

THE EFFECT OF IMMERSIVE TECHNOLOGY ON ENHANCING STUDENT LEARNING: A SYSTEMATIC LITERATURE REVIEW

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Abstract—Education is one of the fundamental factors influencing national development. Educators are required to constantly explore the newest and creative strategies to deliver topics to students and promote students' engagement in the learning process. One technology that has numerous potentials to facilitate the education process is immersive technology. Immersive technology has the potential to improve student achievement by enabling better learning outcomes. This study aims (1) to analyze the trends and impact of immersive technology usage in education; (2) to identify immersive technology that supports students' learning processes in the pandemic era; and (3) to identify the usage of learning theories in educational application development that implement immersive technology to enhance students' learning outcomes. This study examined seventeen selected studies after adopting the selection process of the systematic literature review process by Kitchenham. The selected studies were published between 2018 and 2022 by Emerald Insight, IEEE Xplore, and Scopus. There are three kinds of immersive technology identified in this study: virtual reality, augmented reality, and mixed reality. The study showed the nine types of students' learning outcomes, and the results showed that using immersive technology significantly improved student learning compared to traditional methods. Furthermore, thirteen learning theories were adopted as the basis for developing educational applications. Future research directions are also suggested to continue developing promising and limited new technologies to enhance the variety of education-oriented applications. Immersive technologies designed for learning are still on a long journey, including considerations of readiness and potential effects that may arise for users such as privacy and security concern.

Keywords: augmented reality, immersive technology, mixed reality, students' learning, virtual reality.

Intisari— Pendidikan merupakan salah satu faktor fundamental yang memengaruhi perkembangan nasional. Pendidik perlu terus-menerus menjelajahi strategi terbaru dan kreatif untuk menyampaikan materi kepada siswa dan meningkatkan keterlibatan siswa dalam proses pembelajaran. Salah satu teknologi yang memiliki potensi besar untuk memfasilitasi proses pendidikan adalah teknologi imersif. Teknologi imersif memiliki potensi untuk meningkatkan prestasi siswa dengan memungkinkan hasil belajar yang lebih baik. Studi ini bertujuan (1) untuk menganalisis tren dan dampak penggunaan teknologi imersif dalam pendidikan; (2) untuk mengidentifikasi teknologi imersif yang mendukung proses pembelajaran siswa di era pandemi; dan (3) untuk mengidentifikasi penggunaan teori-teori pembelajaran dalam pengembangan aplikasi pendidikan yang mengimplementasikan teknologi imersif untuk meningkatkan hasil belajar siswa. Studi ini menguji tujuh belas studi yang terpilih setelah mengadopsi proses seleksi literatur sistematis oleh Kitchenham. Studi-studi yang terpilih diterbitkan pada tahun 2018 sampai dengan 2022 oleh Emerald Insight, IEEE Xplore, dan Scopus. Terdapat tiga jenis teknologi imersif yang diidentifikasi dalam studi ini, yaitu realitas virtual, realitas teraugmentasi, dan realitas campuran. Studi ini juga menunjukkan sembilan jenis luaran pembelajaran siswa, dan dari hasilnya menunjukkan bahwa penggunaan teknologi imersif meningkatkan pembelajaran siswa secara signifikan dibandingkan dengan metode tradisional. Selain itu, terdapat tiga belas teori pembelajaran diadopsi sebagai dasar pengembangan aplikasi pendidikan. Arah penelitian masa depan juga disarankan untuk terus mengembangkan teknologi-teknologi baru yang menjanjikan dan terbatas untuk meningkatkan keragaman aplikasi berorientasi pendidikan. Teknologi imersif yang dirancang untuk pembelajaran masih dalam perjalanan panjang, termasuk pertimbangan kesiapan dan efek potensial yang mungkin timbul bagi pengguna seperti masalah privasi dan keamanan.

Kata Kunci: realitas teraugmentasi, teknologi imersif, realitas campuran, pembelajaran siswa, realitas virtual.

