The Influence of Mobile Augmented Reality-Based Sandbox Games on Chinese Characters Learning

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Abstract. With the rapid development of augmented reality technology in the field of education, the availability of learning methods based on mobile AR technology has been verified. However, there is little research on the impact of mobile AR on Chinese character learning. This paper designed and developed a mobile AR Chinese characters sandbox game. Compared with the traditional Chinese characters learning applications, the game is more interesting and effective. The game combines 3D touch interaction, 2D interface interaction, image recognition-based AR interaction and so on. The game can intelligently recommend suitable learning content to learners. In the game, participants write Chinese characters by interacting with the real environment, while changing the virtual environment. The results of this study show that the game has a positive impact on learners' learning of Chinese characters. It can greatly improve learners' learning interest and motivation.

Keywords: Mobile learning · Argument reality · Human-computer interaction · Gamified learning · Chinese characters

1 Introduction

In recent years, mobile learning has developed rapidly all over the world. However, in order to meet the universality and sustainable development of mobile learning, continuous technological innovation and support are needed [1]. Mobile language learning has been in use since 2001 [2]. The popularity of smart phones further promotes the transmission of learning content and accelerates the development of mobile language learning [3]. Mobile learning allows language learners to set up learning tasks based on the current environment, weakening the boundary between formal learning and informal learning. Kukulska-Hulme, found that there was a strong link between game-based learning and mobile learning [4]. Gamified mobile learning methods promote students' learning outcomes through situational awareness and real environment, which is better than non-gamified mobile learning [5]. An interesting game can encourage

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students to use again and again, and then repeat the language content of the study for many times [6].

Augmented reality (AR) technology has been gradually developed in various fields, and has also been emerging in the field of education in recent years. Researchers have found that AR has great development potential in education and can affect students' emotional and cognitive learning results [7]. Educators have found that games can attract players to immerse themselves in them, and gamified teaching methods can effectively improve students' learning performance. AR can further bridge the gap between games and education [8]. Hsu found through experimental research that AR language learning could achieve a high learning effect. At the same time, autonomous AR language learning could also form a higher flow experience, and to a certain extent, could reduce the sense of learning anxiety [9].

Vocabulary is the core of language learning and an important part of language development. Chinese character is a very ancient ideographic language, which is the carrier of Chinese civilization for thousands of years [10]. Therefore, Chinese characters are a necessary and important part of Chinese learning. In the process of teaching Chinese as a foreign language for many years, researchers have found many problems in the teaching of Chinese characters. Among them, compared with English writing, how the strokes of Chinese characters were combined and distributed, and how different Chinese characters were distinguished from each other was a difficulty in learning Chinese characters [11]. How to write Chinese characters in the correct order of strokes is a problem for many Chinese and foreigners alike [12].

However, the writing of Chinese characters has been neglected for a long time. Traditional Chinese characters writing exercises are usually repeated by students to reinforce their memory. But this method does not have the stroke order practice, writing is also very easy to make mistakes. Students could not get feedback in time, and repeated wrong writing strengthened their wrong memory of Chinese characters. The emergence of mobile Chinese characters learning has led to the emergence of strokes in Chinese characters learning, but error information cannot be fed back in time. There is no personalized intelligent push for the learning order of Chinese characters.

2 Literature Review

2.1 Mobile Learning (M-Learning)

So far, there is no definite definition of m-learning. Some researchers try to define m-learning with the equipment and technology required by m-learning, while others define it according to the learning characteristics of students [13]. Although there are different definitions of m-learning, a typical feature of m-learning is that students can keep moving [14]. In any case, the importance of m-learning can't be ignored. M-learning is common in all fields. It also provides and delivers learning content for formal and informal learning [3]. Some researchers have proposed that m-learning will be an important form of lifelong learning [15]. M-learning tool "Explorez", developed for first-year French university students, turned the campus into a virtual French-speaking world. The m-learning tool improved French by enabling students to interact

with different objects on campus through task-based learning and AR. It also incorporated a variety of gamification elements to attract more users to take the initiative to learn [8]. Cavus, has designed a mobile English learning tool. Through experiments, it has been found that m-learning can help students improve their interests in learning English words and their learning performance, which has been well received by students [16].

2.2 Augment Reality (AR)

AR technology is the derivative of virtual reality technology. AR technology is to superimpose virtual objects in the real environment through computer vision technology, so as to enhance the experience of real things. AR technology has been widely used in many fields. For example, Chang, et al. applied AR to mobile navigation to guide tourists to learn the history and geography of tourist attractions [17]. Especially in the field of education has a great impact. Yip et al. used AR video to improve the quality of classroom teaching, which was more efficient than traditional teaching with handouts, and easier to understand complex problems [18]. Solak, applied AR technology to English classes to teach English words. The study found that AR technology had a positive impact on vocabulary learning in language classes and could effectively improve students' academic performance [19].

