Effects of VR on Student Learning: A Scoping Review

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Abstract: Virtual reality allows students to have a fully immersive, real-life experience in subjects that would otherwise be impossible. As students' digital fluency increases, incorporating prevalent media such as immersive interfaces in virtual reality (VR) can help design the students' educational experience. Increased student involvement, higher comprehension, increased proficiency, and students taking ownership of their learning are possibilities when virtual reality is integrated into the educational school system. A scoping review was performed to examine the effects of virtual reality on student learning. Eleven articles were examined in the English language investigating virtual reality-based instruction and its effects on student learning. Outcome measures show a significant improvement in how students' brains are affected through stimulation, absorption, and retention. Other studies indicate the fully immersive experience to assist in student learning and allowing exploration of various perspectives. Therefore, virtual reality seems to be an auspicious compass as defined in this study.

Introduction

The integration of virtual reality into the educational school system allows for a plethora of possibilities, including increased student involvement, greater comprehension, increased competency, students taking charge of their learning. Virtual realities are utilized for enhanced visual and interactive forms of learning, increasing student retention chances. This added contextual layer allows the students to connect between their lives, education, and reality. Allowing students to interact through virtual reality allows them to construct new learning and understanding, bringing to life the objects and subjects there are studying. "Using the situated learning environment created by VR, learners are allowed to operate the objects with their own hands, to observe and to experience carefully" (Liou & Chang, 2018, pg. 1). Virtual reality enhances the activities in which the student engages, immersing them in entirely and expanding their attention, allowing for various interactions, and ultimately taking responsibility for their education.

Significant benefits for student learning in the VR landscape include improved motivation and retention of student learning, a high level of interactivity and collaboration for interpersonal development, the promotion of active and experiential learning, and leveraged exposure to practical skills to deal with real-world demands to name a few. Therefore, this experience allows for promoting increased learning, stimulation of the brain to absorb learning better and emulate the real world. The purpose of this scoping review of literature anticipates outlining research correlated with virtual reality's impacts on student engagement and retention within the elementary classroom. Results from previous studies were gathered and synthesized by the authors to identify trends within the last decade.

This scoping review will be presented as follows. Introduction and background research are discussed in Section I. Scoping review and detailed on the method are covered in Section II. Findings and discussion are delineated and depicted in Section III. The conclusion is discussed in Section IV. Implications for future research and future work are offered in Section V.

Methods

Arksey and O'Malley's (2005) five-stage framework is utilized for the purpose of this scoping review. The five stages consist of: (1) Identifying research questions, (2) Identifying relevant studies, (3) Study selection, (4), Charting the data, and (5) Collating, summarizing, and reporting the results.

Inclusion criteria	Exclusion criteria
Studies on VR in K-12 education	Studies published before 2011
Studies on VR in higher education	Studies including AR, MR, or any other type of XR without the involvement of VR
All studies irrespective of design	Studies in any other language apart from English
AR, augmented reality; MR, mixed reality; XR, extended reality; VR, virtual reality	

Table 1: Full inclusion and exclusion criteria

A. Identifying the Initial Questions

This scoping review intends to investigate critical aspects of virtual reality integration in educational classrooms to identify any contributions to the impact of virtual reality within the classroom and students' retention and engagement. The following questions will determine the focus of this review.

1. What is the impact of VR integration in the educational system and classroom?
2. What is the impact on student retention with the integration of VR?
3. Does the integration of VR improve student engagement?

B. Identifying Relevant Studies

Scoping reviews can cover a broad range of searches and keywords. First, the authors determined key concepts and search terms that would be the best approach for this scoping review. Next, the authors amassed a sum of relevant studies considering the relevant questions.

The leading search concepts were: 1) virtual reality; 2) elementary education; 3) immersive technology. The authors also incorporated Boolean operators to combine and expand the literature search options. Boolean operators such as OR and AND allowed the authors to combine search terms and broaden the results. Table 1 identifies the key search terms.

Database	Google Scholar ERIC IEEE Xplore
Search Terms	"virtual reality" "elementary education" "immersive technology"

Table 2: Key Search Terms

The authors utilized three databases focused on education, educational technologies, computer science allowing all facets of the topics and peer-reviewed literature. In addition, the following databases were utilized 1) Google Scholar, 2) IEEE Xplore, and 3) ERIC. Finally, the search was confined to the last decade to identify trends.

