

# A Review of the Application Research of VR and AR in Children's Education

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## Abstract

**In the contemporary education industry, the application of Virtual Reality and Augmented Reality technologies has been highly influential due to their ability to provide diverse interactivity and immersive sensory experiences. These tools assist children in fully grasping learning content within virtual interactive environments, greatly advancing the informatization process of children's education. This paper adopts a systematic literature review methodology to thoroughly investigate the current state of VR and AR applications in the education of children, a specific user group. The study first introduces the key features of VR and AR technologies as applied in children's education, followed by an in-depth review of relevant research achievements in this field. Finally, the paper analyzes the advantages of applying these technologies in children's education, as well as the challenges that arise during their implementation.**

## Keywords

**Virtual Reality, Augmented Reality, Children's Education.**

## 1. Introduction

In recent years, as technology has rapidly advanced and information networks have developed at an unprecedented pace, many traditional industries, including children's education, have undergone significant upgrades and transformations. Emerging technological tools and innovative teaching methods are profoundly reshaping the landscape of education, offering both new challenges and opportunities. Among these advancements, VR (Virtual Reality) and AR (Augmented Reality) technologies have emerged as prominent products of the information age, significantly influencing how we live, work, and learn.

In the realm of education, the immersive and interactive nature of VR and AR technologies allows learners to engage deeply with concepts and materials, enhancing their comprehension through direct interaction with digital environments. These technologies provide children with the ability to visualize abstract concepts, participate in hands-on learning, and explore complex subjects in a dynamic, safe, and controlled space. Educators are increasingly using VR or AR to create vivid, three-dimensional virtual worlds tailored to children's needs, encouraging exploration, interaction, and creativity. As a result, these tools are instrumental in fostering curiosity, stimulating interest, and nurturing the natural exploratory instincts of young learners. This paper aims to review and analyze the research literature from the past two decades, both domestically and internationally, regarding the application of VR and AR technologies in children's education. The objective is to understand the current state of research, identify emerging trends, and assess the advantages and limitations of these technologies. This analysis will serve as a reference for future research and practical applications of VR and AR in the field of children's education.

## **2. The universal definition of technology**

### **2.1. Virtual Reality**

Virtual Reality technology, originating from advancements in computer science, VR is rooted in computer technology and constructs a highly realistic virtual environment through digital information, engaging multiple sensory systems, including vision, hearing, and touch. [2] VR technology typically includes the following technical supports: Computer graphics is used to generate realistic virtual environments, including the modeling and rendering of terrains, buildings, and objects. Interaction devices and algorithms enable user interaction with the virtual environment, encompassing technologies such as gesture recognition, voice recognition, and haptic feedback. Virtual reality engines are indispensable for VR application development, providing essential support for scene construction, physics engines, rendering, and sound integration.

These components enable users to interact with the virtual environment. They include gesture recognition systems, voice recognition software, and haptic feedback mechanisms, all of which enhance the user's sense of immersion.

### **2.2. AR Technology**

Augmented Reality technology is an emerging technology developed on the basis of virtual reality, enhancing users' perception of the real world by adding information provided by computer systems. AR is a technological innovation that builds upon the foundation laid by VR. It enhances users' perception of the real world by overlaying computer-generated virtual objects onto real-world environments. These virtual objects can include anything from simple images and text to complex 3D models, all of which are designed to enrich the user's interaction with their physical surroundings.

Unlike VR, which fully immerses users in a virtual space, AR keeps the real world in view, allowing for a seamless blend between the digital and physical environments. The interaction within AR environments is therefore more intuitive and natural.

## **3. Characteristics of technological applications of education**

### **3.1. Vivid and Intuitive Learning**

Virtual reality allows children to immerse themselves in simulated real-life environments, making learning more intuitive and engaging. By bringing abstract concepts into visually rich, realistic settings, children can gain a deeper and more direct understanding of the knowledge being taught. Whether it's exploring historical landmarks or observing complex scientific processes, VR helps to make learning more relatable and impactful.

### **3.2. Interactivity**

VR and AR technology enables children to actively participate in their learning environment. They can interact with the virtual world through gestures, voice commands, or touch, transforming learning into an engaging and hands-on experience. This level of interactivity not only captures children's attention but also increases their enthusiasm and motivation to learn, turning passive observation into active participation.