INTRODUCTION

The development of a nation is strongly influenced by education [1]. One of the main processes in education is the learning process. Learning is a complicated process that involves the modification and acquisition of skills, knowledge, and values through study, instruction, reasoning, and observation. An educator should think of new and creative methods to introduce topics to their students and have them perform the exercises they need to hone their abilities [2]. Involving students in their learning is one of the most important aspects of classroom learning. Students are not truly learning, or at least not learning to their full potential, if they are not interested in and actively participating in the educational process [3].

Technology-enhanced learning has become more important in the educational environment because of the advancement of computer and multimedia technologies. Researchers and teachers have attempted to integrate various technologies into educational settings to place students in situations that are both information-rich and interaction-promoting [4]. Information technology is now able to provide support for student learning in a variety of subjects, including those that have been considered difficult by students for decades [5]. Immersive technologies such as virtual reality and augmented reality have enormous potential in a variety of fields, including the education sector [6].

Immersive technology is a system that combines physical and virtual realities. This technology can provide user experiences situated in specific contexts by combining the physical and virtual worlds. These experiences can be utilized for training, learning, and collaboration activities. The technology is developed with advanced computer-aided design (CAD) model processing methods, captivating displays, and user-centered interaction approaches [7]. By employing technology, virtual information is combined with physical data about a real object or place to produce an artificial reality. This hybrid reality mixes virtual and physical information in real time [6]. The immersive technologies discussed here include virtual reality, augmented reality, and mixed reality, all known for providing an encompassing 360-degree visual experience. Virtual reality is known for its ability to create a realistic and interactive three-dimensional environment for users. Augmented reality enhances the real world by adding digital elements without replacing it. Meanwhile, mixed reality combines aspects of both virtual reality and augmented reality [7].

In the realm of education, immersive technology is employed to enhance the learning process by presenting engaging content, thereby

facilitating optimal knowledge transfer to students. In contrast to conventional educational approaches that depend on books and slide presentations, immersive technology such as virtual reality provides a means of visualizing interactive 3D environments where students can actively engage, explore, and acquire knowledge [8]. Virtual reality and augmented reality can improve student achievement because they allow students to get better learning outcomes by using technological means. Immersive technology also strengthens and increases student interest, learning motivation, and positive acceptance of using technology in the educational process [5]. Furthermore, promoting student engagement and good knowledge sharing is one of the most crucial parts of education. Using augmented reality, students can work together virtually while still being physically present [3].

However, it is necessary to know that immersive technology not only depends on its users but also relies on the design created, the implementation process, and its integration with the learning environment. The role of teachers in implementing this technology is crucial, as they are involved in the materials, content, and efficient tools needed to achieve the desired benefits. Teachers also play a significant role in the transition and training process to adopt immersive technology in the learning process [9].

The application of immersive technology in education is limited by the reliance on mobile devices. This is due to the demand for a high-speed internet connection [10], and not all students have access to the latest mobile devices with the necessary specifications for optimal implementation of immersive technology [6]. Furthermore, technically, Fraile et al. [6] mention that there are still issues related to privacy and data security when developing educational applications using immersive technology.

Meanwhile, due to the disruption caused by the COVID-19 pandemic, schools have had to adapt their curriculum, leading to an increased interest among educators in finding suitable and efficient technologies for online learning [11]. Immersive technologies can be utilized in emergency situations where remote learning becomes the only option [9].

Dengel et al. [12] conducted an exploratory review of the literature on augmented reality toolkits for education. Meanwhile, Tang et al. [13] conducted a systematic review of the use of applications that apply immersive technology to medical practice and education. In another context, Prabhakaran et al. [14] also wrote a systematic review about the challenges of immersive technologies in the architecture and construction industries. However, no one has yet conducted a systematic review of how immersive technology



influences learning enhancement and what learning theories are used in the development of immersive technology-enabled learning applications. This study aims to contribute to the understanding of educational applications that utilize immersive technology, including the learning theories employed in their development, as well as how the usage trends and the role of immersive technology in supporting remote learning, which is unavoidable due to the COVID-19 pandemic.

