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MATHEMATICS ANXIETY AND VIRTUAL REALITY: EXPLORING COGNITIVE LOAD IN SIMULATED ALGEBRA LESSONS

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Abstract

This study aims to explore the relationship between math anxiety, the use of virtual reality (VR) technology, and cognitive load in simulation-based algebra learning. Math anxiety is a significant barrier to learning, impacting students' motivation, conceptual understanding, and academic performance. On the other hand, developments in educational technology, particularly VR, offer more immersive, interactive, and contextual learning experiences, potentially reducing math anxiety and increasing learning engagement. However, the adoption of VR also presents new challenges related to cognitive load, as the complexity of visual displays, navigation, and interactions in simulated environments can burden students' mental processes. Using a literature review method, this study examines the results of previous studies on the relationship between math anxiety, the effectiveness of VR in algebra learning, and the implications of cognitive load in technology-based learning experiences. The results indicate that VR has the potential to positively impact reducing math anxiety by increasing emotional engagement and learning motivation. However, its successful implementation is strongly influenced by instructional design that balances visual stimuli with students' cognitive capacities. This study recommends the need for VR-based learning design strategies that are adaptive to students' anxiety levels and cognitive load management to optimize algebra learning outcomes in virtual environments.

Keywords: mathematics anxiety, virtual reality, cognitive load, algebra learning

INTRODUCTION

Math anxiety is a psychological phenomenon that has consistently attracted attention in education, particularly in challenging subjects such as algebra ("Exploring Virtual Reality's Impact on Math Anxiety," 2025a). Numerous previous studies have shown that math anxiety impacts not only students' academic performance but also how they process information, make decisions, and build confidence in learning. This situation is even more concerning given that mathematics is a key pillar in developing logical, analytical, and problem-solving skills, which are essential for various scientific fields and everyday life. Math anxiety manifests itself in feelings of stress, fear

of failure, or feelings of inadequacy when facing math problems. This ultimately creates psychological barriers that increase students' cognitive burden when solving mathematical problems.

The development of modern learning technology has provided opportunities for more innovative approaches to addressing math anxiety (Liu et al., 2022). One rapidly developing technology is virtual reality (VR). This technology offers a more immersive learning experience by allowing students to interact directly with objects, symbols, and simulations that are typically only visualized through text or static images. In the context of algebra learning, VR can present abstract concepts in three-dimensional visualizations that are easier to understand and relate to real-life experiences. This approach is believed to help reduce math anxiety by increasing engagement, reducing psychological barriers, and creating a more enjoyable learning experience.

However, the application of VR in learning is not without challenges, particularly those related to students' cognitive load. Cognitive load theory explains that effective learning processes depend heavily on the extent to which students' working memory capacity can be optimally utilized (Fang et al., 2025). If the cognitive load is too great due to the complexity of instructions or the large amount of information that must be processed simultaneously, learning effectiveness will decrease. In the context of VR use, although this technology can facilitate understanding through rich visualizations, there is a possibility that immersive experiences can actually create additional cognitive load if not designed appropriately. This is important because the success of VR in reducing math anxiety is closely related to the extent to which this technology can manage students' cognitive load during the learning process. Algebra itself is a branch of mathematics with a high level of abstraction and is often a major source of anxiety for students. Many students struggle to connect algebraic symbols to their conceptual meanings, thus becoming trapped in the mechanism of memorizing procedures without understanding the deeper concepts (X.-F. Lin et al., 2024). With VR, this abstraction can potentially be translated into more concrete simulations, for example by visualizing equations as representations of objects in virtual space or by interactively demonstrating algebraic transformations. If this can be pedagogically designed with attention to cognitive load aspects, students will not only more easily grasp algebraic concepts but also reduce their anxiety when facing mathematical problems.