### **3.3. Safety**

Virtual reality provides a completely safe and risk-free learning environment. Children can explore dangerous situations, conduct scientific experiments, or engage in activities that might be too risky in the real world, such as navigating through a fire drill or learning how to react in an earthquake, without any physical harm. This ensures that learning can take place in an exciting yet safe context, offering valuable experiential learning without the associated dangers.

### 3.4. Diversity of Learning Resource

VR and AR offer a wide range of learning resources, such as animations, games, and simulated experiments, which can be customized to meet different children's needs and interests. This variety not only caters to different learning styles but also provides more opportunities for children to engage with the material in ways that they find most appealing and effective.

### 3.5. Personalized Learning

The emergence of VR and AR technology has injected new energy into the field of children's education, to some extent meeting the needs of children in exploring the world as they grow. According to the definition in developmental psychology, children are categorized as those aged 3-15, mainly preschoolers and elementary school students. [3] Children's cognitive development includes growth in areas such as thinking ability, information processing, and problem-solving skills, and their cognitive development level affects their understanding and handling of learning tasks. In the early stages of cognitive development, children may focus more on sensory and motor experiences. As their cognitive abilities improve, they gradually become capable of understanding abstract concepts, logical reasoning, and symbolic representation. Using AR technology can simulate a rich and easily experiential educational environment and context to the greatest extent. Educators can employ VR or AR technology to present knowledge and assist in teaching activities, allowing children to interact with the virtual environment, thereby obtaining immersive visual, auditory, and tactile experiences. This can stimulate their interest in learning, enhance intuitive cognition, and promote the progressive development of their thinking, helping them actively engage in learning, explore proactively, and construct knowledge structures.

## 4. Applications in Children's Education

### 4.1. Educational Games

The core principle behind educational games is to combine learning with fun, promoting education through entertainment. These games are widely used to help children develop skills and explore knowledge, offering considerable practical value. VR and AR children's educational games, which rely on VR and AR technology, create virtual learning environments by simulating real-world scenarios. The game's narrative is designed around the learning content, allowing children to interact with characters by taking on roles within the game. Through completing tasks, children engage in experiential learning. In her exploration of virtual reality platforms such as HIVEPOT and Steam VR, Shuwen found that VR children's educational games are quite diverse, covering subjects like academic learning, science education, and life skills. [4] Ori Inbar developed an AR spelling game for children aged 4-7, designed to align with their cognitive and physical development, providing opportunities for spelling practice at any time. Tian Yuan and colleagues examined the features of AR-supported educational games and developed a mobile augmented reality educational game for preschoolers, proposing new strategies for enhancing the effectiveness of educational games. [5] He Juhou and colleagues created a fully immersive VR English learning game, and their practical research showed that using VR educational games in teaching can significantly boost children's motivation to learn. [6]

### 4.2. Subject-Specific Learning

VR and AR technologies have been successfully implemented in various academic disciplines to enhance traditional teaching methods. For example, AR has been used to create interactive learning environments for subjects like mathematics and science. These technologies allow children to interact with complex mathematical problems or scientific phenomena in real-time, offering a more engaging and hands-on learning experience. VR or AR technology offers more dynamic learning materials and tools, aimed at developing children's skills and cognitive

abilities across various subject areas. Many researchers have explored the use of VR and AR in children's subject education. Chien developed an AR-based "*magic book*" for teaching counting to children, using a contextual storytelling approach that, combined with AR technology, successfully engaged students, demonstrating its effectiveness in early childhood education. [7] Hye Sun Lee incorporated Korea's rich gaming experience into math education, significantly enhancing elementary students' interest in learning math through the use of AR. [8] Edoardo and colleagues found that combining mobile VR technology with traditional teaching methods helped students become more attentive and engaged during music lessons. [9] Liang Bo, using grounded theory, studied the application of VR technology in elementary education. He proposed that VR can be used in subjects like science and Chinese language, allowing children to experience the scenes described in texts in an immersive, time-transcending way, overcoming the practical limitations of real-world science experiments and avoiding potential dangers. This approach fosters children's interest in learning, thus improving their classroom engagement. Xie Ying, drawing on situated cognition and immersive learning theories, designed and developed AR-based case studies for elementary school English lessons, titled "*Let's eat.*" Experimental results showed that integrating AR technology into elementary English classes could effectively boost students' interest and improve their learning outcomes.

