

Design and Implementation of an Augmented Reality Application with an English Learning Lesson

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Abstract—The development of mobile technology makes augmented reality (AR) teaching and learning content in classroom more common in recent years. In English as second language (ESL) learning, previous studies have showed AR's potential advantages. In this study, an English learning lesson with a mobile-based AR application were designed and implemented in primary school level. AR application could help students to improve basic listening and speaking skills in English. Moreover, inquiry-based learning activity was also carried out with AR application. The aim of this research is to explore the effect of well-designed lesson and learning activities with AR application. Face-to-face interviews with the teachers and students show that the AR in ESL has some unique advantages. Students also have positive attitudes towards this technology in the English learning lesson. Limitations of this research were also discussed.

Keywords—*augmented Reality, language learning, English as second language, English as a second language*

I. INTRODUCTION

In recent years, augmented reality (also known as AR) have gained more and more public interest. Thanks to the mobile AR game trends from 2016, people pay more and more attention on AR and its using in several fields, and the same is true in education. With the rapid development of the performance of mobile devices, along with more powerful development kit of AR, mobile-based AR become the main stream of AR content (e.g. Qualcomm's Vuforia, Apple's AR Kit and Google's AR Core).

In the educational field, AR in different learning environment is a hot research topic. Mobile-based AR could be easily taken into the classroom, so it is seen as a valuable teaching tool in classroom [1]. Constructivist learning theory and inquiry-based learning strategies make AR in classroom rational [2], because of its improvement on motivations [3] and engagement [4] in the learning approach. At the same time, the mobile devices and ideas of ubiquitous learning make more and

more group works in inquiry-based learning reasonable [5]. In the AR learning process, more share of knowledge and experience is encouraged. Some studies also demonstrated that AR could bring better learning experience, especially in difficult courses [6]. So it could be seen as a important supplement in classroom [7].

Based on these advantages of AR in teaching and learning, the adoption are more common nowadays.

This study choose the field of English as second language (also known as ESL) learning in China. AR has some potential in ESL field, though most studies focus on the science or mathematics learning. Based on the main advantage of AR on presenting invisible things into the real world through a virtual way, the topic of the ESL lesson are designed in a view of interdisciplinary integration. The lesson with instructional design was designed to match with the design of AR applications and its features.

II. CURRENT STATES AND RELATED WORKS

AR had been related with ESL (English as second language) learning for a long time. In the early days of this technology's development, it had been taken into English learning. Positive attitudes from the college students indicated that AR might be a useful tool in English learning, especially with mobile computing devices [8]. In Wu, Lee and Chang's view, though many of AR applications in education field focused on science or mathematics because these subject had needs of visualization of abstract concepts, special needs in other field like language learning should be noticed [9]. There were indeed many studies on AR in language learning.

Previous studies also showed that AR had some potential in increasing students' learning motivation, on the subject of language learning. However, some issues should be considered when designing the AR application. For example, learning materials should be related with the learning goal properly [10], which meant that researchers should not only place language

learning content on the AR learning system. They should think the relationship between the technology and learning content or activity carefully.

In pre-school level, AR could also be used in English as a second language learning. Leihoa was the application helping children to remember some basic vocabulary in English. The interactive and explorative character AR played was emphasized. Increased motivation and learning autonomy were found [11]. Visual and auditory stimuli in language learning could bring some positive results, especially in learning of new vocabularies. He, Ren and Zhu's proved that pre-school children using AR technology had greater achievement in a case study. Meanwhile, in the teacher's view, visual sense with auditory sense provided by the AR software mobilized kids' enthusiasm [12].

MOW was designed for primary school students to learn words in different language. This application proposed a paring game with two types of marker cards. This application showed the 3D model of the specific object and its vocabulary and pronunciation in different language like English, Spanish and Portuguese. Significant improvement of learning effect and interest were found [13]. AR could also help in learning phonics to improve students' pronunciation. Improvement on the achievement was found on primary school students. Some key words like "*realistic*", "*enjoy*" and "*a new approach to learn*" in the feedback to the AR application revealed high satisfaction towards AR in language learning [14].

In secondary level, AR's positive effect on students' second language learning had been also demonstrated. Moreover, listening and speaking skills in English had been tested and improves were found. In a context-aware ubiquitous learning environment, AR had been praised by both high school teachers and students [15].

Mobile-based AR is often considered along with the ubiquitous learning and life-long learning. Ho, Heish and Sun used AR features in their u-learning application of English learning, and they investigated the difference between students with different cognitive styles. Individuals with field dependent cognitive style overperformed in this study [16]. In the real life context, AR could help users with specific cognitive style or learning strategy.

Besides the skills in listening, reading and speaking, cultural understanding and communicational skills in language learning were also noticed. Liu, Holden and Zheng took AR-based mobile game into the English as second language learning environment. Video record analysis and face-to-face interview data showed students engage deeply in both virtual and physical world during problem-solving process with AR games [17].

In summary, with the help of AR technology, language learning could be more interesting. The skills in several aspects like listening, speaking and reading had been improved, in different learning context. Different characteristics of the learners should be noticed in the future studies on the subject of language learning and AR.

III. DESIGN

This study is aimed on students in the primary school in China. A 45-minute lesson would be designed and the AR application would be a exploring tool in the lesson.

The main aim of this study is to design and implement a mobile-base AR application, which is integrated deeply with a ESL lesson and its instructional design. The effect of the application and the attitudes towards the application, both from teachers and students, are to be considered.