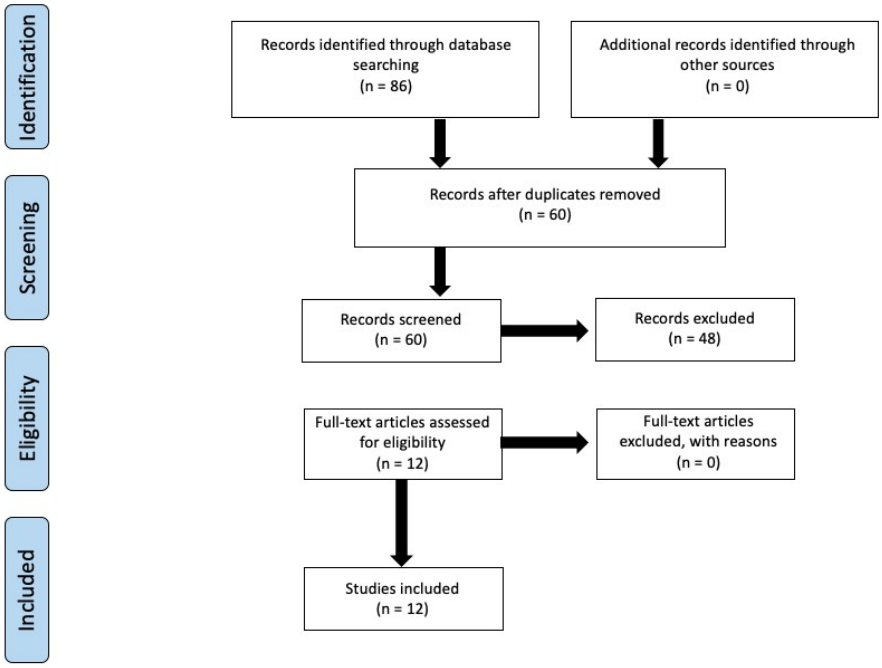

Figure 1: Study Selection

Results

This scoping review's central focus was to identify critical aspects of integrating virtual reality applications within the classroom, specifically within the compounds of K-12 education, influencing the effectiveness of learning, brain stimulation, and retention.

Research indicates that incorporating virtual environments in the form of virtual reality allows for a more immersive experience, stimulating the brain in such a way to absorb better and retain information. "Digital simulations are generally effective because they allow students to experience phenomena that are impossible or infeasible to visit otherwise, they are dynamic and interactive, and they scaffold and assess user learning" (Radu, 2012, pg. 314). Through virtuality, reality and the affordance of a real-world experience allows learners to be wholly immersed in the given virtual reality, allowing the brain to better transfer knowledge to the real world. "This encourages students to engage with the content actively and is likely a factor to improved learning" (Radu, 2012, pg. 314). Experiencing the task or event through various learning styles and appealing to learners' broader audience is vital. "Empowering a friendly learning environment for students and raising their learning interest and motivation" (Liou & Chang, 2018, p. 140). "Learning with game-based iVR (immersive virtual reality) provided a learning experience that was highly immersive, and immediate and personal by situating the learning in the learner's lived experience" (Bodzin et al., 2020, p. 197).

Teachers can encourage learning through this new modality and disseminate knowledge in ways never imagined before. "The preservice teachers identified several reasons that IVR could enhance their performance as to future teachers, including improving access to learning ("being able to go to places that you can't reach otherwise"), providing a sense of immersion ("a real experience so it would be very good for empathy, sympathy and just building experience"), and transcending reality ("it can be fictional, it can be reality, it can be microscopic, it can be macrosopic, … potentially endless")" (Bower et al., 2020, p. 2221). Lastly, the knowledge gap between learning and experiencing is decreased with the immersive virtual reality experience. "VR courses breaks through the limitations of time and space, extends the scope of teaching materials" (Liou & Chang, 2018, p. 140). The preservice teachers identified several reasons that IVR could enhance their performance as future teachers, including improving access to learning ("being able to go to places that you can't reach otherwise"), providing a sense of immersion ("a real experience so it would be very good for empathy, sympathy and just building experience"), and transcending reality ("it can be fictional, it can be reality, it can be microscopic, it can be macrosopic, … potentially endless").

Students have experienced learning in many various facets, including portfolio systems, video creating platforms, learning management systems, gaming apps, blogs, to name a few. Of all of the technologies incorporated into the classroom, nothing equates to implementing virtual reality. "Interactive multimedia in particular provides a powerful tool

for both teachers and learners in the design of environments which enables student learning" (Semple, 2000, p. 21). “Immersion in virtual environments and augmented realities shapes participants’ learning styles, strengths, and preferences in new ways beyond what using sophisticated computers and telecommunications has generated thus far, with multiple implications for K-12 education” (Dunleavy et al., 2009, p. 8). Educational theories maintain that knowledge is something that is building actively through real-world interactive experiences, not something that is passively absorbed. Research of this enhanced technology helps us understand "the potential advantage of immersive interfaces for situated learning is that their simulation of real world problems and contexts means that students must attain only near-transfer to achieve preparation for future learning" (Dede, 2009, p. 67). That "immersion may enhance transfer through simulation of the real world" (Dede, 2009). They are allowing the student to experience the real-world in the safety of their classrooms. "The operator can experience and observe various elements at close range" (Liou & Chang, 2018, pg. 2). "Adolescent learners demonstrated high levels of engagement and flow" (Bodzin et al., 2020, p. 197).