The trends, effects, and learning theories utilized to integrate immersive technology to improve students' learning outcomes were explored and analyzed in the current study. The current study posed three review questions (RQ):

1. RQ1: What are the trends and impacts of immersive technology implementation on enhancing students' learning?
2. RQ2: How can technology's immersive adoption in the education context support learning in the pandemic era?
3. RQ3: What are the learning theories used in the development of learning applications with immersive technology?

MATERIALS AND METHODS

A systematic literature review (SLR) recognizes, evaluates, and translates study sources to answer a research question or research topic. There are numerous varieties of literature reviews, including meta-analyses, fast reviews, evidence syntheses, and narrative reviews. SLR strategy was utilized in this research. Kitchenham proposed software engineering research that adopts Evidence-based Software Engineering (EBSE), where software engineering research and practices are conducted by applying an evidence-based approach. Evidence is defined as findings synthesized from high-quality scientific studies on a specific topic or research question.

The primary method for this synthesis is SLR, which is conducted rigorously and methodically to assist practitioners in developing evidence-based guidelines. EBSE aims to enable practitioners to utilize these guidelines to find appropriate software engineering solutions within specific contexts. Researchers who are interested in the EBSE approach become more competent in the SLR methodology, as evidenced by the increasing quality of SLRs [15].

Review Method

SLR presented in this paper adheres to the overall structure of the Kitchenham methods, encompassing three main phases: planning, conducting, and reporting [16], [17]. In Figure 1, the details of each phase are presented.

Search Strategy

The search strategy consists of steps such as selecting the libraries and determining the right keyword string. The selected digital libraries to use in this paper are Emerald Insight, IEEE Xplore, and Scopus. And the selected studies were published between 2018 and 2022. Then the right keyword string to get the relevant paper is "(virtual AND reality OR augmented AND reality OR mixed AND reality OR immersive AND technologies) AND knowledge AND (students' AND learning) AND application)".

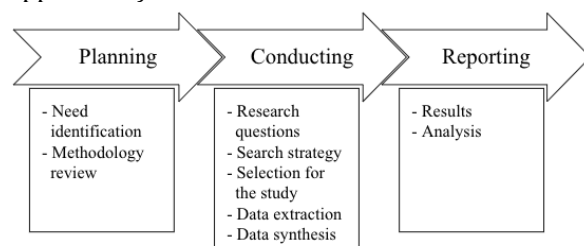


Figure 1. Systematic Literature Review Phases

Selection for the Study

In this stage, there are two criteria to determine which study will be selected. The first one is inclusion criteria, which consist of acceptance criteria used to determine the literature that will be included. And the second one is exclusion criteria, which are used to determine the literature that will be excluded. Studies about students' learning enhancement with immersive technology usage that answer the research question with a relevant abstract and introduction will be included in this study. Studies must also be available in full text to be included in this study.

Meanwhile, studies that are not in English or duplicated with irrelevant abstracts and introductions will be excluded from this study. The paper that summarized the contents was eliminated since the goal of this systematic literature review is to find unique studies on immersive experiences. In the full-text selection process, inclusion criteria were also added, which encompass papers involving the usage of learning theory for system development. The details of the selection process can be seen in Figure 2.

Afterward, each type of student learning as delineated in each paper is correlated with the student's learning outcomes. The observations concerning the use of immersive technology in the realm of education are derived from detailed information about the objectives of the primary studies. This study also indicates whether there is a distinct rationale for bolstering the learning process during the COVID-19 pandemic era. Furthermore, all learning theories utilized in the development of educational applications using immersive

technology to enhance student learning were also identified.

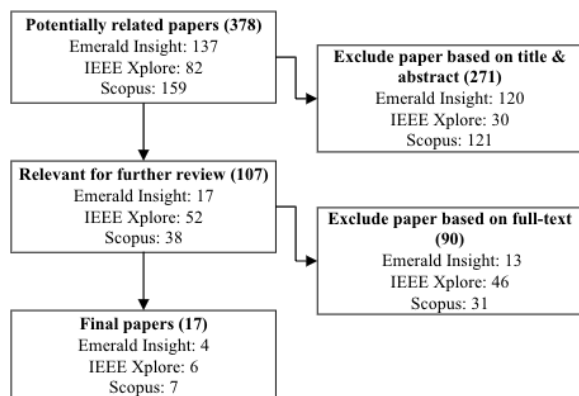


Figure 2. The Selection Processes of Primary Studies

Based on the extraction data above, the data is synthesized by listing, (1) The number of studies of each immersive technology identified from all primary studies; (2) Lists of identified learning types; (3) Mapping between learning types and learning outcome results; (4) Number of studies that have a specific reason to support the learning process in the pandemic era; and (5) The number of studies of each learning theory identified from all primary studies.