### 4.3. Safety Education

Children, due to their immaturity and lack of experience, are often unaware of the potential dangers in their environment. Traditional safety education methods, such as lectures, pictures, and videos, are limited in their ability to provide realistic and interactive learning experiences. VR and AR technologies, however, allow children to safely experience dangerous scenarios such as fires, earthquakes, and traffic accidents in a controlled, virtual environment. These simulations enable them to learn essential safety skills and emergency procedures without facing any real-world risks.

Children's minds are not yet fully developed, making them vulnerable and with weak safety awareness, generally lacking the ability to prevent and handle accidents. Traditional safety education methods, such as verbal warnings, illustrated stories, and animated videos, are often ineffective due to their lack of interactivity and engagement. While safety drills based on real-life scenarios can be effective, they are labor-intensive and not suitable as routine training methods. By using VR or AR technology, children can safely experience scenarios such as fires, earthquakes, drowning, and traffic accidents, and learn how to escape and prevent danger. Zhang Xue and others conducted a quasi-experimental study with 79 children from three elementary schools in urban, suburban, and rural areas to verify the effectiveness of VR technology in identifying and improving children's dangerous traffic behaviors. [10] Ren Nannan developed a new classroom model for applying immersive VR in elementary school safety education, selecting "*Earthquake VR Experience*" resources for teaching analysis and VR environment creation. Practical research has proven that integrating VR technology with safety education and implementing an appropriate teaching model can make the learning process more engaging and improve learning outcomes. Hu Yue designed an AR game titled *The Incredible Adventure* based on interactive storytelling, where children use a mobile app to recognize and scan game cards with safety education knowledge through the camera, engaging in interactive learning. This approach addresses the monotony and lack of content retention present in traditional safety education. Additionally, some scholars have applied VR technology to educate rural left-behind children on preventing sexual abuse, addressing the challenges of imparting sexual knowledge in families and schools for these children.

### 4.4. Special Education

For children with special educational needs, such as those with autism or intellectual disabilities, VR and AR technologies provide immersive, personalized, and interactive learning

experiences. These technologies can be used to create virtual environments that help children overcome cognitive and behavioral barriers. In addition, VR and AR can simulate real-world social interactions, helping children with special needs develop social and communication skills in a controlled and supportive environment.

The application of VR or AR technology in special education for children primarily focuses on early intervention for children with autism and intellectual disabilities. It provides immersive, personalized, and interactive learning experiences that help special needs children overcome cognitive and behavioral challenges, enhancing their learning abilities and life skills. The virtual environments created by VR technology are mainly divided into single-user and multi-user environments, where multi-user environments offer individuals more opportunities for social interaction and role-playing, simulating real-life interactions more realistically. [11] Kijima's research shows that special needs children can use and adapt to simple interactions in simulated environments. [12] Wuang and others used the VR-based motion-sensing device Wii for motor function training in children with Down syndrome, finding that VR-Wii was significantly more effective than traditional occupational therapy, with a notable improvement in gross motor activity. Strickland trained two children with autism on crossing the street, and the results showed that the children could recognize common objects from daily life in the virtual environment and successfully complete the task of crossing the street. The "*VR/AR + Education*" laboratory at Beijing Normal University conducted intervention research on children with autism using a series of natural interactive games based on gesture recognition devices, proving that the use of VR and AR technology can effectively improve the fine motor skills and cognitive levels of children with autism.

#### 4.5. Moral and Ethical Education

VR and AR technologies have been utilized in the realm of moral education, where virtual simulations are used to help children understand ethical decision-making, empathy, and civic responsibility. By placing children in virtual environments that simulate real-life moral dilemmas, educators can foster the development of critical thinking and moral reasoning skills. For instance, VR or AR can be used to teach children about historical events and cultural heritage, allowing them to engage more deeply with these subjects through interactive experiences.

