



The Exploration on Interacting Teaching Mode of Augmented Reality Based on HoloLens

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Abstract. In recent years, the applications of augmented reality and the visualization of mixed reality for education are popular. However the lacking of multi-modal interaction for teaching and learning results in the teaching mode staying at the teacher-centered knowledge-feeding pattern, and the ability of the AR technology underutilized. This paper proposes an interactive teaching mode of augmented reality based on HoloLens, taking full advantage of the device which combines 3D scenes, audio, video and teaching content. Applying gesture, voice, holographic interaction and viewpoint tracking technology to practical teaching, this paper demonstrates a new student-centered teaching mode which includes the dynamic classroom teaching, multi-modal interactive practicing and the multi-form feedback learning. This paper carries out an empirical research in senior one students. The results indicate that the interest and initiative of students in learning are increased, the ability of understanding abstract knowledge is significantly improved, and the academic performance of students is promoted. This paper is devoted to promoting the deep integration of augmented reality and teaching, the innovation in teaching process and method has been explored positively.

Keywords: Augmented reality HoloLens · Interactive learning · Learning environment · Nonlinear interactive teaching mode · Mobile learning

1 Introduction

Augmented Reality technology has developed rapidly and has become an important technology to improve people's quality of life. On the purpose of supplementing the real environment, Augmented Reality technology superimposes the virtual information generated by the computer into the real environment, based on computer display, interaction, network tracking and positioning technology. The cheaper equipment and the easier applications make Augmented Reality popular in games, industry, education and other fields.

There are a lot of applications and teaching experience of Augmented Reality technology in education domestic and international. The integration of virtual and real

interactive mode in education is reforming the traditional teaching mode, which has significant effects on changing the relationships among the learning content, learning style and learning environment. The traditional teaching mode, the teacher-centered classroom teaching style only use the Augmented Reality in simply displaying. Thus the teaching process is one-way and linear, the learners do not explore the learning materials via the latest technology.

1.1 The Background of Augmented Reality Technology Used in Education

The earliest application of Augmented Reality technology in education was the Magic Book proposed by Billinghamurst [1]. They used Augmented Reality technology to create corresponding 3D models based on the contents of the book. Children could observe the model by wearing special glasses to implement the effect of combining reality world with abstract knowledge. However, you could only observe the model and you couldn't interact with the model by hand.

Researchers at the Vienna University of Technology conducted a study of AR technology application in mechanics teaching. The physics engine was used to simulate the physical experiments of experimental mechanics. Students could not only observe models, but also use gestures to interact with the models [2].

Chang (2013) designed an experiment to study the learning behavior of students under the nuclear radiation pollution environment near the Fukushima Daiichi nuclear power plant [3]. These activities could make students feel the impact of radiation pollution. These studies demonstrated the prospects of Augmented Reality technology for emergency response education. It could effectively influence learners' attitude towards emergencies.

In China, many researchers have actively explored and demonstrated the use of AR in Education.

1. Chemistry

Su Cai (2014) and other teachers of Beijing Normal University designed a number of experiments on the virtual and real fusion of chemical materials in junior high schools [4]. The way of interaction can greatly enhance students' interest in learning and strengthen their understanding of the physical microstructure.

2. English

He, Ren and etc. (2014) designed the application named "Happy Words" on mobile device which could scan the word through the camera on the phone or tablet PC [5]. In this way, children could quickly enhance their interest in learning.

3. Special education

Zhu designed (2015) a series of gesture-based matching games by combining the gesture recognition device named Leap Motion with AR technology. It could help children with autism improve their spatial perception and practical ability [6].

The above cases show that AR technology can create a real scientific learning environment, allowing learners to have more initiative. HoloLens can be an interesting

and practical learning aid for students, which strengthens students' various disciplines and promotes students' deep understanding. However, it can be seen from the above that the application of Augmented Reality technology in teaching is relatively monotonous, the teaching resources are not fully utilized. The application of Augmented Reality technology in teaching is still in its infancy.

1.2 Augmented Reality Technology Applied to the Education

Augmented Reality technology makes abstract learning more concrete. It enhances the intuition and concentration of learners. Educators are tireless in their pursuit of Augmented Reality technology in education.