RESULTS AND DISCUSSION

The first search step identified 378 research papers in the initial phase of the search string process. Then, the title and abstract were screened applying the general inclusion and exclusion criteria. From this set, duplicates were also eliminated, giving a total of 107 papers to potentially analyze by reading the full paper text. After the full-text paper reading process, the systematic review identified seventeen empirical studies regarding immersive technology usage for students' learning enhancement. This section gives the details of the study results of the included papers as well as an analysis to answer the research questions of this systematic review.

RQ1: What are the trends and impacts of immersive technology implementation on students' learning enhancement?

In this study, there are three kinds of immersive technologies were implemented to enhance students' learning: augmented reality, virtual reality, and mixed reality. The pie chart (see Figure 3) represents the distribution of primary studies that have utilized these technologies. According to the chart, augmented reality is the most used immersive technology in studies aiming

to enhance students' learning, with 11 studies ([5], [6], [9], [10], [11], [18], [19], [20], [21], [22], [23]) out of 17 primary studies. Augmented reality taking the lead at 11 studies, indicating its significant role in current educational enhancement and greater adoption in practical applications or its relevance in current educational methodologies. Virtual reality follows with its use in 6 studies, suggesting a solid but lesser presence compared to augmented reality. Mixed reality represented by just a single study, appears to be the least explored. The fewer studies on virtual reality and mixed reality might highlight areas for further exploration and development, suggesting potential gaps in the literature or emerging opportunities for future technological advancements. Overall, the charts reflect a clear preference for augmented reality in the educational sector, highlighting current trends in immersive technology and pointing to its capability and applicability in learning environment.



Figure 3. Three kinds of immersive technology with the number of papers

Pombo and Marques [10] state that mobile devices and augmented reality technologies can provide authentic learning experiences. These technologies have the capability to place the learner within an authentic physical and social environment while providing support for the learning processes. One of the newest technologies, augmented reality, is being used in a variety of academic fields and has enormous instructional potential. It synchronizes real-time user engagement with the simultaneous combination of digital and physical information. The educational field has permanently adopted augmented reality among its technological resources. Using this technology, learning may occur not only in the classroom but also at home, in places of play, and in the daily interactions established with others [5]. Furthermore, augmented reality, which provides a more interactive and practical platform compared to traditional education, can help students become more engaged in their subjects. In the instance of the augmented reality device, it permits the incorporation of multiple senses during the learning journey, while also enhancing students' fine motor skills [18].

Learning takes place within the individual and arises out of the relationships and exchanges individuals have with their environment [6]. Six

types of students' learning outcomes have been identified for calculating and analyzing the improvement in student learning. The summary details are presented in Table 1. The most common learning-type outcome used in primary studies is learning gain, or some studies mention it as academic achievement. Student academic accomplishment is one of the most crucial aspects of teaching and learning.

Table 1. Lists of Identified Learning Outcome Types

Learning Outcome Type	Studies Count
Learning gain (academic achievement)	15
Learning motivation	6
Learning experience	4
Learning engagement	3
Satisfaction	2
Analytical & Critical Thinking	1
Knowledge exchange (sharing)	1
Imaginative capabilities	1
Long-term retention ability	1

Working memory abilities, academic resources, performance anxiety, family constitution, social skills, personal perspective, and even genetics must all be taken into consideration when deciding how to evaluate academic progress and how to make it better [5]. Nevertheless, academic achievement becomes the indicator with the highest objectivity, as a concept of the relationship between the strength of learning input and the output results achieved through the interaction between learners and educational resources [5]. Learning gain indicates the extent of actual improvement in learners' knowledge while considering their initial level of knowledge. Learners who already possess sufficient knowledge may not experience a significant increase in their final scores [20].

