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THE DIFFERENCES BETWEEN AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) IN LEARNING

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Abstract: As important achievements of modern science and technology, augmented reality (AR) and virtual reality (VR) technologies have shown great application potential in the field of education. They provide rich interactive experiences and teaching resources for the learning process in different ways. AR technology provides a new perspective for education by superimposing virtual information on the real world. For example, in history classes, students can use AR technology to see 3D models of historical figures in textbooks or observe the re-enactment of historical events. In science education, AR can help students visualize complex molecular structures or the internal structure of organisms, making abstract knowledge concrete and intuitive. VR technology allows users to immerse themselves in the virtual world by building a completely virtual environment. In education, VR technology can simulate a real experimental environment, allowing students to conduct virtual experiments, or let students explore in virtual historical scenes and experience immersive historical education. This paper discusses the differences between AR and VR in learning, focusing on their application in history, medicine, music, physics and physical education. By analyzing the performance in terms of content delivery and interactivity in detail, the study found that AR has clear advantages in real-world applications, while VR is more attractive in immersive and simulation-based learning. The article summarizes the best application scenarios of each technology in different disciplines, based on the support of the cited literature.
Keywords: Augmented Reality (AR); Virtual Reality (VR); Learning; Content delivery; Interactivity

1 INTRODUCTION

With the rapid development of education technology, augmented reality (AR) and virtual reality (VR) have become important tools of modern teaching. Both technologies offer entirely new ways to capture students' attention and facilitate learning. AR enhances learners' interaction with their surroundings by overlaying digital elements onto the real world; VR offers the possibility of experiential learning through a fully immersive virtual environment (Al-Ansi et al., 2023). This paper analyzes the application of AR and VR in five disciplines, focusing on their differences in content delivery and interactivity, aiming to provide reference for educational practice. And it is also constantly promoting innovation in education models and improving learning outcomes.

2 APPLICATION COMPARISON AMONG DIFFERENT DISCIPLINES

2.1 History Education: Application, Content and Interactivity

The application of AR and VR technologies in history education provides learners with a new and immersive historical experience, making history education more vivid and intuitive. In history education, AR gives students virtual access to historical sites and artifacts by providing enhanced museum tours. For example, some AR applications allow students to scan historical artifacts to see relevant background information and 3D models. In addition, this technology can present historical scenes directly within the classroom, providing students with an immersive history learning experience.
In contrast, VR immerses students by constructing virtual historical scenarios, such as simulating ancient Roman battles or major historical events. This fully immersive experience enables students to "live" historical situations, resulting in a deeper emotional understanding of historical events [1].
AR is very intuitive in providing historical background information. For example, by overlaying time lines or event details in a real-world environment, AR helps students build a deeper historical background [2]. VR, on the other hand, provides historical content in narrative form, enhancing understanding of the content by allowing students to experience the dynamics of historical events. AR enables direct interaction with real-world artifacts, such as students scanning artifacts through mobile devices to obtain detailed historical information. In contrast, VR further enhances the sense of engagement and immersion in learning by providing a complete virtual interaction scenario that enables students to explore the virtual environment.
VR performs better in immersive learning, while AR is suitable for exploring specific historical context information.

2.2 Medical Education: Application, Content and Interactivity

The application of AR and VR technologies in medical education is gradually changing the traditional teaching mode,

providing a more intuitive, interactive and immersive learning experience. In medical education, AR is widely used for real-time anatomical visualization and guidance of surgical procedures. For example, AR can help students understand the function of organs and their positioning during surgery by superimposing human models. In addition, some augmented reality tools support real-time clinical simulations to help students get immediate feedback on their real-world actions.

Applications of VR in medicine include virtual surgical simulation and emergency medical training. For example, by simulating disaster scenarios in VR, students can practice decision-making and first aid skills in a fully controlled environment [4].

AR provides layered content where students can step by step learn about complex anatomical structures or surgical steps. VR enhances the mastery of medical content by building virtual hands rooms that allow students to practice repeatedly in a safe manner [5]. AR helps students interact with physical models through real-time visual overlay, such as showing key physiological features on an anatomical model. VR, on the other hand, uses high-pressure environment simulations (e.g., emergency room training) to help students improve decision-making skills and respond to sudden events [6].

VR is suitable for high-risk training scenarios, while AR is more suitable for real-time instruction and anatomical learning.

2.3 Music Education

In music education, AR helps students improve their musical instrument learning skills through augmented reality music score applications. For example, certain tools allow students to adjust their fingering and posture with real-time visual guidance [7]. VR, on the other hand, provides students with a virtual performance space, allowing them to perform in a virtual concert or orchestra, thereby increasing confidence and performance ability.