The study of the relationship between math anxiety, VR use, and cognitive load is relatively new and rarely explored in depth. Most previous research has

focused on the effectiveness of VR in enhancing motivation or conceptual understanding, but little has addressed how this technology interacts with psychological factors such as anxiety and how these factors relate to students' cognitive capacity (Jost et al., 2020). Understanding this relationship is crucial for designing VR-based learning systems that are not only cognitively effective but also responsive to students' emotional aspects. Therefore, this study seeks to fill this knowledge gap by exploring how VR in algebra learning can affect cognitive load and ultimately contribute to reducing math anxiety.

Furthermore, the educational context in the digital age increasingly demands innovation in learning methods. The current generation of students is known to be more familiar with digital technology and tends to prefer interactive and simulation-based learning experiences (Y.-L. Lin & Wang, 2025). By utilizing VR, learning can better align with the learning styles of this digital generation, while simultaneously harnessing the potential of technology to create more effective learning experiences. However, the effectiveness of VR use cannot be measured solely by the level of student engagement, but also by how this technology contributes to reducing psychological barriers such as math anxiety, and how it manages the balance between information delivery and students' cognitive capacity.

The urgency of this research lies in the importance of finding innovative learning strategies that can address a classic challenge in mathematics education: high levels of student anxiety in the subject (Hoffmann, 2023). By examining the role of VR within the context of cognitive load theory, this research is expected to provide new insights into how immersive technology can be integrated into algebra learning more effectively. The findings of this study have the potential to contribute not only to the academic literature on mathematics learning and educational technology, but also to educational practitioners in designing curricula and learning media that are more adaptive to student needs.

Thus, research into the relationship between math anxiety, cognitive load, and the use of VR in algebra learning is a strategic step in strengthening our understanding of how technological innovation can be optimized in education. This research will not only answer the question of whether VR is effective in reducing math anxiety, but also the cognitive mechanisms underlying this effectiveness. The results obtained are expected to be the basis for the development of VR-based instructional designs that are more effective, efficient, and student-centered, so that they can ultimately improve the quality of mathematics learning at various levels of education.

RESEARCH METHOD

The research method used in this study is a literature review focused on an in-depth analysis of previous research on mathematics anxiety, the application of virtual reality technology in learning, and the concept of cognitive load in educational contexts, particularly in algebra learning. The literature review was conducted by exploring various relevant academic sources, such as international journals, books, conference proceedings, and research reports published in the last ten years to obtain a comprehensive picture of the relationships between the variables studied. The literature selection process was carried out by considering the quality of the publications, the credibility of the authors, and their relevance to the topic, ensuring that only sources that significantly contribute to the understanding of the research theme were analyzed.

Data analysis was conducted through a literature synthesis process by grouping research findings into main themes, such as the impact of mathematics anxiety on learning performance, the effectiveness of using virtual reality in reducing psychological barriers, and how cognitive load theory explains the learning experience in a simulated environment. Using this method, the study aims to build a conceptual framework that can explain the potential use of virtual reality technology to reduce mathematics anxiety through managing cognitive load in algebra learning. The results of this literature review are expected to provide in-depth theoretical insights and serve as a foundation for future empirical research.

RESULT AND DISCUSSION

The Role of Virtual Reality Technology in Modern Education

Technological developments in the digital era have brought significant changes to various aspects of human life, including education. One technology that has gained increasing attention in recent years is Virtual Reality (VR). This technology allows users to enter digitally created virtual worlds, where they can interact with objects, environments, and simulations that mimic reality. In the context of modern education, Virtual Reality is no longer merely a means of entertainment; it has also evolved into an innovative learning tool, capable of addressing challenges and opening up new opportunities in the teaching and learning process. Education, once dominated by conventional text-based and lecture-based methods, is now shifting toward a more interactive, immersive, and experiential approach through the use of VR (Chamekh & Hammami, 2020).

