject matter by using VR technology to deliver personalized feedback [5].

VR has a notable benefit in education as it offers a cost-effective solution [6]. Instead of arranging physical models or field trips, educational institutions can generate a virtual environment that can be accessed by multiple students simultaneously. Moreover, technology can create a secure and regulated learning environment for students, particularly when working with complex machinery or hazardous materials [7].

The use of VR in education has the capability to revolutionize the learning experience for students through immersive and captivating encounters that can enhance their comprehension of the subject. Providing an interactive VR experience has the potential to connect theoretical concepts with practical applications, thereby equipping students with the confidence to face future challenges. With the continuous advancement of technology, it is highly probable that VR will become an essential component of the education system, offering students a potent means to amplify their learning [8].

Educational learning theories refer to frameworks that provide an explanation of how people acquire knowledge, skills and attitudes. They are aimed at comprehending the learning processes and the various factors that affect them. There are diverse learning theories, including behaviorism, cognitivism, constructivism and humanism, among others.

Comprehending learning theories is crucial for educators since they offer a foundation for developing effective teaching approaches, learning materials and evaluation tools [9]. When teachers understand how people learn, they can customize their instructions to cater to the unique requirements of each learner and facilitate profounder learning. Moreover, knowledge of learning theories enables teachers to create encouraging learning environments that enhance student engagement, motivation [10] and success. In the realm of VR, various learning theories can be used to design effective VR-based learning experiences. However, the research in this area is still relatively new, and more studies are needed to understand the most effective ways to design and implement VR applications for education.

Designing effective VR-based learning experiences relies heavily on the incorporation of learning theories. The utilization of these theories in VR can enable educators to devise immersive and interactive learning experiences that captivate students and facilitate more efficient and effective learning. With the progression of VR technology, it is becoming progressively crucial for educators to comprehend how to apply learning theories in designing VR-based learning experiences effectively.

However, it is crucial to critically evaluate the current state of VR technology, including its drawbacks, in order to gain a comprehensive understanding of its implications and challenges.

One notable limitation of most contemporary VR devices is their close proximity to the user's eyes, with screens positioned within 10 cm. This setup raises two significant concerns that impact the user experience and overall health. Firstly, unlike real-life vision, which allows for dynamic focus adjustment at varying distances, VR devices typically require a fixed focus at a specific distance. This discrepancy can result in a noticeable difference between the natural visual experience and the virtual environment, potentially affecting the level of immersion and realism perceived by users [11].

Furthermore, the long-term effects of LCD or OLED screen emissions on eye health remain insufficiently studied. Given the direct exposure of the eyes to the emitted light during extended VR sessions, it is crucial to consider the potential implications for eye health. While ongoing research aims to address this concern, the current lack of comprehensive studies calls for caution and prompts questions about the potential long-term consequences of prolonged VR device usage.

Apart from the optical considerations, there are additional health concerns associated with VR technology. Some individuals may experience issues like loss of balance or feelings of nausea due to the disruptions caused by the virtual environment. These adverse effects, commonly referred to as cybersickness or simulator sickness, can arise from a mismatch between the visual, vestibular and proprioceptive sensory systems [12]. The prevalence and severity of these symptoms can vary among users, affecting their comfort, well-being and overall acceptance of VR technology.

Acknowledging and addressing these negative aspects is crucial when proposing methodologies for the use of VR. Researchers and practitioners need to account for potential health risks and develop suitable strategies to mitigate them. This may involve designing VR experiences that minimize eye strain, incorporating regular breaks or utilizing technologies aimed at reducing the risk of cybersickness. Furthermore, providing adequate training and acclimatization to VR environments can help users overcome issues related to balance and motion sickness.

By recognizing the limitations and potential challenges associated with current VR technology, researchers can work towards enhancing the safety, user experience and acceptance of VR applications. Continued research into the long-term effects of VR usage on eye health and the development of effective methods for mitigating cybersickness are vital. By addressing these concerns, we can responsibly and effectively harness the full potential of VR while ensuring the well-being and satisfaction of users.

This paper explores the utilization of learning theories in VR settings for educational purposes. The seventeen studies included in the paper were identified and extracted from a database, which underwent a rigorous screening process based on established inclusion and exclusion criteria to ensure that only high-quality studies were selected. The selected studies contained educational theories or approaches that were analyzed in detail. It is worth noting that the number of studies included in this research is relatively limited. This is attributed to the presence of a research gap in the development of VR learning environments that adequately incorporate VR learning theories, as indicated in [13]. The purpose of the paper is to provide a comprehensive overview of the relevant learning theories and approaches in VR-based education. It aims to serve as a guide for future researchers and students who wish to delve deeper into this subject matter and field to better understand the learning theories and approaches that are most effective in using VR for education.

2. The Relevant Literature

The relevant literature section provides a summary of various studies that have explored the use of virtual reality (VR) technology in education. Leung et al. [14] examined how VR-based learning environments could support different learning theories, such as constructivist learning theory and social cognition theory. Chen [15] focused on how VR technology can be used to enhance learners' engagement and participation in the learning process, particularly in the context of constructivist learning.

Checa and Bustillo [16] conducted a review of proposals for serious games in immersive VR environments and provided recommendations for improving these tools. Radianti et al. [17] analyzed the existing research on the use of immersive virtual reality (IVR) in higher education and highlighted its potential for creating engaging learning environments.

Overall, the relevant literature suggests that VR technology can provide immersive and engaging learning experiences and understanding learning theories can aid in designing effective VR-based learning interventions. This study aims to review recent research on the application of learning theories in VR-based education, conducting a thorough analysis of each learning theory and educational approach across different educational levels.

In their study, Leung et al. [14] analyzed the impact of VR technology on learning theories in education. The authors discussed four prominent learning theories, namely constructivist learning theory, situated learning theory, embodied cognition theory and social cognition theory, and they presented how these theories could be implemented in VR-based learning environments. Additionally, the authors demonstrated how VR-based learning environments could provide opportunities for learners to experience immersive and interactive learning situations, which can facilitate the application of these learning theories. For example, VR technology can create a virtual environment that closely mimics real-world situations, allowing learners to engage in active learning and knowledge construction. Additionally, VR-based learning environments can provide learners with social interaction opportunities, facilitating the application of social cognition theory.

Overall, Leung et al.'s [14] study shed light on the potential of VR technology to enhance learning in education and provided insights into how established learning theories could be applied in VR-based learning environments.

Additionally, Chen [15] examined how VR technology can be utilized to support constructivist learning principles. Specifically, the article emphasizes how VR's technical abilities can improve learners' participation and engagement during the learning process. The article introduces the VRID model as a way to provide clear instructions on designing and developing virtual learning environments that align with the principles of constructivist learning.