The resulting matrix of learning outcome types used to analyze learning enhancement and the results from all primary studies are given in Table 2. The results show that the learning assessment of immersive technology usage was mostly effective and yielded a significantly higher outcome compared to the students who did not utilize immersive technology in their learning process.

The adoption of various technologies in formal and informal educational settings is growing quickly. It has been proven that all methods that encourage active participation in the learning process are quite successful at helping students develop both cognitive and metacognitive skills. Users can get fully immersed in a virtual environment where real-life scenarios can be recreated thanks to immersive technology [21]. Students in augmented reality groups experienced significantly greater incremental learning gains compared to those who did not utilize immersive technology for learning [20].

Table 2. Mapping between Learning Type and Outcome Results

Learning Outcome Type	Higher/ Significant	Moderate	Lower
Learning gain (academic achievement)	[5], [6], [8], [9], [10], [11], [18], [20], [21], [22], [24], [25], [26], [27]	[28]	-
Learning motivation	[5], [10], [11], [19], [27]	[23]	-
Learning experience	[6], [9], [25]	[28]	-
Learning engagement	[21], [25], [28]		-
Satisfaction	[22], [24]		-
Analytical & Critical Thinking	[8]		-
Knowledge exchange (sharing)	[20]		-
Imaginative capabilities	[19]		-
Long-term retention ability	[23]		-

These findings suggest that immersive technology, such as the augmented reality system, offered more effective teaching representations, eliminating the need for acquiring representations from other aids or communication techniques used by the non-immersive usage groups. In certain learning environments, the utilization of immersive technology, such as augmented reality, is also advantageous for students' learning gains. Moreover, learning engagement is rated as extremely attractive, with a positive impression of the application's usability and the immersive technology [21].

Additionally, there are results that demonstrate a moderately significant outcome because of students found immersive learning modules to be highly intriguing and engaging. However, the calculated knowledge gains using quizzes showed more moderate results, despite the data indicating a highly positive user experience and perceived improvement in learning by the students. This is because in the clinical setting, it is important to assess students' competence in terms of skill development and the application of medical ethics. Evaluating these skills is quite challenging, thus research in medical education necessitates reflective learning to assess the application of knowledge in clinical practice [28].

RQ2: How can technology's immersive adoption in the education context support learning in the pandemic era?

Figure 4 reflects the number of studies that stated the potential for applying immersive technologies during the COVID-19 pandemic. It



shows that a minority, specifically three studies (equivalent to 18% of the total primary studies) that emphasize the utilization of immersive technology to facilitate students' learning processes during the COVID-19 pandemic ([9], [11], [28]). Conversely, the larger portion, fourteen studies (82%), did not mention the pandemic. This does not imply a dismissal of the relevance of immersive technology during the pandemic; rather, these studies have focused on the broader implications and applications of immersive technology in learning without the specific context of COVID-19 pandemic.

The data might show that there hasn't been much written about the usage immersive tech during emergencies, but this suggests a recognition of the unique circumstances the pandemic presented, which may have necessitated innovative educational approaches like immersive technology to support remote learning. These numbers show the understanding of how the academic community has responded to an unprecedented global event with technology.

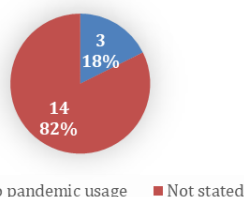


Figure 4. The number of papers that utilize immersive technology to support learning in the pandemic era

The COVID-19 pandemic has shifted the focus of educational activities towards online learning through digital technology. Many students in schools rely on digital technology for their learning. Immersive technology can be utilized in emergency situations where remote learning becomes the only option [9]. Due to the disruption caused by the COVID-19 pandemic, schools have had to adapt their curriculum, leading to increased interest among educators in finding suitable and efficient technologies for online learning. Just like the reading learning process for elementary school students conducted during the COVID-19 pandemic with the assistance of additional tools like the Evoke Education System (EES). The integration of immersive technology in EES has demonstrated potential for being adaptable to remote learning to help teachers teach reading skills to their students [11].