With the development of many wireless devices and local registration technologies, ubiquitous collaborative learning and situational learning can be enhanced. The teaching mode obtained by the whole system has the advantages of strong interaction, high convenience, and outstanding personalization.

AR technology is used to construct a scenes such as a science museum. Compared with the traditional teaching mode, the interactive teaching model based on augmented reality technology has two innovations: various teaching modes and teaching contents can be used; interactive teaching organization promotes communication between students and teachers.

2 Interactive Teaching Mode Based on Augmented Reality Technology

2.1 Comparison Between Traditional Teaching Mode and Interactive Teaching Mode Based on Augmented Reality Technology

The traditional teaching mode mainly includes the transfer and the internalization of knowledge. In the traditional teaching mode, teachers are the main guides. While in the process of knowledge internalization, the students need to take a lot of practice. In the interactive teaching mode based on HoloLens, the knowledge internalization is completed with the auxiliary of Augmented Reality technology. The comparison of the various elements between traditional teaching mode and interactive teaching mode is shown in Table 1.

Table 1. Comparison of elements between traditional teaching mode and nonlinear active interactive teaching mode

	Traditional teaching mode	Interactive teaching mode
Teacher	Classroom manager	Classroom assistant
Student	Passive receiver	Active learner
Teaching form	Teaching After-school training	Teaching After-school feedback Interactive learning
Classroom content	Knowledge explanation	Problem exploration
Technical application	Display	Enhanced display Autonomous interaction exploration Collaborative discussion

2.2 The Embodiment of Interactive Teaching Mode Based on Augmented Reality Technology in High School Geography Teaching

In the traditional geography teaching mode, teachers pay more attention to students' academic performance and less attention to students' psychological state in the learning activities. Under this circumstance, the knowledge cannot be applied in practice, which is not in line with the teaching objectives of cultivating students' geographical thinking and improving geographical teaching quality. The interactive teaching mode based on Augmented Reality technology enhances students' ability to use geography knowledge in the following ways:

- Augmented Reality technology and geographical knowledge have been fully integrated, which lets students take the initiative to participate.

Because of the particularity of geography teaching, a large number of maps and models have appeared in geography teaching. When students interact with 3D models. They obtain a lot of useful geographic information by exploring independently. For example, in the chapter of celestial bodies in high school geography, students use the voice and gestures to zoom in, zoom out and move the 3D models of celestial bodies. They understand the intrinsic connection between celestial bodies by video. They can understand the particularity and universality of the earth with the help of HoloLens. They can acquire more knowledge through independent exploration and master the appropriate learning methods by using Augmented Reality technology. As shown in Fig. 1.

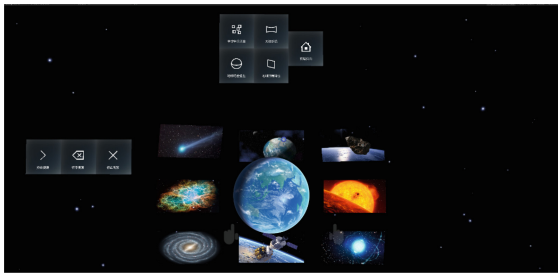


Fig. 1. Interactive celestial scene

There is more cooperation between students. There is less interaction between students in the traditional teaching mode. Individuals are independent learners. A multi-person collaborative demonstration is proposed in the interactive teaching mode of AR. At the same time, different students are equipped with different devices to interact with the same Augmented Reality scene. Taking high school geography teaching as an example, when students have doubts about the particularity of the earth, other students in the same group can demonstrate the formation of atmosphere to him (Fig. 2).

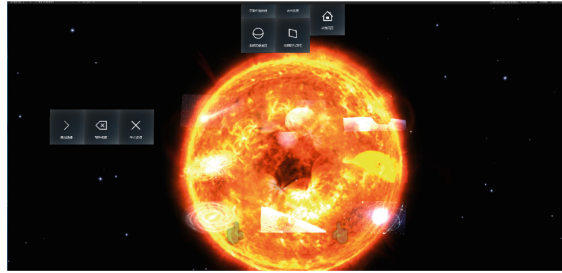


Fig. 2. Picture of the star

- More communication between students and teachers.