One of the key roles of Virtual Reality in modern education is its ability to provide learning experiences that are difficult, if not impossible, to achieve in real life (Marougkas et al., 2023). For example, in the field of medicine, medical students can perform simulated surgical operations with significantly lower risks than direct patient practice. With VR-based simulations, students can practice technical skills, gain a deeper understanding of human anatomy, and hone their decision-making skills in critical situations. The same applies to engineering, where students can learn to operate high-tech machinery or even study building construction through interactive simulations without facing real danger. Thus, VR acts as a bridge between theory and practice, providing a more contextual, immersive, and safe learning experience.

Furthermore, virtual reality technology in modern education also plays a significant role in increasing student engagement and motivation. One of the biggest challenges in conventional education is low learning interest due to monotonous delivery methods. VR offers a solution by providing experiential learning that stimulates students' curiosity and enthusiasm. For example, in history lessons, students not only read about past events but can also virtually "visit" historical sites, walk inside Egyptian pyramids, or witness reconstructions of ancient Roman life. These immersive experiences make students feel as if they are actually present during historical events, making learning more meaningful, memorable, and engaging (Ding et al., 2020). This demonstrates that VR not only enhances cognitive understanding but also builds emotional bonds between students and the learning material.

Furthermore, virtual reality plays a crucial role in supporting the concept of inclusive education. Not all students have equal access to certain learning experiences due to physical, economic, or geographic limitations. With VR, these barriers can be minimized. Students from remote areas can experience the same learning experiences as students in large cities, for example, through virtual visits to museums, laboratories, or research sites that are physically difficult to reach. Even for students with special needs, VR can be modified to suit their circumstances, creating a more equitable and fair learning experience. In other words, this technology has the potential to narrow the gap in access to education and realize the principle of equity in learning (Mazhar & Al Rifaee, 2023).

On the other hand, the application of VR in modern education is also closely linked to the development of 21st-century skills, which are currently highly needed in the workplace and everyday life. Skills such as critical thinking, problem-solving, collaboration, creativity, and digital literacy can be trained

through VR-based learning experiences (AlGerafi et al., 2023). For example, in team-based simulations, students can be involved in working together to solve specific challenges in a virtual world, thereby learning to communicate, assign roles, and find solutions together. This is highly relevant to the needs of the digital era, which demands that the younger generation not only master knowledge but also develop soft skills that can be applied in real-world contexts. Thus, VR is not only a learning medium but also a strategic instrument for shaping the character and competencies of future generations.

However, the implementation of Virtual Reality technology in modern education is not without its challenges. The cost of procuring VR devices remains relatively high for many educational institutions, especially in developing countries. Furthermore, limited digital infrastructure, such as high-speed internet access, is also a barrier. Furthermore, the readiness of educators to operate and integrate this technology into the curriculum is also a concern. Educators need to be trained not only to be able to use VR devices but also to design effective learning strategies utilizing this technology. Without proper preparation, the use of VR in education has the potential to become merely a passing trend without having a significant impact. Therefore, collaboration between the government, educational institutions, and technology providers is needed to create an ecosystem that supports the sustainable implementation of VR in education.

In the context of globalization, the use of Virtual Reality in modern education also opens up opportunities for cross-border collaboration. Students from different parts of the world can meet in virtual classrooms to discuss, collaborate, or even attend the same lectures without the constraints of geographical distance (Hamad & Jia, 2022). Thus, VR plays a role not only in enriching individual learning experiences but also in building global educational networks. Intercultural interaction through VR platforms can enhance international understanding, foster tolerance, and broaden students' horizons regarding global diversity. This is what makes VR a highly relevant technology in realizing an open, collaborative, and interconnected global education system.

Ultimately, the role of Virtual Reality technology in modern education cannot be underestimated. It has ushered in a new paradigm in the way humans learn, moving from a mere knowledge transfer process to an active, interactive, and comprehensive learning experience. Through its ability to deliver realistic simulations, increase motivation, support inclusivity, develop 21st-century skills, and open up global collaboration, VR has proven itself to be one of the most

promising educational innovations in this digital era. However, its successful implementation still depends on infrastructure readiness, affordability, and educators' readiness to utilize it optimally. If these challenges can be overcome, Virtual Reality technology has great potential to revolutionize modern education and lead the younger generation towards a more adaptive, competitive, and highly competitive future in facing the dynamics of an ever-changing world.