Virtual reality and other immersive technologies are incredibly practical tools. Extensive reviews have demonstrated how virtual reality can be utilized for teaching technical skills and anatomy [28]. In lifelong learning, the

utilization of immersive technology can be extended to various domains of study and education [9]. Furthermore, according to Egaji et al. [11] immersive technologies can also be utilized in the education of children with various disabilities, including autism. Applications that implement immersive technology offer convenience in engaging with children; compared to interactions with adults, children tend to be more familiar with animated characters [11].

Another benefit provided by this technology for education is during school visits or trips, which are supplementary activities to classroom learning. With this technology, direct visits that temporarily cannot be conducted due to the COVID-19 pandemic can be replaced with virtual visits, thereby not eliminating the experimental aspect of school trips [9].

Furthermore, the use of simulation environments through immersive technology for education during the pandemic can also be leveraged in medical education. The COVID-19 pandemic has made it difficult for medical students to have clinical placements, thus requiring a simulation environment that replicates real-life situations and enables learners to access clinical experiences easily and flexibly through virtual reality [28].

Among the seventeen primary studies, only three of them mentioned the potential utilization of immersive technology during the COVID-19 pandemic. The remaining fourteen primary studies did not specifically address the COVID-19 pandemic, yet they did not assert that immersive technology couldn't be employed during this period. Fraile et al. [6], even though not explicitly addressing the potential of immersive technology during the pandemic in their study, had one of the goals of developing immersive technology applications to create more accessible resources for learners during critical moments in the learning process.

RQ3: What are the learning theories used in the development of learning applications with immersive technology?

The most frequently identified learning theories are constructivist learning theories, followed by cognitive theories and collaborative learning. The identification of learning theories is provided in Table 3.

Table 3. Lists of Identified Learning Theories in Primary Studies

Learning Outcome Type	Studies Count
Constructivist learning theories	7
Cognitive theory	3
Collaborative learning	3



Learning Outcome Type	Studies Count
Cognitive theory of multimedia learning (CTML)	2
Socio-constructivist theory	2
Bloom Taxonomy	1
Self-directed learning	1
Creative thinking	1
The theory of 'learning by doing'	1
Behaviourism learning theory	1
Adult learning theory (cognition and problem-solving)	1
Meaningful learning theory	1
Discovery learning theory	1

Based on Fraile et al. [6], constructivism encompasses a collection of psychological and pedagogical theories founded on the notion that every educational input should influence human development, which stands as the fundamental aim of education. Knowledge acquisition occurs internally within individuals and emerges from the interactions and transactions individuals engage in with their surroundings. This process is rooted in an active, constructive learning framework. Constructivism revolves around three fundamental principles: the student assumes an active role in shaping their learning journey; knowledge emerges from a collaborative process within a social context; and the role of the teacher involves facilitating the student's learning construction through guidance and direction [6].

Constructive learning theory has transformed the purpose of computer-assisted learning from merely encouraging student engagement to expecting them to be able to select their own learning materials. It promotes students' internal motivation to learn more actively, enabling them to adapt, clarify, and summarize the original concept of curriculum [27].

Enhanced learning can be achieved by offering enhanced opportunities for learners to construct knowledge. This becomes a fundamental consideration for providing adequate materials for learners along with their surrounding environment and suitable social context. For the effective utilization of technology, it's imperative to provide an easy starting point for novice learners and to offer increasingly sophisticated projects as time progresses. Hence, a tool designed for constructionist learning provides students with the chance to engage in experimentation, exploration, and uninhibited self-expression. This occurs without the confines of a predetermined plan, a rigid schedule, or set instructions [6].

In the context of constructivist theory, recent research has concentrated on immersive technology such as augmented reality as a potential technical solution. Augmented reality allows users to fully immerse themselves in a simulated

environment. In terms of pedagogy, augmented reality facilitates the implementation of contextual learning approach, which emphasizes learning is more effective when it occurs within a particular context and is integrated into a physical environment [21].