In their review, Checa and Bustillo [16] examined 135 proposals for serious games in immersive VR environments. The review analyzes the forum, nationality and date of publication of the articles, as well as the application domains, target audience, design, technological implementation, performance evaluation procedure and results. The aim is to identify the standards of the proposed solutions and differences between training and learning applications and provide recommendations for the improvement of these tools. The study provides a basis for future research on serious games in immersive VR environments, which can enhance both learning and training tasks.

In their study, Radianti et al. [17] undertook a comprehensive analysis of existing research exploring the use of immersive virtual reality (IVR) in higher education. The design characteristics, research aims and insights acquired from IVR applications in the educational setting were thoroughly assessed by the researchers. Their findings indicate that IVR can create an engaging and captivating learning atmosphere, stimulating active participation and augmenting information retention. As a result, the study suggests a research plan to fill these gaps in the existing literature and emphasizes the potential of IVR as a tool to transform higher education.

Overall, the relevant literature suggests that the use of VR in education has the potential to provide immersive and engaging learning experiences that can enhance learning outcomes, and understanding the underlying learning theories can aid in designing effective VR-based learning interventions.

This study offers a valuable contribution by reviewing recent research that explores the application of learning theories in VR-based education. It conducts a thorough analysis of each learning theory and educational approach to gain a comprehensive understanding of them. Furthermore, the study takes into account all educational levels, providing a holistic view of how VR can align with different learning theories and approaches.

3. Planning the Study

In this study, we have followed Kitchenham's guidelines [18], which are intended to assist senior and junior researchers in exploring the different theories and approaches associated with learning in information technology. The review is organized into three primary sections: planning, conducting and presenting the results.

3.1. Research Objectives

The purpose of this study is to provide academics and educators with a comprehensive overview of recent research on educational theories and practices related to the use of VR systems in education and tutoring. The study aims to present a detailed evaluation of these findings.

3.2. Search Strategy

The relevant literature for the study's objectives was obtained by utilizing the Scopus database. Through the use of manual searches employing Boolean operators such as "AND" and "OR" alongside carefully chosen keywords, publications' abstracts, keywords and titles were explored. The search terms included terms such as "education", "learning", "training", "tutoring", "teaching", as well as "educational theory", "educational approach", "educational methodology", "higher education", "college", "high school", "secondary school" and "primary school" (Table 1).

Table 1. Search Keywords.

Search Keywords Using Boolean Operators
("virtual reality" OR "VR") AND {("education" OR "learning" OR "training" OR "tutoring" OR "teaching") OR ("higher education" OR "university" OR "college" OR "high school" OR "high school" OR "secondary school" OR "primary school") OR ("educational theory" OR "educational approach" OR "educational methodology")}

This systematic method proved successful in identifying relevant studies in the field of education. In total, 4162 studies were discovered, providing valuable insights aligned with the study's objectives.

3.3. Inclusion and Exclusion Criteria

To ensure the selection of appropriate studies for analysis in this study, a rigorous process was undertaken to establish a set of inclusion and exclusion criteria, as illustrated in Figure 1. This approach was implemented to guarantee that the chosen studies align with the specific requirements and objectives of the present investigation.

In order to concentrate on the most relevant and recent research regarding VR and education, Scopus search filters were applied to manually select a time frame spanning from 2012 to 2022. The chosen time frame holds great significance as it offers an up-to-date and comprehensive perspective on the pertinent research within the field of VR and education. Careful deliberation was given to determine an appropriate duration that would facilitate a thorough analysis of the subject matter. It was crucial to include the most current data to ensure the accuracy and relevance of our findings.

Consequently, the investigation commenced in 2012 and concluded in 2022, thereby incorporating the most contemporary and pertinent data available. By adhering to this designated time frame, our aim is to attain a comprehensive and current understanding of the subject matter at hand. This deliberate approach empowers us to encompass the most up-to-date research in our analysis, ultimately enhancing the validity and reliability of our findings.

In addition to the specified time frame, the inclusion criteria for selecting studies require accessibility to the complete text and the presence of both an English abstract and manuscript. This ensures that the chosen studies can be thoroughly examined and incorporated into the analysis.

To ensure the quality of the selected studies, it was determined that only those with well-designed educational settings and research methods would be included. A well-designed educational setting encompasses various factors that promote effective learning and teaching. This includes the use of appropriate teaching methods, engaging materials and relevant resources, all of which contribute to optimal learning outcomes for students.

Likewise, a well-designed research methodology refers to a rigorous and valid approach to conducting research. This entails employing appropriate data collection techniques, employing sound sampling methods and utilizing robust statistical procedures to ensure the validity and reliability of the research results. By adhering to specific criteria regarding educational settings and research methodologies, the study aims to ensure the inclusion of high-quality studies that can provide valuable insights and contribute to the overall analysis.

Upon reviewing the abstracts of each study, activities that were not relevant to virtual reality (VR), activities that did not involve immersive VR experiences, and activities that occurred outside of a classroom context were excluded. The primary rationale behind this decision was to ensure that only educational theories, approaches and methodologies closely associated with immersive VR content and implemented within classroom settings were included.

To further narrow down the selection and exclude studies that did not meet the criteria for this particular study, a thorough review of the entire body of each work was conducted. Studies that did not incorporate an experimental group receiving VR treatment, studies that did not consider the impact on learners following the intervention, and studies that did not assess and report the results of these interventions were also excluded from the analysis.

By employing this process of assessment and selection, the study aimed to maintain a focus on educational research that specifically addressed immersive VR within the classroom context. This ensured that the included studies aligned with the objectives and requirements of the present investigation, resulting in a more targeted and meaningful analysis.

In order to ensure the relevance of the selected studies to the primary, secondary or non-tertiary education context, studies solely focusing on vocational abilities unrelated to these educational levels were deemed irrelevant and thus excluded from the analysis. This decision was made to maintain a coherent focus on in-class education, which aligns with the primary scope of this study.

Additionally, studies related to physical activities, surgical procedures, neurological treatment and rehabilitation were also excluded from the analysis. These studies were determined to fall under a different educational approach with distinct characteristics that diverge from the scope examined in this review. Moreover, it was observed that the repository contained a substantial number of studies primarily focused on surgical procedures and medical training in relation to VR and education. Consequently, to maintain consistency and coherence within the study, these studies were excluded from consideration.

By implementing these exclusion criteria, the study aimed to ensure that the selected studies were directly relevant to the in-class educational context and aligned with the specific objectives of the research. This approach allowed for a more focused analysis of educational aspects related to VR, contributing to the accuracy and depth of the findings.

In this study, studies that did not incorporate a theory of learning or approach were deemed ineligible and subsequently excluded from the analysis. It is important to highlight that a total of 55 studies were rejected based on this criterion, ensuring that only studies with a strong theoretical foundation were included in the final analysis.