2.3 Gamified Learning (G-Learning)

Gamification is the use of game design elements in non-game environments [20], and gamification learning is the integration of game design principles into the learning process. Gamification can improve students' learning efficiency, but different from games, gamification learning needs to consider many obstructive factors [21]. Based on the mobile gamification learning system, Su applied the mobile gamification learning method to the learning process of scientific knowledge in primary schools, and found that gamification learning can not only improve students' learning motivation, but also have a positive impact on students' academic performance [22]. Gamification can be used not only for classroom learning, but also to improve users' participation and motivation in online learning. Nike ID, for example, allows users to design their own shoes. The health industry has launched a variety of g-learning apps [23].

3 System Development of the AR Educational Game

3.1 Preliminary Preparation and System Design

Designing a mobile AR system requires some preparatory work. AR can enhance real objects, so we need to prepare a real target object first. We specially designed a recognition card for the game (as shown in Fig. 1), to achieve the superposition with virtual objects. The card can identify different game objects and aims to learn different Chinese characters. In addition, we need to prepare a mobile device equipped with a camera to carry the system.

Fig. 1. AR sandbox game recognition card, used to achieve the superposition with virtual objects.

After the preparatory work is finished, we will begin to design and develop the mobile AR sandbox game to learn Chinese characters. To make the game more interesting and immersive, we designed a main story: animals live in a forest. One day, birds find a lot of different materials that can be used to make the forest more beautiful, but how to build it? The user is a small builder who helps animals complete the construction of the forest.

First, we need to design and make the game objects needed in the sandbox game. After making 3D models with 3D modeling tools, import them into the game engine. In addition, the design of game UI is also required, including the shape, color and style of UI. Then follow the design drawings for layout and construction. After the scene is made, it needs to be further processed in order to make it more realistic and beautiful. Add some particle effects in the 3d scene, and display the effects that cannot be seen in real life in the game with particle effects, making the game more delicate and interesting. At this point, the entire AR virtual environment is created.

The AR sandbox game is designed to help students write Chinese characters correctly. After students log in to the system, follow the system to guide the operation of the learning game. Then students can begin to learn the content of Chinese characters. The main learning content of the game is the writing of Chinese characters. Students identify the card through the mobile device's camera and swipe their fingers across the screen based on the virtual path. The writing process will be constantly tested and feedback. Every stroke of writing has a right or wrong judgment. If the stroke of the swipe is correct, a virtual animation demonstration will appear on the path, along with the corresponding animation and sound effects. While watching the cartoon, students can also observe the writing process of the strokes again. If the stroke is wrong, the virtual animation will not be displayed, and there will be an error message and sound effects.

The learning content of Chinese characters in the game is not programmed, but the intelligent recommendation is made by analyzing the learning situation of students.

According to the students' problems in writing, recommend the Chinese characters suitable for the students to learn next. For example, a student in the process of writing stroke "丿" always writing is not standard, system will recommend contains the stroke of Chinese characters. The specific system design process is shown in Fig. 2.

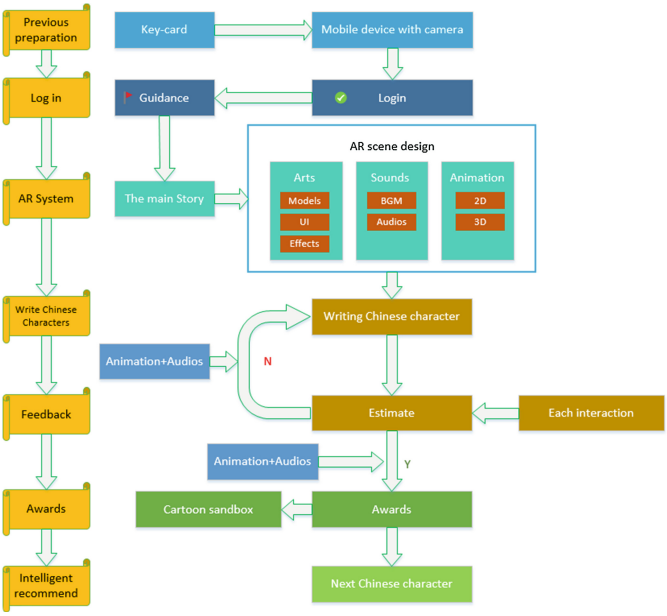

Fig. 2. AR Chinese sandbox game design flow chart. The left shows the overall structural process, and the right shows the diagram for each process.

After students successfully write Chinese characters, they will be given a complete sandbox. They can also watch the correct written animation over and over again.