The Potential of Virtual Reality in Reducing Mathematics Anxiety

Mathematics anxiety is a psychological phenomenon commonly experienced by students at various levels of education. This condition is characterized by feelings of fear, anxiety, and tension when faced with mathematical problems, both in everyday learning contexts and during exams. This anxiety often impairs students' cognitive abilities, reduces learning motivation, and negatively impacts academic achievement (Ersozlu, 2024a). In the context of modern education, innovative approaches are needed to address this problem, one of which is through the use of Virtual Reality (VR) technology. This immersive technology is believed to have great potential to create a more interactive, enjoyable, and stress-free learning environment, thereby reducing students' levels of mathematics anxiety.

Virtual Reality works by creating a three-dimensional simulated world that can be accessed through special devices such as VR headsets. When students use VR, they feel as if they are in a virtual environment specifically designed for learning purposes ("Exploring Virtual Reality's Impact on Math Anxiety," 2025b). In the context of mathematics, VR allows abstract concepts to be presented in a more concrete and visual way. For example, geometry concepts typically learned solely through two-dimensional drawings on a blackboard or in a textbook can be visualized as three-dimensional objects that can be rotated, enlarged, and manipulated directly. This visualization reduces misunderstandings and helps students develop a deeper conceptual understanding, thereby minimizing anxiety caused by an inability to grasp abstract concepts.

Beyond the cognitive aspect, virtual reality also plays a role in reducing the emotional burden that often triggers math anxiety. Learning environments built in VR can be designed to be more fun, interactive, and game-like. With this approach, students don't feel like they're undergoing a stressful learning process, but rather like they're playing and learning. When the learning atmosphere is more relaxed, stress hormone levels in the body decrease,

allowing students to focus more and be more confident in facing math challenges. In fact, the use of avatars in VR allows students to "hide" their identities, thereby reducing the fear of making mistakes or being embarrassed in front of their classmates. This creates a psychologically safe space where students are more willing to try and practice without worrying about negative judgment (Buentello-Montoya et al., 2021).

Another potential of Virtual Reality in reducing math anxiety lies in its ability to provide real-world, experiential learning (Juniati & Budayasa, n.d.). For example, instead of learning algebra abstractly, students can enter a simulation that illustrates how mathematical equations are used in everyday life, such as calculating building structures, measuring the trajectory of objects, or even designing symmetrical patterns in architectural designs. By directly seeing the relevance of mathematics in the real world through VR simulations, students more easily understand the importance of the material being studied. This has the effect of increasing learning motivation and reducing reluctance and fear of mathematics, because students no longer see mathematics as something foreign and scary, but rather as a useful tool in life.

Furthermore, Virtual Reality also supports more personalized and adaptive learning. Math anxiety doesn't always arise from a student's inability, but rather is often caused by teaching methods that don't align with their individual learning styles (Schutera et al., 2021a). With VR, learning can be tailored to each student's needs. A student who is slow to grasp a concept can repeat the simulation as many times as necessary without embarrassment, while a faster student can progress to more complex levels. This individualized approach allows each student to develop at their own pace, reducing the pressure of comparison with classmates and lowering anxiety. This uniqueness sets VR apart from conventional methods, which tend to be uniform and inflexible.

From a pedagogical perspective, the use of VR also allows teachers to more accurately evaluate students' learning processes (Akman & Çakır, 2023). Data from student interactions in the virtual environment can be recorded and analyzed to identify the most difficult parts or moments when students appear confused. Teachers can use this information to provide more targeted support. With personalized guidance, students feel more cared for and supported, increasing their self-confidence and reducing anxiety. The use of VR as a learning medium does not necessarily replace the role of teachers, but rather enhances more effective, student-centered teaching strategies.