To ensure a rigorous and transparent research process, the research adhered to the guidelines and instructions outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement [19]. PRISMA guidelines are specifically designed to enhance transparency and quality in reporting systematic reviews and meta-analyses, providing researchers with a standardized framework to follow. By adopting these guidelines, readers can critically evaluate the methods and findings of such studies with greater confidence.

The PRISMA guidelines offer detailed criteria and recommendations for each section of a systematic review, including the title, abstract, introduction, methods, results, discussion and funding sources. They cover crucial aspects such as study selection, data extraction, risk of bias assessment and statistical analysis. Adhering to these guidelines ensures consistency and clarity in reporting, fostering increased rigor and transparency in systematic reviews and meta-analyses.

These guidelines also emphasize the significance of conducting a comprehensive literature search, establishing clear inclusion and exclusion criteria and appropriately assessing study quality and risk of bias. Furthermore, they advocate for the use of flow diagrams to visually represent the study selection process, providing a clear and concise overview.

By incorporating the PRISMA guidelines and following the suggested flow chart, the researchers were able to effectively document and track any modifications made throughout the review process in a dynamic manner. This documentation serves as valuable evidence, promoting transparency and accountability in the research methodology.

In addition, the inclusion and exclusion procedures were precisely outlined in a flow diagram, aligning with the PRISMA statement guidelines. This diagram provides a visual representation of the step-by-step screening and selection process, offering a comprehensive overview of how studies were identified, assessed and ultimately included in the final analysis. By adhering to the PRISMA guidelines, the research methodology is fortified, ensuring the reliability, replicability and validity of the findings.

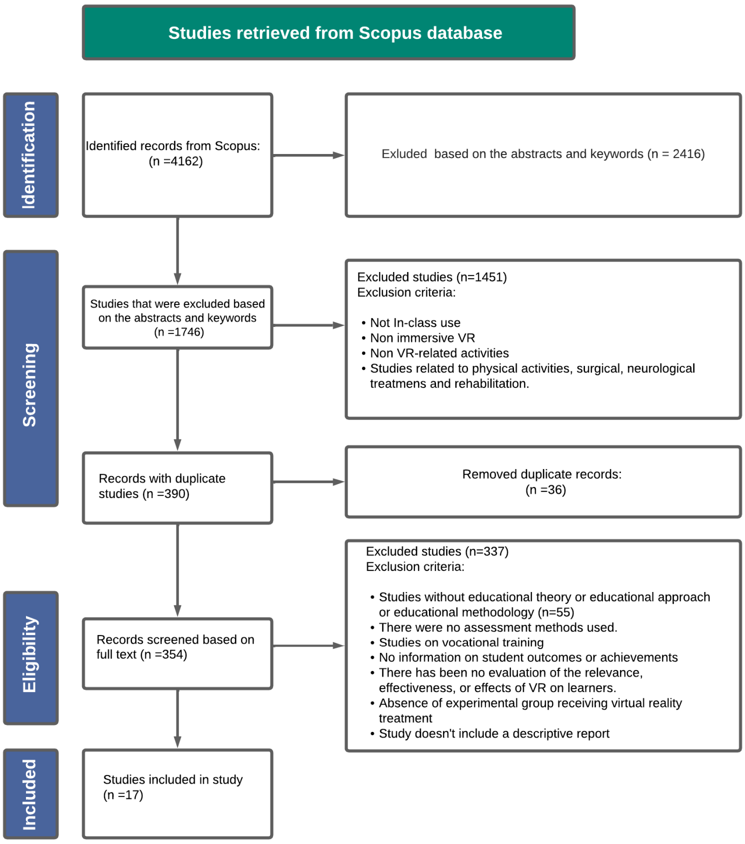

Figure 1. Studies that were obtained from the Scopus database (as shown in the following table).

4. Theories, Approaches and Methodologies

Five educational approaches, one methodology, five learning theories and one theoretical framework were found in the included literature from the seventeen studies that were obtained from the Scopus database (as shown in the Table 2 and Figure 2).

Table 2. Learning theories and educational approach.

Paper	Learning Theory or Educational Approach
Sedlák et al., 2022 [20]	Cognitive load theory (CLT) (Theory)
Meyer et al., 2019 [21]	Cognitive Theory of Multimedia Learning (CTML) (Theory)
Bendeck Soto et al., 2020 [22], Megat et al., 2020 [23], Xu and Ke, 2017 [24], Zhang et al., 2017 [25]	Constructivism learning (Educational approach)
Kamińska et al., 2017 [26]	Design thinking (DT) (Educational approach)
Li et al., 2022 [27], Pande et al., 2021 [28], Pirker et al., 2017 [29]	Experiential Learning (Methodology)
Akman and Çakır, 2019 [30]	Flow Theory (Theory)
Chang et al., 2018 [31], Remolar et al., 2021 [32]	John Dewey's theory of learning by doing (Theory)
Sedlák et al., 2022 [20]	Learning through problem solving (LPS) (Educational approach)
Sedlák et al., 2022 [20]	Scientific discovery learning (SDL) (Educational approach)
Southgate et al., 2018 [33]	Social Constructivism (Theoretical framework)
García-Bonete et al., 2018, [34]	Technological Pedagogical ContentKnowledge Framework (TPACK) (Theory)
Ou K-L et al., 2021 [35], Wilson et al., 2017 [36], Zhang et al., 2017 [25]	The gamification of learning (Educational approach)