3.2 Human-Computer Interaction

In the writing process of Chinese characters, there are various ways of interaction, such as AR interaction, two-dimensional interaction and three-dimensional interaction. Human-computer interaction is changing from single-channel interaction to multi-channel interaction, and people are also pursuing more natural interaction.

In the game, AR interaction is used to identify the card, and the real object is identified and processed by computer vision technology, thus the virtual object is superimposed on the card in the way of 3d registration. Students can observe the virtual sandbox from different angles and distances to give them an immersive experience (as shown in Fig. 3). To a certain extent, it can reduce students' learning anxiety and improve their learning interest.

Students can swipe and click on the user interface to select the materials they like (for making the sandbox) and the Chinese characters they want to learn (as shown in

Fig. 3. Chinese characters sandbox from the perspective of AR. Overlay card and sandbox environment. The pictures show various situations during the writing process.

Fig. 3). Different virtual objects can be created by selecting different materials. Different Chinese characters can identify different sandbox scenes and learning contents, which will bring students a richer and more interesting experience.

After select the materials and Chinese characters, students need to click and swipe along the path of the Chinese characters in the virtual sandbox on the touch screen, and then the previously selected materials can be created on the path and superimposed with the virtual sandbox in real time. The feedback in the writing process of Chinese characters not only includes the animation of creating materials, but also the animation feedback and sound feedback after each writing is completed (as shown in Fig. 4). These feedback methods are more intense and timelier, so that students can better understand their writing and correct them. Prevent students from forming wrong reinforcement, which is difficult to correct in the end.

3.3 Intelligent Recommendation

Intelligent recommendation is to search the learning content suitable for users in the database and recommend it to users in the selected area of Chinese characters by analyzing users' operation and learning situation. At present, a lot of learning applications are designed in the background learning process, including learning contents and order. Students can't choose the contents of learning that are suitable for their current learning situation, which reduces the learning efficiency and autonomy of students.

The intelligent recommendation function in AR Chinese characters sandbox game can realize students' personalized learning, timely solve the problems in the learning process and carry out intensive training. In order to improve students' learning autonomy and initiative, they can get additional rewards by completing intelligent recommendation tasks.

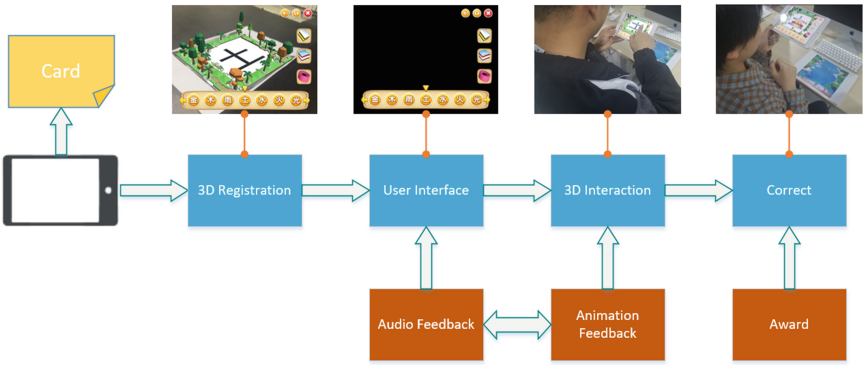

Fig. 4. Human-computer interaction flow chart. Interactive flow and feedback of AR sandbox games in use.

4 Method

4.1 Participants

There were 76 participants in this study, all of whom were sophomores majoring in digital media. Their mother tongue is Chinese, and they have a certain understanding of AR technology, with certain software evaluation ability. The students were divided into two groups, 38 of whom were assigned to the experimental group (Group 1) and the rest to the control group (Group 2). The two groups of students were taught by the same teacher, who works on virtual reality and Chinese characters. All students will be able to use the tablet and be familiar with a variety of interactive modes (Fig. 5).

Fig. 5. Pilot experiment process. The left picture is the AR environment, and the right picture is the traditional media environment.

4.2 Measuring Tools

The measurement methods used in this study were pre-test and post-test. Questionnaire survey was used to measure the differences of two different Chinese learning methods from four dimensions. The four dimensions are learning interest (D1), immersion (D2), interactivity (D3) and learning style (D4). The measurement method was independent sample t-test. Pre-test aims to measure whether the two groups of students are satisfied

with the traditional Chinese characters learning methods. Post-test is to measure the satisfaction of two groups of students with AR Chinese characters learning method and Chinese characters learning method based on tablet computer through Likert five-point scale. The Cronbach's alpha value of the questionnaire was 0.916.