In the new teaching mode, the teaching environment is relatively relaxed and pleasant. The teacher conducts demonstrations while teaching. As for the abstract knowledge that is difficult to understand, the students can use the equipment to deepen understanding. The cooperation has been formed between students and teachers. For example, in the geography classroom, the teacher's teaching and presentation are synchronized. In the process of the exploration, the problem is directly fed back to the teachers.

3 Classroom Teaching

3.1 Interactive Teaching Mode

The interactive teaching mode of Augmented Reality based on HoloLens realizes the relationship between knowledge imparting and knowledge internalization. The knowledge in the traditional classroom is acquired in interactive learning. According to the connotation of interactive teaching mode and instructional design theory, the teaching mode is mainly composed of three parts. In the three parts, augmented reality technology and mobile learning are powerful tools for the construction and generation of interactive learning environment. As shown in Fig. 3.

3.2 Creating Interactive Teaching Resources of Augmented Reality Based on HoloLens

Considering the appropriate interactions and models, we collect resources, and construct links between knowledge and models for different disciplines. The teaching characteristics of different disciplines are various. For example, in the geography class, the understanding and mastery of the geographical concept are emphasized. Models

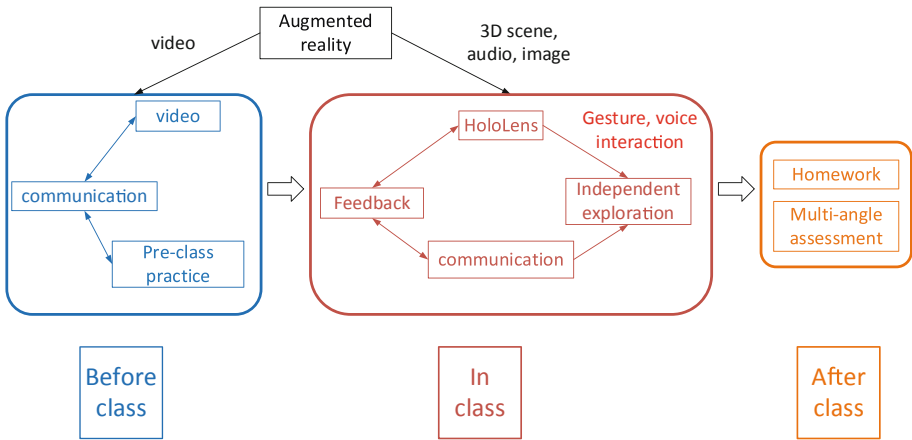


Fig. 3. Augmented reality interactive teaching mode based on HoloLens

such as the Earth, the Moon and the Sun are produced according to the true state. After importing models into the Unity, the scene is configured and developed, so that the wearer can observe the revolution system of the Earth around the Sun while using the teaching application. The experiencer can click the virtual button in the interface to move, rotate, zoom in or zoom out the models. This interaction can also be applied to other celestial models.

3.3 Augmented Reality Interactive Teaching Method Based on HoloLens

The HoloLens constructs local area networks. It shares virtual objects and space anchors between multiple devices. When teachers operate virtual objects, students can observe synchronously through the device. Taking high school geography teaching as an example, teachers wear equipments to demonstrate the rotation of the earth for students on the same local area network. The earth model can also be scaled to focus on some key knowledge, such as the regression line.

3.4 Augmented Reality Teaching Interaction Based on HoloLens

- Using Video Screens for Pre-class Demonstrations

The multimedia teaching video embedded in the augmented reality teaching software based on HoloLens. The first lecture named “Cosmos, Celestial Body, Celestial System” and the second lecture named “Earth - ordinary and special planet” on the topic of “Earth in the Universe” comes from the online quality course. The user can use AirTap gesture to click the UI video play button, or use the voice “play” to play the videos. When the video is playing, the user can also use the AirTap gesture to pause the video, or use both hands to rotate, zoom in and zoom out the video.

- Explaining the Celestial Movement Chapter Using Gesture Control Interaction

AirTap gesture: A gesture specified by the HoloLens, which can be used to click the interactive buttons on the interface. As shown in Fig. 4.