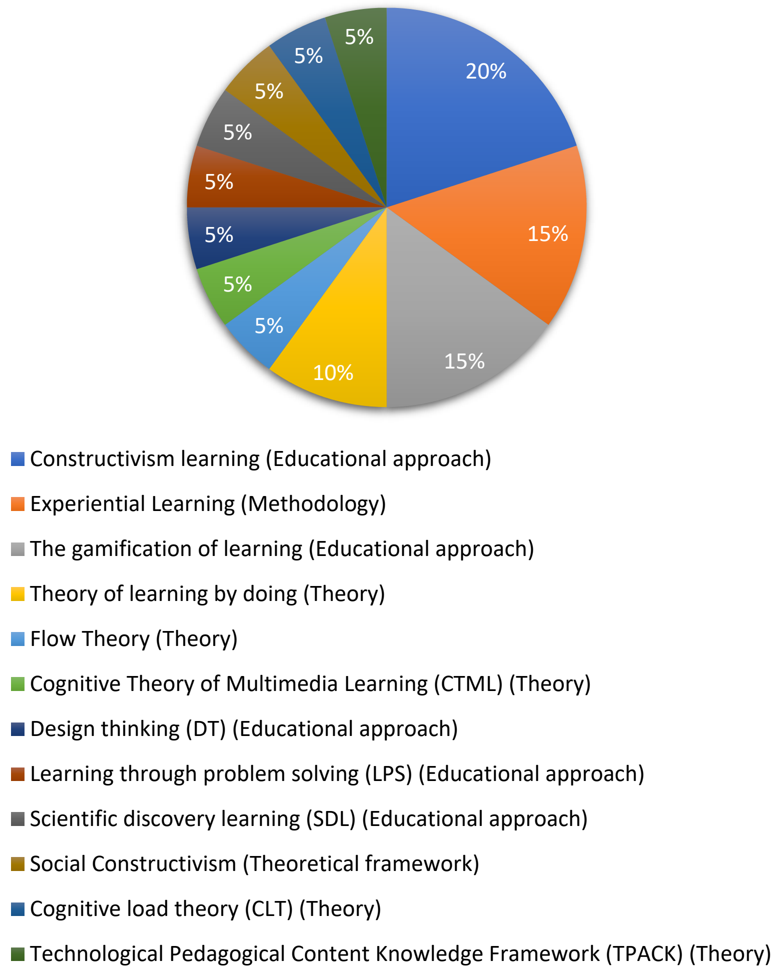

Figure 2. Learning theory and educational approach frequencies.

Constructivism learning, experiential learning, the gamification of learning, John Dewey's theory of learning by doing (or more simply known as learning by doing), flow theory, Cognitive Theory of Multimedia Learning (CTML), design thinking (DT), learning through problem solving (LPS), scientific discovery learning (SDL), social constructivism, cognitive load theory (CLT) and the Technological Pedagogical Content Knowledge Framework (TPACK) are the twelve different components that were incorporated in VR educational contexts, and they are presented in the following section.

4.1. Constructivism

Constructivism was the most commonly referred learning theory in the studies, appearing four times.

According to constructivism learning theory, the learner constructs new knowledge as part of a group or independently, based on prior knowledge and experiences, by participating in a situation rather than passively absorbing information [37]. Based on Piaget [38], learners develop their own knowledge of the world through their experiences and interactions with their environment. In this view, learning is not just about acquiring information but also constructing meaning and understanding through exploration and discovery.

VR technology provides a powerful tool for facilitating constructivist learning experiences. VR allows students to participate in immersive, interactive environments that provide opportunities for exploration, experimentation and discovery. This makes VR an ideal platform for implementing constructivist pedagogy in education. Recent studies have demonstrated that VR can be effective in promoting constructivist learning outcomes in a variety of educational contexts [39]. In addition, VR can be used to create safe and supportive learning environments that encourage students to take risks, express their ideas and engage in meaningful learning experiences [40].

One limitation of utilizing constructivism in VR learning environments is the learner's reliance on the instructor, impeding their ability to function autonomously. Learners often depend on the instructor for guidance and support, limiting their independent exploration and self-directed learning. Additionally, the learning process in VR is influenced by the learner's prior knowledge, which can either facilitate or hinder the acquisition of new knowledge. To address these limitations, it is crucial to design VR experiences that promote learner autonomy and provide opportunities for independent exploration while also considering and addressing learners' prior knowledge through effective scaffolding techniques.

In conclusion, the use of VR technology can help support constructivist learning in education by providing immersive, interactive environments that promote exploration, experimentation and discovery. By incorporating VR into the education process, teachers can create opportunities for students to actively engage in the construction of knowledge and understanding, promoting deeper and more effective learning outcomes.

4.2. Experiential Learning (ExL)

Experiential learning (ExL) was mentioned three times in the studies as one of the learning theories and educational methodologies used.

As a methodology, experiential learning posits that learning is most effective when it involves a cycle of concrete experience, reflective observation, abstract conceptualization and active experimentation. This theory was first proposed by [41], who suggested that learners need to engage in all four of these processes in order to fully internalize new knowledge and skills.

Experiential learning emphasizes hands-on, active learning experiences that engage learners in the process of creating meaning from their experiences [41]. Furthermore, experiential learning focuses on the emotions, cognitive abilities and environmental characteristics of the learner in the context of observations and interactions.

When comparing all learning theories, it is the most appropriate for virtual reality learning environments because it encourages the learner to act autonomously within the artificial environment. The learner can interact within the artificial environment to gain new knowledge, resulting in new experiences and memories. The goal of experiential learning is to promote deep understanding and long-term retention of information and skills by facilitating the construction of knowledge through direct experience.

It is mostly used as a learning theory to simulate real-life situations and hands-on experiences.

Virtual reality technology provides a unique tool for facilitating experiential learning in education. VR allows students to participate in immersive, interactive environments that simulate real-world experiences. This allows students to actively engage in learning activities and to explore, experiment and reflect on their experiences in a way that promotes deep learning and understanding.

Recent research has proven that VR is beneficial in facilitating experiential learning in a range of educational environments [29]. Experiential learning, for example, has been demonstrated to improve perceived educational outcomes, attract students' interest and enhance enjoyment [28]. It also enhances content knowledge, enhances immersion and creates a sense of presence, increases motivation and engagement [28], supports the development of higher-order thinking skills such as problem-solving and critical thinking, and enhances students' ability to apply abstract concepts in real-world situations.

The application of experiential learning (ExL) in VR educational contexts faces specific limitations. One limitation pertains to the challenge of accurately reproducing real-life sensory experiences and the depth of physical interactions within virtual environments. While VR can offer immersive and interactive experiences, it may not fully capture the intricacy and authenticity of real-world encounters. Additionally, developing high-quality

VR simulations for experiential learning requires substantial time and resources, which can limit the availability of diverse and captivating learning scenarios. Furthermore, the effectiveness of feedback and reflection and integral aspects of experiential learning may vary in VR settings due to technological constraints or limited opportunities for immediate and tailored feedback. Overcoming these limitations necessitates ongoing technological advancements in VR, thoughtful instructional design and continued research to enhance the authenticity and effectiveness of experiential learning in VR educational contexts.

In conclusion, the use of VR technology can help to support experiential learning in education by providing immersive, interactive environments that promote hands-on, active learning experiences.

4.3. Flow Theory

Flow theory, also known as the flow state, is a psychological concept that refers to a state of complete focus, enjoyment and immersion in an activity. According to Csikszentmihalyi [42], the flow state is achieved when an individual is fully engaged in an activity that is challenging but within their skill level and when there is a clear and immediate feedback loop.

VR technology, with its immersive environments and interactive elements, can provide the necessary conditions for the flow state to occur. In education, VR technology has been found to facilitate the flow state, leading to improved learning outcomes [30].

A significant drawback of flow theory is its primary focus on individual experiences, overlooking the social and cultural contexts that can profoundly shape and influence flow experiences. This limitation becomes particularly noteworthy within VR educational contexts, where VR possesses the potential to immerse learners in collaborative educational experiences.