Traditional learning is swiftly becoming outdated. As learners embrace new technologies faster than their teachers, it is a challenge for teachers to stay afloat. Learning for the new generations requires teaching to become immersive, hands-on, and implemented in a way that appeals to this new generation of learners. Learners who are gamers and utilize such platforms may find it challenging to learn in the traditional classroom. Therefore, by implementing virtual reality, learners "can learn in a quick and happy mode by playing in the virtual environments" (Pan et al., 2006, p. 20). "Over 90% of students approved of using 3D immersive VR to enhance learning, stating it to be good and innovative" (Maheshwari & Maheshwari, 2020, p. 9).

Subject areas that were once difficult to understand, now with the use of "these applications show that VLE (virtual learning environment) can be means of enhancing, motivating and stimulating learners' understanding of certain events, especially those for which the traditional notion of instructional learning have proven inappropriate or difficult" (Pan et al., 2006, p. 20). "Students appreciated learning Physics using more graphical and animated approach as it would assist them in understanding the topics better" (Sulaiman et al., 2020, p. 5). Another study showed that "while the results clearly showed the positive conformity group to recall more about the lecture than the negative group, it was found that the control group, where the room was empty with no other students, had the greatest improvement in memory" (Maheshwari & Maheshwari, 2020, p. 9).

A study conducted by Dunleavy et al. (2009) to determine whether augmented (AR) and virtual reality (VR) aid or hinder the learning and teaching process. This multiple qualitative research case study was conducted in the northeastern United States and involved two middle schools (6th and 7th grade) and one high school (10th grade). Through various means of data collection, "teachers and students reported that the technology-mediated narrative and the interactive, situated, collaborative problem-solving affordances of the AR simulation were highly engaging, especially among students who had previously presented behavioral and academic challenges for the teachers" (Dunleavy et al., 2009, p. 8). Furthermore, “students often become so engrossed in beaming information to each other via the infrared function that they ran out of time to complete the more important activities, such as finding and analyzing data or sharing and discussing the data with their teammates” (Dunleavy et al., 2009, p. 14).

Other "studies have shown that immersion in a digital environment can enhance education in at least three ways: by allowing multiple perspectives, situated learning, and transfer" (Dede, 2009). Situated learning happens when students are placed in that environment or situation and can learn how to maneuver through the situation at hand. Situated learning is not feasible for all students or classrooms. What the integration of virtual reality does is allow "immersive interfaces can draw on the power of situated learning by enabling digital simulations of authentic problem-solving communities in which learners interact with other virtual entities (both participants and computer based agents) who have varied levels of skills" (Dede, 2009). Studies indicate "students in more immersive viewing conditions rated the content higher and were more inclined to repeat the experience" (Chua et al., 2019, p. 172). "When students use this technology, they feel more engaged and excited, in theory translating into more focus and better acquisition of knowledge" (Maheshwari & Maheshwari, 2020, p. 8).

Conclusion

In this scoping review, a literature review was conducted using a multitude of articles examining the effects of virtual reality technology on student learning. The advantages of virtual reality technology are discussed, and case studies on how virtual reality is now being used in education. Based on the findings of this scoping review, virtual reality-based innovations have the potential to have a drastic impact on student learning. This scoping review has provided how VR has affected student learning. The results have indicated how VR can be integrated and effectively used in education classrooms to enhance student learning and create an environment to stimulate the mind for better retention. As mentioned in previous studies, students are given control of their learning environment. This control affords them the opportunity to enhance their learning. The fully immersive experience also allows them to be fully engaged with little distraction for better retention of material, guiding them to a more conceptual understanding improvement. VR also allows the learners' to envision their

ideas more clearly, reflect on their learning and experience, and prompts knowledge acquisition. Fostering the educational experience and appealing to the learner is crucial. VR will transform the way students learning occurs. Immersive learning through various forms of media to stimulate learning within students is essential. Taking learning from the classroom and bringing that knowledge into the real world is the core of immersive learning. Current research supports incorporating immersive learning and virtual reality into the classroom, optimizing the learner experiences to understand better what is being taught and transfer it to the real world.

Implications For Practice and Future Research

Students' curiosity and inventiveness can be sparked by virtual reality, an indispensable trait that can change their academic careers. The majority of authors saw virtual reality as an inherent learning tool for higher education; nonetheless, the maturity of virtual reality's usage in higher education remains debatable. In K-12 education, the majority of the virtual reality technologies promulgated in the examined articles were still in the experimental stage and were primarily assessed for performance and usability. Educational specialists and specifically instructional designers can employ findings from this scoping review to learn how the integration of virtual reality can enhance students learning outcomes. Future studies should investigate how each of these questions influences virtual reality in the learning experience.

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