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Original Research Article

A Study of Students' Subjective Perspectives on Visual Behavior in AR learning environments

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Abstract: Augmented reality (AR) technology, with its unique composite of real and imaginary, three-dimensional visualization, and deep immersion, has injected new vitality and change into traditional classroom teaching models and learning styles. This study examines the literature to determine the applications of AR in education, which include empowering subject teaching, integrating educational games, and inventing topic teaching materials. Several studies have shown that AR has a positive effect on student learning. However, the majority of current research focuses on the objective effect evaluation of AR applications and does not examine students' visual patterns and behavior paths in AR learning environments from a subjective perspective. Given the relevance of this perspective, the study recommends a research route for students' visual behavior in an AR education environment based on existing research.

Keywords*:* Augmented reality (AR); Student visual behavior; Subjective perspective; Pedagogical applications
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1. Introductory

With the development of artificial intelligence, the education industry is shifting its attention to modern technologies. China's education has been emphasizing the digital transformation of education, 2024 Huai Jinpeng pointed out that President Xi Jinping attaches great importance to the digitalization of education, and considers the digitalization of education to be an important breakthrough in opening up new tracks of education development and shaping new advantages in education development. The state has strongly promoted the transformation and upgrading of education digitization, as well as education reform, in order to achieve new development. The development of virtual reality and augmented reality technology has provided educators with fresh ideas for digital instructional tools.

2. Overview of AR education research

Currently, "AR+Education" is a hot study subject in the realm of education. The author searched the China Knowledge Network Academic Journals Network Publishing Database using the phrase "AR+Education" and found 205 articles. After evaluating the influential publications, we can see that the academics' works on AR education primarily focus on the following aspects:

2.1. Exploring the role of augmented reality technology on student learning effectiveness

It has been established that using augmented reality (AR) in instruction has a beneficial and favorable promoting effect on students' learning efficacy. After a meta-analysis of 40 experiments and quasi-experiments at home and abroad, Xiaoyong[1] et al. concluded that AR technology has a positive facilitating effect on learning

effectiveness, and that this effect mainly focuses on the two aspects of academic performance and motivation to learn. Pengfei Zhu et al conducted experiments with senior high school students and the results of the study showed that AR technology has significant immediate effects and good pedagogical retention on students' learning of microstructure knowledge in the subject of Chemistry in high school[2]. Altinpulluk H analyzed the findings of an examination of 58 publications published in eight journals of Educational Technology under the SSCI from 2006 to 2016 and concluded that AR technology is effective in terms of students' academic success and enthusiasm to learn [3]. Yuan Ling et al used contour maps to confirm that AR 3D video teaching is better than 2D video and can achieve teaching goals more efficiently[4]. However, there are fewer studies on students' visual focus and movement paths in AR teaching images from the perspective of AR teaching.

2.2. Focusing on research on the application of augmented reality technologies in the fields of education and learning

Teachers recognize AR's unique benefits, which include the potential to enhance learning and teaching quality, add value to the educational process, and increase students' understanding and knowledge. Contemporary students, who are digital natives, are also discovering the wonders of AR technology to stimulate their interest in learning. This paper classifies the performance of augmented reality in education into the following three dimensions:

2.2.1. Subject teaching + AR

Since 2009, Prof. Cai Su's team at Beijing Normal University has been dedicated to the deep integration of augmented reality technology and education, as well as empirical study in subjects such as mathematics, geography, biology, language learning, and campus guides[5]. AR technology is not only widely employed in primary and secondary scientific disciplines, but it is also beneficial in the arts. For example, elementary school Chinese character mnemonic software based on AR technology has piqued the interest of elementary school pupils in learning[6]. Numerous cases show that AR technology is widely applicable.

2.2.2. Educational games + AR

The case of combining AR technology with educational games first originated in the United States. Schrier's 'The War of Independence Revisited', created at MIT in 2005, was one of the first instructional games to employ AR technology[7]. Students use subjective perspectives as characters in the War of Independence to supplement their historical understanding. In the domestic study, Chen Xiangdong and Cao Yanglu designed an AR educational game called "Happy Treasure Hunting"[8] . The game contains three roles for students to choose, namely historian, biologist and geographer. After choosing a character, students are given a task and use their mobile devices to scan the task markers in the real-life scene to answer questions. Correct answers will lead to treasure. Therefore, the game not only stimulates students' interest in learning, but also meets the teaching needs of teachers.