In conclusion, flow theory suggests that the immersive and interactive nature of VR technology can facilitate the flow state in education and lead to improved learning outcomes. VR has been found to increase student engagement, motivation and problem-solving skills. As VR technology continues to evolve, it has the potential to revolutionize education by providing students with immersive and engaging learning experiences.

4.4. The Gamification of Learning

The gamification of learning has been a popular trend in recent years, with the aim of enhancing student engagement and motivation. With the advent of VR technology, gamification in education has taken a step forward. VR enables students to immerse themselves in a simulated environment, making the learning experience more memorable and impactful [30].

In VR-based gamification, students can interact with virtual objects and scenarios, allowing them to experience and learn in a hands-on manner [43]. For example, students can learn about history by visiting virtual historical sites or learn about anatomy by exploring virtual body parts. This creates an immersive and interactive experience, making the learning process more enjoyable and engaging [44].

VR can also help to overcome the limitations of traditional education, such as the inability to provide students with real-life experiences. VR enables students to simulate real-life scenarios and make decisions based on their experiences, allowing them to develop critical thinking skills [45].

A significant limitation of gamified learning experiences is that while they can initially engage learners, learners may view them as mere distractions if the incorporation of gameplay elements or rewards is not carefully integrated into the educational content.

In conclusion, the gamification of learning through VR technology provides a unique and engaging learning experience. By incorporating VR into the education process, students can learn and retain information better [36], and teachers can assess students' progress in a more meaningful and interactive way. With the increasing popularity and advancements of VR technology, we can expect to see an even greater integration of VR into the education field in the future.

4.5. Cognitive Theory of Multimedia Learning (CTML)

The Cognitive Theory of Multimedia Learning (CTML) proposes that students can learn better from multimedia materials when they are designed to support their cognitive processes [46]. According to this theory, students learn better when they are presented with words and images that work together to convey information rather than with words or images alone.

With the advent of VR technology, CTML has become increasingly relevant in education. VR allows students to immerse themselves in a simulated environment and interact with virtual objects and scenarios. This can help enhance their learning experience by providing opportunities for them to experience and process information in a more meaningful and engaging way [21].

When used in VR educational contexts, the Cognitive Theory of Multimedia Learning (CTML) has some limitations. CTML may not fully account for the special qualities of immersive VR experiences since it was designed primarily for traditional multimedia learning. It does not give much consideration to the effects of presence and embodiment in VR, nor does it explore the advantages of social interaction and teamwork in immersive learning environments. In order to develop theories that specifically address the complexities of learning in VR educational settings, more research is therefore required.

In conclusion, the CTML and its application in VR technology can enhance the learning experience for students by providing them with opportunities to engage with multimedia materials in a more meaningful and interactive way.

4.6. John Dewey's (1938) Theory of Learning by Doing

John Dewey's [47] theory of learning by doing emphasizes the importance of hands-on, experiential learning in the educational process. According to Dewey, students learn best when they are actively involved in the learning process rather than simply passively receiving information. This approach to education is based on the idea that learning is an active, rather than passive, process [47].

VR technology provides a unique opportunity to apply Dewey's theory of learning by doing in education. VR allows students to immerse themselves in a simulated environment and interact with virtual objects and scenarios in a way that is both hands-on and experiential. This can help enhance their learning experience by providing opportunities for them to engage with the material in a more meaningful and interactive way [31].

Studies have shown that VR can be effective in promoting experiential learning and enhancing students' engagement and motivation [48].

In summary, when considering VR educational contexts, John Dewey's theory of learning by doing encounters limitations due to the lack of physical interactions, the difficulty in replicating social interactions, and the need for further exploration of cognitive and emotional effects in immersive virtual experiences. To fully harness the potential of Dewey's theory in VR, it is essential for researchers and practitioners to find creative solutions that address these limitations and bridge the gap between physical, social and cognitive aspects of learning within the VR environment.

In conclusion, the application of John Dewey's theory of learning by doing in VR technology can enhance the learning experience for students.

4.7. Social Constructivism

Social constructivism is a learning theory that emphasizes the importance of social interactions and experiences in the learning process. According to this theory, knowledge is not simply transmitted from teacher to student but is instead constructed through the process of negotiation and collaboration among learners [49]. In this view, learning is not just about acquiring information but about participating in a community of learners, engaging in dialogue and co-creating meaning and understanding.

VR technology provides a powerful tool for facilitating social constructivist learning experiences. VR allows students to participate in immersive, interactive environments that foster social interaction and collaboration, providing opportunities for learners to engage in dialogue, negotiate meaning and co-create knowledge in real time [33]. This makes VR an ideal platform for implementing social constructivist pedagogy in education.

Social constructivism, although valuable for comprehending the significance of social interaction in learning, encounters limitations when applied to VR education. Replicating genuine social interactions within VR environments proves challenging as VR may not fully capture the intricacies and depth of face-to-face interactions. Moreover, the assumption of a shared understanding and consensus among learners becomes difficult to achieve in the diverse cultural and background contexts of VR. Additionally, facilitating effective social negotiation and scaffolding poses challenges in VR, where the availability and quality of peer support and guidance can vary. To optimize social learning experiences in virtual environments, it is crucial to explore these limitations further and develop strategies that address these challenges.

The use of VR technology can help support social constructivist learning in education by providing immersive, interactive environments that foster social interaction and collaboration among learners.

4.8. Scientific Discovery Learning (SDL)

The approach to education known as scientific discovery learning (SDL) accentuates the significance of hands-on learning experiences to explore and discover scientific concepts. VR technology can augment the effectiveness of SDL by generating interactive and immersive learning environments that allow students to explore scientific concepts in innovative and exciting ways.

The foundation of SDL rests on the belief that students learn most effectively when they are actively involved in the process of discovery. Through encouraging students to explore and experiment with scientific concepts, SDL fosters a more profound comprehension of the subject matter. VR can enrich SDL by constructing lifelike and immersive simulations of scientific concepts, enabling students to experiment and explore in a secure and regulated environment.

In VR SDL, students are introduced to virtual environments that simulate scientific concepts and phenomena, such as the structure of molecules, the behavior of particles or the surface of distant planets. Through VR, students can interact with these virtual environments in novel ways that are unachievable in traditional classroom settings. They can manipulate objects, observe changes over time and conduct experiments in real time.

VR SDL holds the advantage of being able to simulate complex and abstract concepts that are challenging to visualize in conventional classroom settings. For instance, 3D representations of atoms can help students develop a more profound comprehension of their properties and behavior. Moreover, VR can provide students with visual and auditory feedback to facilitate their understanding of intricate concepts.