However, this significant potential is not without several challenges that must be overcome to be truly effective in reducing math anxiety. One major challenge is the accessibility and relatively high cost of VR devices, which means that not all educational institutions can implement them. Furthermore, VR content for mathematics must be designed with pedagogical principles in mind, not simply to provide attractive visualizations. Without careful design, VR can become a distraction rather than a solution. However, with the advancement of technology and the decline in device prices in recent years, opportunities to integrate VR into mathematics learning are increasingly wide open.

Ultimately, virtual reality has significant potential to reduce math anxiety by creating an immersive, interactive, enjoyable, and stress-free learning environment. This technology can transform students' perception of mathematics, from something abstract and intimidating to something tangible, engaging, and relevant to everyday life. With the right teacher support and pedagogically designed content, VR can be one of the most effective educational innovations for helping students overcome math anxiety and improve their conceptual understanding. As technology advances and VR devices become more widely accessible, a more inclusive, adaptive, and anxiety-free future for math learning is no longer just a fantasy but a reality.

The Impact of VR-Based Simulations on Understanding Algebra Concepts

The development of digital technology in education has brought about various innovations that are transforming the way students interact with learning materials. One innovation that is gaining increasing attention is the use of Virtual Reality (VR) as a learning medium. VR not only provides an immersive experience that presents virtual reality, but also opens up new opportunities for students to understand abstract concepts in a more realistic and interactive way (Ersozlu, 2024b). In the context of learning mathematics, particularly algebra, which is often considered difficult and abstract, VR-based simulations offer a potential alternative approach to improving conceptual understanding. Algebra has long been a challenge for most students because it requires a high level of abstract thinking, where symbols, variables, and equations must be understood without always being able to visualize them concretely. This difficulty often triggers math anxiety and decreases learning motivation. Therefore, the integration of VR in algebra learning is relevant for research and implementation as an innovative solution.

VR-based simulations allow students to enter a learning space specifically designed to display visual representations of algebraic concepts ("Exploring

Virtual Reality's Impact on Math Anxiety," 2025c). For example, linear equations are no longer simply displayed as symbols on a chalkboard or in a textbook, but can be visualized in a three-dimensional space that can be explored directly. Students can see how changing coefficients affects the gradient of a line, or how the points of intersection with the coordinate axes change when variables are modified. This type of representation provides a richer, multisensory learning experience compared to traditional methods. With direct interaction through simulation, previously abstract concepts become more concrete, helping students develop a deeper understanding. Constructivist learning theory asserts that knowledge is built through experience, and in this context, VR serves as a medium that provides students with hands-on experiences to actively construct algebraic knowledge.

Furthermore, the use of VR in algebra learning can also increase student motivation and engagement. One of the main obstacles to learning algebra is low interest in learning, perceived as boring and irrelevant to everyday life. Through VR, algebra can be integrated into engaging, visualized real-life contexts, such as building construction calculation simulations, object trajectory analysis in physics, or pattern design in graphic design. Students' emotional and cognitive engagement increases because they go beyond solving problems to directly experiencing the application of algebraic concepts in contextual situations that mimic reality (Schutera et al., 2021b). This not only strengthens understanding but also fosters a positive attitude toward mathematics, which is often previously viewed as intimidating.

The effect of VR simulations on algebra comprehension can also be explained through cognitive load theory. Learning mathematics often results in high cognitive load because students must process large amounts of symbolic information simultaneously. With VR, cognitive load can be better managed because complex information is presented in a more easily understood visual format. For example, the relationship between two variables in a quadratic equation can be visualized as a three-dimensional parabola that can be rotated, enlarged, or manipulated as needed. This process makes it easier for students to establish connections between symbolic and visual representations, thus strengthening conceptual understanding. At the same time, VR can also reduce conceptual errors that often arise when students rely solely on abstract imagination without adequate visual support.