3. A proposed study of student sight patterns in AR instruction

There are more studies on human eye movements but less on students' visual behavior in AR teaching and students' sight can reflect numerous significant letters, which play a vital function in enhancing student learning and improving teacher instruction. In the field of education, the study of visual behavior covers the following areas:

3.1. Impact of various instructional media and forms of presentation on student learning effectiveness

Zheng Runnan, Chang Tianle, et al designed and carried out an eye movement experiment on high school physics students, and the findings revealed that the cues in the GeoGebra animation helped students shorten the time it took to retrieve key information and promote deep cognitive processing and memory of physics knowledge, whereas the effect of decorative details was not significant[9]. Zhang et al.[10] started from "three-quarter screen", which is a commonly used presentation method in online courses, and utilized eye-tracking technology to explore the effects of different teacher presentation formats on students' cognitive load and attention.. It was found that dynamic information attracted students' attention more than static information. Rui Liu et al.[11] In order to investigate whether there is a significant difference between the effects of two different video formats, 3D video and 2D video, on student learning outcomes, cognitive load, and psychological feelings of learning, an experimental study was conducted. The study found that, while 3D video can provide a better learning experience, 2D video is more successful in terms of learning performance and cognitive load.

3.2. Student sightings can reflect important information and current research lacks subjective perspective studies

Although modern educational theory emphasizes "student-centered teaching," in practice, the assessment of students' learning status is primarily based on instructors' subjective views. It is difficult to accurately reflect students' intentions. A literature search found that "visual behavior" is less important to the field of education, indicating that the issue is still in its early phases of research. From a psychological standpoint, traditional classrooms are frequently examined from the viewpoint of the instructor or a third party, which is not scientific. In order to examine the true needs and opinions of students, it is most suitable to conduct research from students' first perspective[12]. According to related research: 83% of the information acquired by human beings comes from vision, while hearing, touch, smell and taste account for 11%, 3.5%, 1.5% and 1% respectively[13] . Therefore, this study aims to utilize the eye-tracker to record the students' AR inquiry learning process and mine the valuable rules.

4. Research ideas on students' visual behavior based on AR teaching environment

4.1. AR learning environment setup

There are two techniques to create AR learning environments. One approach is to employ existing AR resources and AR apps, then pick appropriate AR resources for the building of the learning environment based on the features of the chosen instructional material. For example, there is a systematic and flawless AR program on the market for primary school science that creates relevant AR scenes based on the content of each chapter of the textbook. Another option is to create your own augmented reality materials. Self-development allows the AR environment required for the study to be precisely planned and realized in accordance with the research's unique requirements.

4.2. Data collection using devices based on eye-tracking technology

In this study, tests may be conducted using two types of eye-tracking equipment: wearable eye-tracking devices and external eye-tracking devices that are compatible with AR applications[14]. To begin, make sure that

the eye-tracking devices you use are very precise and efficient, and that they can reliably collect students' eye-movement data in the augmented reality learning environment. At the same time, the gadget should be worn in such a way that it does not interfere with the students' learning process, ensuring the experiment runs smoothly and data is collected effectively. The primary measuring elements of this study are students' visual behaviors which are quantified in terms of gaze area, gaze duration, and gaze count. Furthermore, to make the study's findings more persuasive, the eye-tracking data must be paired with data gathered through questionnaires and interviews for full analysis. If the experimental conditions allow, additional measurements of eye-beat amplitude and trajectory can be included, which will aid in revealing more precisely the characteristics of students' eye gaze behavior and intrinsic patterns as seen from a subjective perspective in an AR learning environment.

4.3. Synthesizing the analysis with questionnaires and interviews

The questionnaire design for this study is organized into four modules: learning experience feelings, subjective viewpoint attention content and variables affecting attention. The interview method was a blend of structured and semi-structured interviews. Structured interviews serve as an outline for research questions, allowing for the quantification of interview data; semi-structured interviews, on the other hand, allow students to fully express their own ideas while also eliciting more deep-seated subjective feelings and insights.

5. Summary

According to the current research results, eye movement research has been relatively perfect in the traditional field of education and teaching, but there are still some gaps in the application and development of virtual reality and augmented reality in these two emerging fields. The author believes that in AR teaching, unlike the previous ordinary teaching resources presented on the plane, the teaching resources presented by AR technology are 3D three-dimensional. Students' attention is consequently diverted from the plane to the space. Students can move their subjective perspectives freely with their mobile devices, which can reflect their individual characteristics to a greater extent. Therefore, after this aspect of research, the law of the students' focus of attention in it can be discovered and the theory and practice of AR education research and eye-tracking experimental research can be enriched.

About the author

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