Another advantage of VR SDL is its capacity to personalize learning experiences to cater to the individual needs of each student. VR environments can be designed to align with different learning styles and skill levels, enabling students to explore and experiment at their own pace. This customization can improve learning outcomes and overall performance, especially for students struggling with a particular concept.

Due to challenges simulating real scientific phenomena, the high cost and time required to develop high-quality VR simulations, the replication of effective collaboration, and the lack of appropriate guidance and feedback, scientific discovery learning (SDL) has limitations in VR educational contexts. Further study and technology developments are required to get beyond these limitations so that SDL can achieve its potential in VR learning completely.

To conclude, VR SDL provides a potent learning tool that enables students to explore and experiment with scientific concepts in innovative and thrilling ways. By generating immersive and interactive learning environments, VR SDL allows students to develop a more profound comprehension of scientific concepts and prepare for future challenges. As the use of VR in education expands, VR SDL will become an increasingly important tool for educators to improve learning outcomes and prepare students for scientific careers.

4.9. Cognitive Load Theory (CLT)

Cognitive load theory is a well-established framework for optimizing learners' working memory capacity by managing cognitive load during learning. VR is an immersive and interactive technology that is gaining popularity in education. However, the highly immersive VR environment can create a high cognitive load on learners, making it difficult for them to process and retain information. Therefore, optimizing cognitive load is crucial for effective VR learning experiences.

The cognitive load theory identifies three types of cognitive load: intrinsic, extraneous and germane. Intrinsic cognitive load is the inherent complexity of the learning material, while extraneous cognitive load is caused by irrelevant or poorly designed learning materials. Germane cognitive load is the cognitive effort required to build meaningful connections between new and existing knowledge.

To optimize cognitive load in VR learning environments, designers must consider all three types of cognitive load. For example, designers can reduce intrinsic cognitive load by breaking down complex concepts into smaller, more manageable pieces of information. They can also reduce extraneous cognitive load by eliminating distractions and unnecessary information in the VR environment. Finally, they can increase germane cognitive load by designing VR learning experiences that encourage learners to actively engage with the material and build connections between new and existing knowledge.

Appropriate feedback is also essential for optimizing cognitive load in VR learning environments. Feedback can help learners monitor their cognitive load and adjust their learning strategies accordingly. It can also help learners identify areas where they need to focus their attention, which can increase their germane cognitive load and improve their overall learning outcomes.

When it comes to VR educational contexts, there are challenges in applying cognitive load theory (CLT) due to the potential rise in cognitive load caused by the immersive nature of VR and the requirement for well-designed instructional approaches. The limited research available on the application of CLT principles in VR emphasizes the necessity for additional exploration and evidence-based guidelines to enhance cognitive load management in VR education.

In summary, optimizing cognitive load in VR learning environments is crucial for effective and engaging learning experiences. By understanding the different types of cognitive load and designing VR experiences that optimize cognitive load, designers can help learners process and retain information more efficiently, achieve better learning outcomes and prepare for real-world challenges.

4.10. Design Thinking (DT)

The utilization of design thinking (DT) in education has become increasingly prevalent as it provides a human-centered approach to problem-solving by emphasizing empathy, creativity and iterative prototyping. VR is a technology that immerses learners in a simulated environment that provides a secure space for experimentation and exploration. The integration of DT and VR can lead to powerful learning experiences that enhance critical thinking, collaboration and innovation skills.

DT can be implemented in VR in education to develop interactive and captivating learning environments that cater to the needs of the learners. The process begins with empathy, understanding the challenges and requirements of the students. DT also involves ideation, where several ideas are generated, and prototyping, where a solution is designed and tested. In VR, students can test their ideas in a simulated environment, obtain immediate feedback and make enhancements.

DT in VR can also be utilized to provide personalized learning experiences. Students can learn at their own pace and interact with the content in a way that aligns with their learning style. DT can help educators design VR experiences that cater to the specific needs and interests of individual students.

Applying design thinking (DT) to VR educational contexts presents specific limitations. One limitation involves the challenge of fully replicating the intricate real-world constraints and complexities that are integral to design thinking. Although VR offers immersive and interactive experiences, it may not capture the nuanced challenges and contextual factors encountered in real-world design projects. Collaborative aspects of design thinking, such as teamwork and co-creation, may also face hurdles in VR environments due to limited communication channels and difficulties in synchronizing collaborative activities. Moreover, the accessibility and affordability of VR technology may hinder the widespread adoption of design thinking approaches in educational settings. To overcome these limitations, further research is required to explore effective techniques for adapting and enhancing design thinking processes in VR, ensuring the integration of genuine design experiences and efficient collaboration tools in the virtual environment.

In conclusion, the integration of DT and VR can enhance the learning experience by providing a secure space for experimentation, personalized learning and iterative prototyping. This approach can enable students to develop critical thinking, collaboration and innovation skills that prepare them for real-world problem-solving.

4.11. Learning through Problem Solving (LPS)

The approach of learning through problem solving (LPS) emphasizes the use of real-world problems to teach students new skills and knowledge. To enhance this approach, VR can provide an immersive and interactive environment that allows students to apply critical thinking, problem-solving and decision-making skills to solve problems.

LPS is an active learning approach that encourages students to solve real-world problems, helping them develop a deeper understanding of the subject matter and prepare for real-world challenges. VR provides an ideal platform for LPS, as it creates a highly immersive and interactive environment that allows students to experience real-world situations safely. For instance, they can interact with complex machinery or practice emergency response scenarios without any risks [50]. Additionally, VR offers instant feedback, enabling students to improve their problem-solving skills.

In VR LPS, students use the tools and resources available in the virtual environment to solve real-world problems. For example, medical students may use their knowledge and problem-solving skills to diagnose and treat a virtual patient with a specific condition [51]. The VR environment provides the necessary equipment and resources to help students make informed decisions.

Another advantage of VR LPS is its ability to customize the learning experience to meet the needs of individual students. The VR environment can be designed to match the learning style and skill level of each student [52,53]. Struggling students can be given additional resources or time to solve a problem, helping them achieve better learning outcomes and improve their overall performance.

Applying learning through problem solving (LPS) to VR educational contexts presents challenges. One such challenge involves developing VR simulations that accurately depict the complexity and variability found in real-world problem-solving scenarios. While VR can provide immersive experiences, it may struggle to capture the dynamic nature of problem-solving processes and the wide range of potential solutions. Additionally, the creation of high-quality VR simulations requires considerable time and resources, resulting in limited availability of diverse and captivating problem-solving scenarios. Moreover, the effectiveness of feedback and guidance within VR environments can vary, which is crucial for fostering learners' problem-solving skills. Addressing these limitations necessitates further research and development aimed at enhancing the authenticity, diversity and effectiveness of VR-based problem-solving experiences. The goal is to ensure that these experiences align with the complexities of the real world and provide adequate support for learners' growth and development.