4.3 Procedure

The objective of this study is to compare the effect of AR Chinese characters learning method and tablet Chinese characters learning method. During the experiment, we first taught the students in the control group. Before the class, we prepared tablet computers for each student and selected a Chinese character learning app in the store. Before the class began, students' satisfaction with the traditional Chinese writing practice was measured to see if it was consistent with the experimental group. In class, the teacher asked the students to open the downloaded learning application of Chinese characters and learn the writing part of Chinese characters according to the learning mode of the APP. The writing part of Chinese characters was mainly evaluated. The method of writing Chinese characters is to give students a Chinese character and then ask them to describe it in red according to the system prompts, and they will be rewarded whether they are correct or not. After half an hour of learning, the students were asked to measure their satisfaction with this method of learning Chinese characters.

In the experimental group, the teacher prepared a tablet computer and a card for each student before class and pretested the students. In the course, since students have mastered AR technology, there is no need for instructions. Students open the AR Chinese characters sandbox system designed by us and learn the writing of Chinese characters through identifying the card and various interactive operations. Satisfaction was also measured after half an hour of learning.

5 Results

We got two sets of data during the experiment. The first set of data is a survey on the satisfaction of two groups of students with the traditional Chinese characters learning methods. As shown in Table 1, the satisfaction of the two groups of students is consistent. The data in Table 1 shows that the two groups of students are not satisfied with the traditional Chinese writing learning methods and there is no difference between them.

Table 1. The difference of group 1 and group 2

No.	Group	Mean	SD	F	p
D1	1	1.66	0.627	0.075	0.223
	2	1.84	0.679		
D2	1	1.92	0.712	0.843	0.432
	2	1.79	0.741		
D3	1	1.89	0.798	0.068	0.569
	2	2.00	0.805		
D4	1	1.74	0.795	4.396	0.748
	2	1.68	0.620		

As shown in Table 2, it can be seen from the average value of the two groups of data that the average value of the experimental group is higher than that of the control group as a whole. But compared with Table 1, the learning interest (D1, Mean1 = 4.29, Mean2 = 3.89), immersion (D2, Mean1 = 4.29, Mean2 = 3.84), interactivity (D3, Mean1 = 4.29, Mean2 = 3.76) and learning style (D4, Mean1 = 4.13, Mean2 = 3.68) of the experimental and control groups were significantly improved.

Table 2. Independent sample t test results of group 1 and group 2.

No.	Group	Mean	SD	F	p
D1	1	4.29	0.802	3.994	0.067
	2	3.89	1.034		
D2	1	4.29	0.694	10.006	0.038
	2	3.84	1.103		
D3	1	4.29	0.654	6.524	0.006
	2	3.76	0.943		
D4	1	4.13	0.777	1.652	0.021
	2	3.68	0.873		

Through the independent sample t test of the two groups of data, it is found that students are very interested in the two Chinese characters learning methods, and there is no significant difference (D1, $F = 3.994$, $p = 0.067 > 0.05$). However, Chinese characters learning games based on AR have better immersion (D2, $F = 10.006$, $p = 0.038 < 0.05$), interactivity (D3, $F = 6.524$, $p = 0.006 < 0.01$) and learning style (D4, $F = 1.652$, $p = 0.021 < 0.05$).

To sum up, students had good feedback on both learning styles, but the experimental group had better immersion, interaction and learning style than the control group.

6 Discussion

Mobile AR sandbox games use AR to superimpose virtual sandbox models on the card. Students can interact with virtual objects in the sandbox in real time. The game will give feedback in various ways, so as to master the correct writing method of Chinese characters in the process of playing the game, and obtain the corresponding rewards.

The students used AR to superimpose the card and virtual scenes in the game. AR firstly processes virtual scenes through computer vision technology and computer graphics, and then superimposes with real objects. Therefore, AR can integrate virtual objects with real objects in a very realistic way, giving people a strong sense of immersion [24, 25]. Students can freely control the Angle of observation and learning, and have more flexible operation. There are various sandbox scenes in the game, and students can choose different materials for secondary construction. The sandbox also contains animation of various small animals, which is very interesting. In addition, the

interactive mode in the game is rich and the feedback is timely. While playing the game, students can timely find and correct mistakes. Finally, the whole process of the game is controlled by the students themselves, and the learning content can be selected according to their preferences and intelligent recommendations. To a certain extent, it can realize students' personalized learning of Chinese characters writing.

7 Conclusion

The paper designed and developed a Chinese characters learning game, which is presented in the form of AR sandbox. Students can choose sandbox scene and learning content in the game. The system combined various interactive modes properly and provided students with better interactive experience. In addition, the learning content of students is personalized recommendation through the intelligent recommendation system, so students can learn more suitable Chinese characters. In the future, we will improve the accuracy and judgment basis of intelligent recommendation, so that students can have more choices. Finally, we will also add other contents of Chinese characters, such as pronunciation, usage and so on.

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