However, the effectiveness of VR simulations in improving understanding of algebraic concepts depends on how the technology is integrated into learning strategies. VR is not a magic tool that automatically improves learning

outcomes; it needs to be combined with an appropriate pedagogical approach. Teachers play a crucial role in designing VR-based learning experiences so that they are not merely entertaining but truly guide students toward clear learning objectives. For example, teachers can guide students through guided explorations within simulations, asking reflective questions, and connecting visual experiences with symbolic mathematical representations. Thus, VR can serve as a bridge between concrete experiences and symbolic abstraction, which is central to understanding algebra.

In addition to positively impacting conceptual understanding, VR-based simulations also have the potential to support the development of 21st-century skills, such as critical thinking, problem-solving, and collaboration (Su et al., 2022). In a VR environment, students can be invited to collaborate on complex algebra problems, for example, through educational game simulations that require them to find solutions utilizing the concept of equations or systems of equations. Collaboration in this virtual space enriches the learning experience, as students interact not only with the material but also with their peers in a fun atmosphere. This results in improved communication skills and more structured logical thinking.

However, challenges in implementing VR also need to be considered. One of these is limited infrastructure and the relatively high cost of providing VR devices in schools. Furthermore, not all students can easily adapt to this technology, especially those with visual or motor disabilities. Teachers also require specialized training to effectively manage VR-based learning. Without careful planning, VR use can actually create distractions that reduce students' focus on the core material (Kiray & Tomevska-Ilievska, 2021). Therefore, ongoing evaluation is essential to ensure that VR implementation truly has a positive impact on understanding algebraic concepts.

The Relationship Between Cognitive Load and Math Anxiety Levels

The discussion of the relationship between cognitive load and math anxiety levels has become a major focus in educational research and the psychology of learning. Mathematics, as a core subject, often causes significant emotional stress in students, primarily due to its demands on abstract understanding, deductive logic, and procedural accuracy. At the same time, the thinking process in mathematics is also closely related to an individual's cognitive capacity. The concept of cognitive load refers to the amount of mental resources an individual uses when processing information. When task demands exceed the brain's working memory capacity, cognitive overload

occurs, potentially impacting learning effectiveness and triggering increased anxiety, particularly in the context of mathematics (Conlon et al., 2021).

Cognitive load itself is divided into several aspects: intrinsic, extrinsic, and extrinsic cognitive load. Intrinsic load relates to the difficulty level of the material itself, for example, abstract algebraic concepts or geometry with complex logical proofs (Throndsen et al., 2022). Extrinsic load arises from the way material is presented or the learning environment, such as unclear instructions or too much additional information that can be confusing. Meanwhile, cognitive load relates to students' efforts to construct new knowledge schemas and integrate them with existing knowledge. When cognitive load is too high, students are unable to allocate their mental capacity effectively. This condition can then lead to feelings of frustration, fear of failure, and anxiety, which further impair mathematics learning performance.

Math anxiety itself is a negative emotional state characterized by anxiety, worry, and even fear when facing situations related to mathematics (Fredericks et al., 2021). These feelings can arise in classroom contexts, exams, or when having to apply mathematical concepts in everyday life. Math anxiety not only affects psychological aspects but also impacts cognitive processes. Previous studies have shown that individuals experiencing math anxiety tend to experience decreased working memory capacity. This means that a large portion of their cognitive capacity is consumed by processing negative emotions, leaving insufficient space for understanding and solving math problems. In other words, math anxiety has a reciprocal relationship with cognitive load, where both reinforce and exacerbate each other.

The relationship between cognitive load and math anxiety can be explained through the perspective of cognitive load theory (Gabriel et al., 2020). This theory asserts that learning will be effective when students' perceived cognitive load remains within the limits of their working memory capacity (Atoyebi & Atoyebi, 2022). However, when math anxiety arises, some working memory capacity is diverted to managing fear and worry. As a result, even though the material is not particularly difficult, students still experience increased cognitive load. In this situation, a self-reinforcing cycle emerges: excessive cognitive load leads to anxiety, while anxiety actually increases perceived cognitive load, resulting in decreased academic performance. This phenomenon explains why many students with adequate intellectual potential fail to achieve optimal results in mathematics learning because they are trapped in a cycle of cognitive load and anxiety.