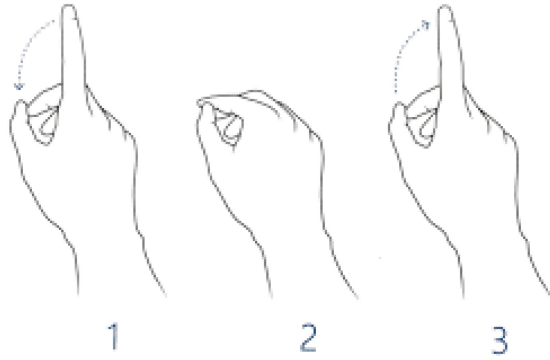


Fig. 4. AirTap Gesture

Two-hand gesture: A gesture that uses AirTap gesture to work together with both hands (both hands must be detected by HoloLens at the same time). The model can be zoomed in and out when both hands are simultaneously active.

Drag and drop: Move the hand while keeping the AirTap gesture.

The holographic buttons are used in the UI interface designed for the geography teaching system. The users can click on the button with the AirTap gesture. The main function of UI interface is to switch the learning scenes and play back the multimedia teaching videos. As shown in Fig. 5.

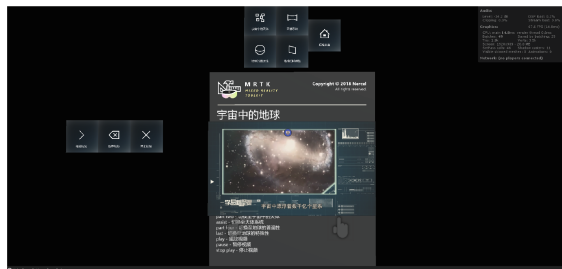


Fig. 5. UI interface in the upper left field of view

For example, in a celestial scene, users can see pictures of eight different celestial bodies. When the users gaze at the corresponding picture, the name of the celestial body is displayed next to the picture. When the users click the corresponding picture with the Airtap gesture, the holographic model or particle effect of the celestial body is

displayed. Learners can vividly and intuitively observe the characteristics of different celestial bodies. As shown in Figs. 6 and 7.

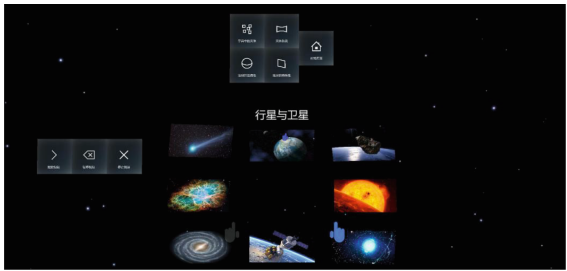


Fig. 6. Celestial scene

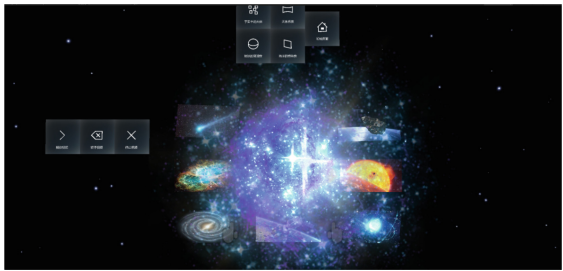


Fig. 7. Celestial scene (crab nebula particle)

- Selecting Speech Recognition Interaction for Cosmic Scene Switching

In the main scene (initial page), the user can see a virtual description window suspended in midair. The description window will explain the learning objectives of the course, the development tools of the project, and the keywords of the voice interaction. The left side of the signboard is virtual buttons for controlling multimedia teaching videos. The multimedia teaching videos can be played, paused and stopped by voice. The video management signboard is provided in each scene. Users can also realize the function of the virtual button through specified voice instruction. As shown in Fig. 8.



Fig. 8. Initial page

4 Experiment

This paper makes an empirical study of HoloLens-based learning environment in the field of geography, taking the first section of the earth in the universe in high school geography as an example, which is divided into three major parts: celestial bodies, celestial systems and the universality and particularity of the earth. It is hoped that the advantages of Augmented Reality technology in education will be discussed with the researchers of educational technology through the introduction of the case.