The key factors that influence the learning process include the quality of engaging circumstances, abrupt comprehension or perception, significant exploration and acknowledgment, the attributes of cognitive structure, and the level of focus or ambition (advanced cognitive learning). The cognitive capacity is influenced in two ways by virtual reality technology due to its technical attributes. Virtual reality and other immersive technologies can be utilized in preschool physical education programs. They can enhance students' attention and experience, facilitate the assimilation of new and prior knowledge more efficiently, and aid in the development of cognitive structures and cognitive psychological activities. Prior evaluation and understanding of students' cognitive processes are essential in this approach, enabling students to enhance their learning and personal growth [25].

Integrating technologies such as immersive technology into educational processes facilitates collaborative learning. The concept of collaborative learning refers to a method where students work together in small groups and develop objects, ideas, concepts, phenomena, or applications with a larger number of individuals. Teachers utilize collaborative learning methods because knowledge is created not only through the teacher-learner relationship but also through interactions among learners themselves. Students can engage in collaborative learning and develop additional skills such as teamwork, critical thinking, reflection, and participatory learning. These competencies are vital for continuous education, which aims to empower students towards autonomy and contribute to shaping a sustainable and equitable future [5].

Practical Implication

Immersive technologies that support innovative learning approaches or features are those that can provide engaging, interactive, unique, and profound learning experiences, leading to enhanced learning at both cognitive and affective levels, as well as increased motivation for learning. For example, one tool that supports innovative learning approaches for children is by involving the use of human-controlled avatars that can be seen through screens. The avatar on the screen speaks and moves in real-time, even though it is controlled by the teacher from a different room or location, providing flexibility in delivering the learning material [11].



Immersive technology such as virtual reality that provides a 3D immersive interactive environment allows students to engage, explore, learn, and increase their motivation which is crucial facet of education. Virtual reality as an educational tool is also greatly valuable in the constructivist educational philosophy, since it encourages active learning, involvement, and student motivation, resulting in improved learning results [18].

The future of immersive technology still has a long way to go. Immersive technology still requires significant development ahead to fully support the learning process. In medical education, the expansion of immersive technology approaches such as virtual reality can be utilized for competencies that might be difficult to systematically teach during clinical placements. This technological approach will be capable of supporting student learning as a supplement in curriculum areas of medicine where teaching opportunities might still be infrequent or varied [28].

Furthermore, in the field of neuroanatomy, mixed reality and other immersive technologies have undergone initial validation stages, demonstrating that mixed reality can be applied to learning with validity comparable to existing 2D learning regarding students' learning outcomes. In the future, mixed reality and other immersive technologies can be made even more interactive by incorporating enhancements and placing mixed reality within formal medical curricula as standard medical education enablers [26].

CONCLUSION

In this study, the results of our analysis are presented, which are based on a systematic review of empirical studies in the literature. This systematic review has confirmed that immersive technology, especially augmented reality, enhances student learning more effectively than traditional methods. It supports learning across various settings, not just in classrooms but also at home and during play, integrating multiple sensory experiences and improving motor skills. Despite the fact that only a few studies discuss immersive technology in the context of the pandemic in this study, it is clear that such technology offers valuable support for remote learning during times of educational disruption. Its contribution to remote education is noteworthy. This study identified constructivism, cognitive theory, and collaborative learning as the predominant learning theories guiding the development of immersive learning applications. These findings offer insights into the ongoing evolution of educational technology and its capacity to enrich the learning landscape.

This study has some limitations, including the use of only three databases, which might not represent the full range of relevant papers. Papers were only considered up to 2022, potentially missing studies on immersive technology developed during or for pandemic-related challenges. Additionally, a more thorough analysis is needed on the use of such technology during the pandemic, especially concerning possible negative impacts on the learning process.

The trends and impacts of using immersive technology in education have been established in this study. These insights provide a solid base for future research focused on developing educational applications with immersive technology to improve learning outcomes. Analyzing how different learning theories are applied can guide the creation of effective, functional educational tools. Further research could delve into specific educational levels or subjects for a more thorough understanding of how immersive technology enhances learning. Additionally, investigating the correlation between various immersive technologies and learning theories will be beneficial. Future studies should also expand their database sources and timeframes, assessing the technology from various perspectives to understand its full potential and address any risks, such as privacy and security concerns.

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