In conclusion, VR LPS provides an engaging and effective learning experience that can help students develop critical thinking, problem-solving and decision-making skills. As the use of VR in education continues to grow, VR LPS will become increasingly important in preparing students for real-world challenges.

4.12. Technological Pedagogical Content Knowledge Framework (TPACK)

The TPACK framework, a theoretical model proposed by Mishra and Koehler in 2006 [54], outlines the interrelationship between technology, pedagogy and content knowledge in creating successful educational experiences. It emphasizes the need to effectively integrate these three elements to create engaging and effective learning experiences. Considering the development of VR technology, TPACK has become increasingly important in the field of education.

The TPACK model suggests that to effectively use technology in education, it is crucial to understand how content, pedagogy and technology interact. In VR education, this means designing learning experiences that integrate subject matter content with pedagogical approaches and VR technology.

For instance, a VR learning experience designed for a science class could include interactive simulations that allow students to explore scientific concepts in a virtual environment [34]. In this scenario, content knowledge (scientific concepts) is integrated with pedagogical methods (interactive simulations) and VR technology to create an effective and engaging learning experience.

The application of the Technological Pedagogical Content Knowledge Framework (TPACK) in VR educational contexts has certain limitations. One limitation pertains to the requirement for teachers to possess expertise in both VR technology and pedagogical strategies specific to VR, necessitating additional training and professional development. Effectively integrating VR into the curriculum and instructional practices also demands a deep understanding of subject matter content and how to align it with VR experiences. Furthermore, the ever-evolving nature of VR technology poses challenges in keeping pace with advancements and ensuring the availability of up-to-date resources and tools for educators. Additionally, the cost and accessibility of VR equipment and resources may hinder widespread implementation in educational settings. To address these limitations, continuous support and training for educators are essential to enhance their TPACK in the context of VR, alongside efforts to improve the affordability and availability of VR technology for educational purposes.

The TPACK framework is a valuable tool for designing effective learning experiences by integrating technology, pedagogy and content knowledge. As VR technology continues to develop in education, TPACK becomes even more relevant in designing engaging and effective VR learning experiences that foster deep understanding and engagement.

5. Discussion

VR has the potential to enhance learning outcomes by providing immersive and interactive experiences aligned with various learning theories or educational approaches. Learning theories provide valuable insights into the design and implementation of VR in education. They offer a theoretical framework that helps educators understand how learners engage with the virtual environment, process information and construct knowledge. By aligning VR experiences with learning theories, educators can optimize the effectiveness of VR in enhancing learning outcomes.

Cognitive load theory, for example, suggests that learners have limited cognitive resources, and overloading these resources can hinder learning. VR can be designed to manage cognitive load by providing interactive and immersive experiences that optimize the use of working memory. By carefully structuring the presentation of information and tasks in VR, educators can ensure that learners' cognitive resources are allocated efficiently, facilitating better comprehension, retention and application of knowledge.

The experiential learning theory emphasizes the importance of hands-on experiences and reflection in the learning process. VR offers a unique opportunity to create realistic and immersive simulations that allow learners to actively engage with content. By providing a safe and controlled environment, VR enables learners to experiment, make decisions and learn from the consequences of their actions. The reflective component of experiential learning can be facilitated in VR by providing opportunities for learners to review and analyze their experiences, enabling deeper understanding and meaning-making.

The constructivist learning theory highlights the active role of learners in constructing their own knowledge. In VR, learners can interact with the virtual environment, manipulate objects and engage in problem-solving activities. This active participation facilitates the construction of knowledge through firsthand experiences and interactions. VR can also provide scaffolding and support to learners, guiding them through the learning process while still allowing for autonomy and exploration.

Furthermore, VR has the potential to increase motivation and engagement, as suggested by theories such as flow theory. The sense of presence and immersion in VR can evoke a heightened sense of interest and intrinsic motivation in learners. The autonomy provided by VR experiences allows learners to take ownership of their learning, making choices and decisions that align with their interests and preferences. The challenges presented in VR can stimulate a state of flow where learners are fully immersed and deeply engaged in the learning process, leading to enhanced learning outcomes.

Additionally, learning theories help in promoting collaboration, communication and social presence in VR. Social constructivism highlights the importance of interactions with instructors, peers and experts in the learning process. VR can facilitate these interactions by creating virtual environments that enable learners to collaborate, discuss and learn from one another. Learners can engage in joint problem-solving activities, share perspectives and receive feedback, promoting a sense of community and social presence in the virtual space.

However, it is essential to consider various factors when integrating VR into education. Learning theories guide educators in aligning VR experiences with specific learning objectives to ensure that they are purposeful and effective. Accessibility and usability considerations help ensure that VR technology is inclusive and usable by all learners. Evaluation of outcomes allows educators to assess the impact of VR on learning and make informed decisions about its integration.

This paper analyzed a total of 17 studies related to learning theories or learning approaches using VR in educational contexts. Among these studies, the constructivism learning approach was found to be the most frequently used. Specifically, this approach was used in four out of the seventeen studies analyzed.

It is worth noting that out of the 12 different learning theories or approaches to VR in education that were explored in the studies, constructivism learning was the most commonly used. This finding suggests that educators and researchers recognize the value and potential of using constructivism learning in VR-based educational settings. It also shows that active and learner-centered education's core values are aligned with constructivism learning's value of delivering engaging and interactive learning experiences. Constructivism learning can be incorporated into virtual reality to provide students with practical experiences, opportunities for problem-solving and simulations that resemble real-world scenarios. This enhances knowledge retention and develops students' critical thinking abilities. This finding also highlights the need for further research to optimize the incorporation of constructivist learning into VR-based education, resulting in advancements in teaching methods, curriculum development and educational technology. Constructivism learning is widely used in VR-based education, which highlights its potential to revolutionize methods of learning.

Constructivism learning is an approach to education that emphasizes the active participation of learners in constructing their own knowledge and understanding of a subject matter through hands-on experiences and interactions with their environment. In the context of VR-based education, this approach can involve creating virtual environments that allow students to explore and experiment with concepts in an immersive and engaging way.

Moreover, the gamification of learning is a promising approach to education in VR as it takes advantage of the intrinsic motivation and involvement that games provide to enhance the learning experience [28,55]. By introducing game-like aspects such as points, badges, leaderboards and rewards into educational content, learners are more likely to remain interested and invested in the learning process [45,56]. VR technology is ideal for gamified learning because it allows immersive and interactive experiences that can replicate real-life situations and offer immediate feedback to learners. This can foster a sense of accomplishment and progression, which can further bolster learners' motivation to persevere and accomplish their learning goals. Overall, the gamification of learning in VR has the potential to make education more captivating, enjoyable and effective.