The main purpose of this study is to explore the impact of HoloLens-based teaching on students' learning experience and learning performance.

- Experimental Subject

The sophomores of senior high school in Xinyang were selected as the experimental subjects. A total of 57 questionnaires were sent out, 41 of which were valid, including 21 in traditional classroom and 20 in a classroom where HoloLens is used (Fig. 9).



Fig. 9. After-class interview scene



Fig. 10. Device experience teaching

- Research and Design

Experimental subjects are divided into two groups with the same number of learners. Random grouping and pre-questionnaires ensured that learners had the same initial state of learning. Both groups learned the same teaching content with the same teacher. In this study, group A is the control group, group B is the experimental group. The traditional teaching mode is used in group A, and mixed teaching mode are used in group B. Through the questionnaire survey and interview in the after-class, the difference of learning effect between the two groups was compared. Questionnaires can help us understand learners’ learning situation in a wide range. Interviews can help us to get a deeper understanding of learners’ learning stage (Fig. 10).

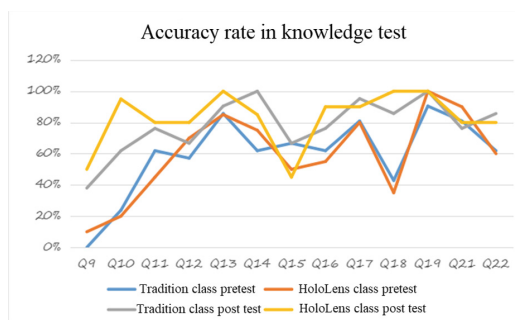
- Research Results

The result of the pre-test and post-test questionnaire is analyzed (measured by the correct rate). Overall analysis results (Table 2):

Table 2. Analysis of the results of pre-test and post-test questionnaire

Accuracy Rate	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q21	Q22
Tradition class pretest	0%	23.81%	61.90%	57.14%	85.70%	61.90%	66.67%	61.90%	80.95%	42.86%	90.48%	80.95%	61.90%
HoloLere class pretest	10%	20%	45%	70%	85%	75%	50%	55%	80%	35%	100%	90%	60%
Tradition class post test	38%	61.90%	76.19%	66.67%	90.48%	100%	66.67%	76.19%	95.24%	85.71%	100%	76.19%	85.71%
HoloLervs class cost test	50%	95%	80%	80%	100%	85%	45%	90%	90%	100%	100%	80%	80%

Table 3. Broken line diagram of correct rate of knowledge points



In most cases, the accuracy curve of HoloLens class post-test is higher than traditional classroom post-test curve, which indicates that the students in the interactive class finally understand the knowledge better than the traditional classroom. It can be

seen that the improvement of the correct rate of students in interactive class is greater than that in the traditional class (Table 3).

As for the interview, most students think that the explanation is more thorough, more impressed, more innovative, more interactive and easier to understand. The spatial thinking ability of students is better when the augmented reality technology is used in class.

They also put forward the shortcomings of applying Augmented Reality technology in teaching. There will be obvious shaking when wearing the equipment, which is not conducive to eyesight, therefore the equipment is not suitable for using too often (Table 4).

Table 4. Analysis of the results of interviews

Advantages of using HoloLens	Disadvantages of using HoloLens
Deep impression	Obvious sloshing of the device
Strong sense of novelty	Damage to eyesight
Strong interaction	Insufficient depth and breadth of teaching
Improvement of Spatial thinking ability	Too much attention to the device

5 Conclusion

This paper proposes a multimodal virtual reality fusion display teaching mode based on HoloLens. The dynamic teaching environment of high school geography teaching is constructed. The gesture, voice, holographic interaction and viewpoint tracking technology in this technology are used to realize the teaching mode of 3D scenes, audio, images and videos teaching display and interaction. According to the comparison between before-class and after-class correct rate of interview results, the mixed teaching mode is suitable for the learning of abstract knowledge. Compared with the traditional teaching mode, the correct rate of test is higher. The initiative of students is also improved. It has good application value.

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