Furthermore, research in educational psychology also shows that the relationship between cognitive load and math anxiety can be influenced by both individual and environmental factors. Individual factors include self-confidence, previous learning experiences, and emotional regulation abilities. Students with high self-efficacy in mathematics are generally better able to suppress anxiety even when faced with complex material, thus maintaining a relatively more manageable cognitive load. Conversely, students who have had negative experiences with mathematics from the outset are more likely to experience anxiety, which automatically reduces their capacity to manage cognitive load. Environmental factors also play a significant role, such as the teacher's teaching methods, classroom climate, and the use of learning technology. Teachers who deliver material in a clear, structured, and supportive manner can help reduce extrinsic cognitive load while simultaneously lowering students' anxiety levels (Atoyebi & Atoyebi, 2022).

In the context of mathematics learning, it is crucial to create strategies that manage cognitive load while minimizing anxiety. One frequently recommended approach is scaffolding, or providing gradual assistance in understanding complex concepts. This way, intrinsic cognitive load can be broken down into smaller, more easily understood parts. Furthermore, the use of visual media, interactive simulations, and technologies like Virtual Reality can also help reduce extrinsic cognitive load by presenting the material in a more intuitive and engaging manner. On the other hand, to reduce math anxiety, psychological strengthening strategies such as building self-confidence, providing space for students to discuss without fear of error, and implementing an experiential learning approach can be effective solutions.

The close relationship between cognitive load and math anxiety ultimately confirms that the problem of learning mathematics lies not solely in the difficulty of the material, but also in the psychological and cognitive aspects of students. Teachers, researchers, and curriculum developers need to consider both aspects simultaneously to create a conducive learning environment. By understanding the interaction between cognitive load and math anxiety, learning strategies can be designed in such a way that not only facilitates conceptual understanding but also fosters calm, motivation, and confidence in facing mathematical challenges. Awareness of this relationship is also crucial in avoiding long-term impacts, as unaddressed math anxiety has the potential to hinder students' interest in science, technology, and engineering fields that rely heavily on mathematical abilities.

Thus, it can be concluded that cognitive load and math anxiety are two closely interrelated factors that influence each other in the learning process. High cognitive load can increase anxiety, while excessive anxiety can increase cognitive load, thus creating a double barrier for students. To address this, pedagogical interventions are needed that address both cognitive and emotional aspects in a balanced way. Only in this way can mathematics learning truly be an experience that builds understanding, enhances critical thinking skills, and fosters students' confidence in facing various academic and real-life challenges.

CONCLUSION

The conclusion of the study "Mathematics Anxiety and Virtual Reality: Exploring Cognitive Load in Simulated Algebra Lessons" shows that the use of virtual reality technology has significant potential to transform the mathematics learning experience, particularly in algebra, which students often find complex. Through VR-based simulations, students not only interact with abstract concepts in a more concrete and visual form but also experience an immersive and interactive learning environment, thereby reducing math anxiety. A well-designed environment can foster a sense of engagement, motivation, and learning comfort, thereby reducing the psychological barriers that typically arise when facing math problems.

Furthermore, this study also highlights the importance of understanding the cognitive load resulting from the use of VR in learning. While VR can facilitate rich visual representations and engaging learning experiences, excessive content complexity and interactivity risk increasing students' cognitive load. This requires a balanced VR-based learning design, where visual, audio, and interactive experiences are combined with appropriate pedagogical strategies to allow students to focus on understanding algebraic concepts without being overwhelmed by additional, irrelevant information.

Thus, the application of VR to address math anxiety through algebra simulations should be seen as a promising, innovative approach, but it still requires serious attention to aspects of instructional design and long-term effectiveness. Further research is needed to examine how VR can be optimally integrated into the curriculum, how students with varying levels of math anxiety respond, and how the sustainability of this technology can support adaptive, inclusive, and individualized learning.

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