The application of VR or AR in children's moral education primarily involves simulating scenarios and interactive experiences to help children make moral decisions, develop empathy and interpersonal relationships, foster a sense of responsibility and citizenship, and cultivate values. Red culture, as a valuable resource for ideological and moral education, plays a key role in these efforts. Chen Jiajia and others believe that integrating VR and AR technology with the promotion and learning of red culture can diversify its promotion, strengthening children's understanding of red culture and fostering sound values. They designed a virtual reality platform combining VR, AR, and H5 technologies to facilitate children's learning of red culture. [13] Li Xuanlin and others mentioned the importance of providing preschool children with "*boundaryless*" learning environments. For example, using AR technology to recreate historical sites like the Chongqing Zhazidong Concentration Camp, including martyr cells and interrogation rooms, enhances the authenticity of historical relics and deepens children's understanding of history and red culture. Shim Jaekwoun conducted a study involving 162 elementary school students in Korea to assess the effectiveness of a VR-based moral education program. The results showed that the program significantly improved children's moral sensitivity. [14]

## **5. Advantages of its application in the field of children's education**

### **5.1. Increased Learning Motivation and Interest**

VR and AR technologies create immersive learning environments that engage children in ways traditional methods cannot. These technologies capture children's attention and stimulate their intrinsic motivation to learn, making them more active participants in the educational process.

### **5.2. Enhanced Learning Outcomes and Memory Retention**

Studies have shown that VR or AR technologies improve learning outcomes and memory retention compared to conventional teaching methods. Since children are able to interact directly with the learning material, they develop a deeper understanding of the content and are better able to retain the information they acquire.

### **5.3. Promotion of Multisensory Learning**

VR and AR technologies engage multiple senses in children, including sight, sound, and touch, fostering a multisensory learning experience. This immersive approach allows children to better understand and absorb knowledge by engaging different sensory channels, leading to a more holistic learning process.

### **5.4. Opportunities for Independent Learning and Exploration**

VR or AR provides children with the freedom to explore and learn at their own pace. They can choose learning paths that align with their interests and abilities, enabling them to engage in self-directed learning. This autonomy encourages children to take ownership of their education, fostering independent learning skills that will benefit them throughout their lives.

### **5.5. Support for Special and Personalized Education**

VR and AR technologies offer adaptive learning environments that can be customized to meet the unique needs of each child. This is particularly beneficial for children with learning disabilities or those requiring special education, as the technology can provide tailored learning experiences that accommodate their specific challenges.

### **5.6. Development of Practical Skills and Creativity**

Through interaction with virtual objects and environments, children can develop practical skills and foster creativity. For example, VR and AR can simulate real-world tasks such as scientific experiments or design projects, allowing children to apply their knowledge in practical, hands-on ways.

## **6. Conclusion**

As VR and AR technologies continue to advance and become more widespread, their application in children's education is expected to grow. These technologies not only enrich the learning content but also provide new ways for children to engage with educational material, helping to bridge the gap between traditional teaching methods and modern educational needs. The rapid development and increasing use of VR and AR technologies are driving the digitization of education, offering new possibilities for the future of children's learning.

However, like all technologies, VR and AR also presents certain challenges. Excessive or improper use of these technologies may hinder deeper cognitive development in children, potentially leading to over-reliance on digital tools and virtual environments. This could negatively affect their real-world social interactions and emotional development. Furthermore, some children may become overly dependent on technological tools to solve problems, which could impair their critical thinking and problem-solving abilities. [15]Educators and developers

must carefully consider how to balance the integration of VR and AR in educational settings to maximize benefits while minimizing potential drawbacks.

Sustainability and accessibility are also pressing concerns, as the high cost of VR and AR equipment may limit its widespread adoption in schools and households. Additionally, maintaining and updating this technology requires ongoing investment and specialized knowledge. To overcome these barriers, collaboration between governments, educational institutions, and industry is essential to reduce costs and ensure sustainable support for these technologies.

In terms of educational research and policy, more studies are needed to fully understand the impact of VR and AR on children's learning and development. Additionally, policies and regulations must be established to govern the use of VR and AR in children's education, ensuring the legality, safety, and educational value of the content. Privacy and data security are critical issues, especially when it comes to the collection and processing of children's personal data. Policymakers must implement strict privacy protection measures to ensure that VR and AR technologies are used responsibly and safely in educational contexts.

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