AR superimposes interactive content directly onto the instrument, such as tagging the correct finger position or displaying real-time pitch feedback. In contrast, VR offers complete simulations where students can practice collaboration with other musicians or rehearse in a virtual environment. AR allows students to get corrective feedback in real time during practice, while VR allows students to engage in more complex music scenarios, such as simulated music competitions or collaborative performances [7]. Through the application of these technologies, music education is no longer limited to traditional classroom teaching, but has become more interactive and intuitive. Students can improve their music understanding, performance skills and creative ability through virtual experience. At the same time, these technologies have also brought new teaching methods and innovative experiences to music education.

AR is more suitable for individual skill development, while VR is better for team collaboration and immersive music learning.

2.4 Physics Education: Application, Content and Interactivity

AR helps students better understand physical phenomena by superimposing the visualization of waveforms or electric fields in real-world experiments. VR offers a virtual laboratory where students can explore advanced physics concepts such as optical experiments or quantum mechanics.

AR helps students understand abstract physical concepts by combining theory and experiment, such as real-time observation of the relationship between force and motion. VR allows students to explore complex scientific phenomena, such as simulations of nuclear reactions, through detailed virtual experimental scenarios.

AR allows students to interact with real-world experimental equipment while enhancing realistic visuals. VR provides immersive interactions where students can simulate and test physical hypotheses in a virtual environment.

AR is more effective in combining theory with practice, while VR has advantages in simulating complex and dangerous experiments.

Through the application of AR and VR technologies, physics education becomes more vivid and intuitive, helping students understand physical principles and concepts and improving their experimental skills and scientific inquiry abilities. These technologies provide students with a safe and controllable environment to explore physical phenomena, making the learning experience richer and more effective. With the continuous advancement of technology, the application of AR and VR in physics education will become more and more extensive, helping to cultivate scientific and technological talents in the new era.

2.5 Physical Education: Application, Content and Interactivity

AR promotes physical education through real-time feedback and action correction. For example, augmented reality fitness apps can guide students through movements and provide real-time suggestions for improvement [7]. VR helps students simulate competition scenarios or experience new sports through virtual training environments.

AR analyzes movement data in real time, such as speed, distance and angle of motion, providing students with detailed performance reports. VR allows students to participate in immersive sports training by simulating training scenarios, such as a virtual treadmill or rock climbing experience.AR helps students improve technical performance through visual cues and real-time corrections, while VR improves collaborative and competitive skills through virtual arenas or team

competitions.
AR is more suitable for individual skill optimization, while VR is more prominent in team training and immersive experiences.

3 CONCLUSION

The application of AR and VR technology in the field of education has great potential and advantages, but there are some limitations. In practical application, teachers should choose appropriate technology according to teaching objectives and students' needs, and combine with traditional teaching methods to bring into full play the advantages of these technologies and improve teaching quality.

3.1 Advantages of AR

Lower cost: AR technology can be implemented through smart phones and mobile devices at a lower cost, which makes more schools and educational institutions affordable. For example, in history teaching, students can view the virtual reconstruction of historical scenes through the AR application program on their smart phones, and this low-cost learning method can benefit more students [7].

3.2 Advantages of VR

Immersive Experience Strong: VR technology is able to provide students with a highly realistic virtual environment that completely immerses users as if they were in the real world. This immersive experience allows students to deepen their knowledge and improve their learning. For example, in medical teaching, students can train in surgical simulations through VR devices to experience the surgical process first-hand, and this immersive learning experience can give students a deeper understanding of surgical techniques and operating procedures, while also improving students' surgical skills.

4 CONCLUSION

The differences between augmented reality (AR) and virtual reality (VR) in the learning process are mainly reflected in the degree of immersion, interactive methods, learning scenarios, equipment requirements, and learning experience. VR technology, with its highly immersive characteristics, creates a completely virtual learning environment for learners, which is suitable for complex simulation training and immersive learning, especially for subjects that require in-depth understanding and experience of abstract concepts. AR technology, by superimposing virtual elements in the real world, provides a more intuitive and auxiliary learning experience, which is suitable for explaining complex concepts and immediate applications in the real world.
Overall, AR and VR technologies have important application value in the field of education. AR technology has low cost, strong portability and good interaction, and is suitable for some disciplines that require contextual learning and strong interaction, such as history, geography, language, etc. VR technology has strong immersive experience, good simulation, and rich educational application scenarios, which is suitable for some disciplines that require immersive experience and simulation of real scenes, such as medicine, physics, chemistry and so on. In practical application, teachers should choose appropriate technology according to teaching objectives and students' needs, and combine with traditional teaching methods to bring into full play the advantages of these technologies and improve teaching quality.
The respective advantages of both make them play different roles in education. VR technology is more suitable for those subjects that require a high degree of simulation and immersion, such as medicine, engineering, and architectural design; while AR technology is more suitable for subjects that require direct guidance and information enhancement in the real world, such as natural sciences, history, and art.
In summary, educators should choose appropriate technical means according to specific teaching needs and students' learning characteristics to maximize the advantages of AR and VR technologies and promote the effectiveness and fun of learning. In the future, with the continuous development and maturity of technology, AR and VR technologies are expected to be more deeply integrated into the education system, bringing more possibilities for learning.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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