This article provides an overview of various learning theories that have been effectively employed in the design and implementation of VR applications for educational settings. Within the realm of VR, these theories serve as guiding principles to enhance the learning experience and promote meaningful engagement.

In the case of augmented reality (AR), which closely aligns with VR in terms of technology, different learning theories are applied to optimize the AR learning environment. Specifically, AR applications draw heavily upon theories such as constructivism, situational cognition, connectionism, independent learning and physical cognition [57].

Constructivism emphasizes the active participation of learners in constructing their own understanding of knowledge through hands-on experiences and interactions with the virtual environment. Situational cognition theory focuses on how learners perceive and understand information within specific contextual settings, facilitating immersive learning experiences in both VR and AR.

Connectionism theory emphasizes the importance of establishing connections between concepts and ideas, enabling learners to form a comprehensive network of knowledge. This theory is particularly relevant in AR applications where learners can relate virtual elements to real-world objects and scenarios, fostering a deeper understanding of the subject matter.

Independent learning theory acknowledges the significance of self-directed learning and encourages learners to take ownership of their educational journey. In the context of AR, learners can independently explore virtual objects and information, actively seeking knowledge and developing critical thinking skills.

Physical cognition theory recognizes the importance of bodily movements and interactions in the learning process. In both VR and AR, physical movements and gestures can be incorporated to enhance the immersive experience, allowing learners to interact with virtual objects and manipulate them in a way that deepens their understanding.

By incorporating these learning theories, VR and AR applications for educational settings can provide learners with interactive, dynamic and personalized learning experiences, fostering engagement, knowledge retention and critical thinking skills.

In summary, the integration of VR in education offers significant benefits by providing an immersive environment that aligns with different learning theories, enhancing teaching and learning experiences. However, to effectively utilize VR, it is essential to have a comprehensive understanding of its advantages, limitations and impacts on learning and teaching processes.

It is important to acknowledge that VR technology, while offering immersive experiences, comes with certain limitations and concerns. One notable concern is the proximity of VR device screens to the user's eyes. This close positioning can lead to fixed focus and potential long-term effects on eye health. Additionally, some users may experience health issues such as balance disruption and nausea when using VR. Recognizing these challenges is crucial when developing methodologies for VR usage in educational settings.

To address these concerns and enhance user experience and safety, several considerations should be taken into account. First, addressing eye health concerns requires implementing measures to minimize the potential risks associated with prolonged exposure to VR screens. This can involve designing VR experiences that incorporate appropriate breaks, implementing adjustable focus mechanisms and providing guidelines for responsible usage.

Minimizing cybersickness, which can cause discomfort and nausea, is another important aspect to consider. This can be achieved by optimizing the visual and auditory elements of VR experiences, reducing latency and ensuring smooth interactions within the virtual environment.

Furthermore, providing appropriate training and guidance to users is crucial for ensuring the safe and effective utilization of VR technology. Educators should receive training on integrating VR into their teaching practices, understanding the potential risks and benefits, and developing strategies to maximize learning outcomes while ensuring user well-being.

Continued research plays a vital role in uncovering new insights into the potential of VR in education and addressing its limitations and concerns. This research can inform the development of improved VR technologies, guidelines and best practices for educational settings. Responsible implementation of VR in education involves continuously evaluating its impact on learning, refining teaching methods and ensuring ethical and privacy considerations are upheld.

In conclusion, VR has the potential to greatly enhance teaching and learning experiences in education. However, to fully harness its potential while ensuring user well-being, it is essential to have a thorough understanding of its benefits, limitations and impacts on learning and teaching. By addressing concerns related to eye health, cybersickness and user training, and through continued research and responsible implementation, VR can be effectively utilized to enrich education and create immersive and engaging learning environments.

6. Conclusions

This study identified five educational approaches, one methodology, five theories and one theoretical framework that have been used in the context of VR in education. The identified theories and approaches include constructivism learning, experiential learning, the gamification of learning, John Dewey's theory of learning by doing, flow theory, Cognitive Theory of Multimedia Learning, design thinking, learning through problem solving, scientific discovery learning, social constructivism, cognitive load theory and the Technology Pedagogical Content Knowledge Framework (TPACK).

It is important to mention that out of the seventy-two studies that met the inclusion and exclusion criteria, and before excluding studies without an educational theory or approach, only seventeen of them included at least one educational theory or approach. This statement suggests that a mere 30% of the studies are using an educational theory or approach to offer an educational experience to the learners, indicating that the majority of studies, about 70%, are not utilizing any such theories or approaches. Therefore, only a small fraction of the studies that met the inclusion and exclusion criteria included in the analysis made use of educational theories or approaches for VR-based learning interventions, suggesting a lack of consideration for theoretical foundations. This could result in suboptimal alignment with established educational theories and potentially affect intervention effectiveness. Therefore, it is crucial to consider the role of educational theories in designing and implementing VR-based learning interventions.

Additionally, experiential learning theory proposes that learning occurs through a cycle of concrete experiences, reflective observation, abstract conceptualization and active experimentation. This makes it highly suitable for VR in education because VR provides a unique opportunity for learners to engage in immersive and realistic experiences [58]. VR can simulate scenarios that are difficult, if not impossible, to replicate in the physical world. By allowing learners to actively engage with these scenarios, they can reflect on their experiences, conceptualize new knowledge and experiment with different approaches to problem-solving. This aligns with the core principles of experiential learning theory and can lead to more effective learning outcomes. Therefore, experiential learning theory is a natural fit for VR in education.

VR allows students to participate in immersive, interactive environments that provide opportunities for exploration, experimentation and discovery. This makes VR an ideal platform for implementing various pedagogies in education. Recent research has shown that VR has the potential to be effective in enhancing learning outcomes across a range of educational settings [59].

In conclusion, the use of VR technology in education has the potential to revolutionize the way students learn and engage with complex concepts and ideas. By incorporating VR into the education process, teachers can create opportunities for students to actively engage in the construction of knowledge and understanding, promoting deeper and more effective learning outcomes.

A limitation of this research is the limited number of papers that were reviewed. However, this limitation arises due to the fact that research in this particular field is still in its early stages.

Lastly, as the authors of this study move forward, they express a strong commitment to expanding their research and exploring the newfound discoveries in greater detail. Recognizing the value of these new findings, the authors aim to dedicate future work to comprehensively addressing and investigating the implications they hold within the field. The subject, age group of learners, apparatus utilized, instructional design of learning materials, the implementation of VR and the methodologies employed in each included study will be considered and evaluated in future research, including their respective results. Moreover, in the future expansion of the current study, the measurement of the impact of VR technology on students' learning process will be further explored and assessed. Future research could also delve into the potential correlation between physical training, vocational training and VR education. The authors of this study firmly believe that such endeavors will open up new pathways for exploration, leading to a deeper understanding of learning within VR.

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