A. Instructional Design

Nowadays, the "*deep integration of information technology and education*" is a hot topic in China. Many researchers made efforts on the integration of advanced technology and the teaching and learning process in school. At the same time, courses or lessons which are interdisciplinary are popular and encouraged in China. Taking some science knowledge into an ESL lesson, with the help of AR, may have some positive effect on primary students.

So, in this study, the lesson named "The sun and eight planets" with some learning activities with mobile-based AR applications were designed. This is an English lesson for students in the primary school in China. Besides the English contents, more facts about the solar system and planets which are related to science lesson are mentioned in this lesson.

The basic goal or aim of this lesson is to just memorize the words about planets in English (e.g. Mercury, Mars et al.). Based on the basic knowledge of planets, the inquiry-based learning activity is designed for exploring the location of different planets in the solar system and their distances from the sun. This inquiry-based learning activity is the core of this lesson and the reason of using AR technology in this lesson. Besides that, students could learn some facts about the solar system and eight planets. Reading and speaking activities are designed in this lesson to make students to use the words and sentences they learnt in the communication with partners.

In this lesson, every two students would have a tablet, so they could learn with the AR application together. In some activities, students would find that cooperation is needed. But the group setting was not fixed. Students would be asked to join a larger group again based on their favorite planets to read some facts about the planets. This is the group task section in this lesson.

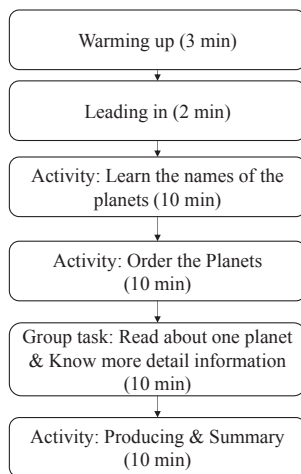


Fig. 1. Structure of this lesson

The basic structure is shown in Fig. 1. In this lesson, the mobile-based AR application is used in the learning activity. The first 5 minutes of the lesson is Warming up and leading in, short introduction and interactive of teacher and students were designed to bring out the topic of this lesson: Solar System. Next the AR could take the Solar System, which is not easily seen in the real life, into the classroom. In this section, the technology made students closer to the learning content. The basic knowledge about the planets including the names of the planets and these words' pronunciation was taught in this part.

Then students were asked to give a correct order of the 8 planets. This part is not only about English but also related to science. Students would work with their desk mate because of the difficulty of this task. One student should arrange the marker cards while his or her partner taking the tablet's camera to capture the cards. When they finished it, they could see the whole Solar System and 8 planets again. They could place the planets in the classroom again through AR.

Students with some basic impressions about the planets may have their own favorite planet. The teacher would ask them to join the group of each planet by their own. Every group would have some reading material and a short video introduction about the planet they choose, and these materials were all in English. Students could get more detail information of their planet. After group learning, a simple presentation was taken so students could have chance to speak and communicate, which is a producing process in this lesson. At the end, a simple task on the application would help students to review the basic facts or descriptions about eight planets. The last part of this lesson was the summary guided by the instructor.

B. Augmented Reality Application Design

In this study, the application containing four main features is designed and implemented. This mobile-based AR application, called Solar Explore, which could run on both iOS and Android devices so it could be used in the classroom through the tablet devices. Aimed on the four sections in the lesson of the Sun and Eight Planets, Solar Explore contains four main features: (1) Say "Hello" to Solar System; (2) Explore the order of planets; (3) Show the Solar System and (4)

Planets and their descriptions. These features are designed and implemented to make the activities in instructional design more vivid and interactive.

This application was developed based on the Unity 3D engine. Vuforia SDK was used to create the AR scenes. Some hard devices are needed for the features in this application such as camera and gyroscope.

1) Say "Hello" to Solar System

This feature is designed to make the solar system and eight planets visible in the environment students in. The gyroscope on the smart phone or tablet is used to detect the location and orientation of student in the classroom. When student take the camera orientation to the pre-setting orientation of the solar system or the planets, the system or planet would appear in the students' view with the real environment, just like Fig. 2. tudents could use the device's camera as their "eyes" to watch the Solar System and planets in a very close distance.

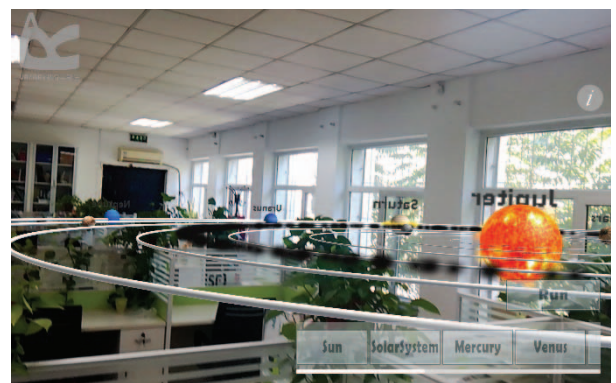


Fig. 2. Using AR application to see planets in the real world

Students could use their own devices to watch the whole solar system and specific planet. All planets' rotation and revolution could be seen in this solar system. When students touch the planet on the screen of the tablet, they could learn the pronunciation recording by a native speaker of this planet in English.

2) Explore the order of planets

This feature is designed to help students to learn the correct order of the eight planets in the solar system, which was an important part in this lesson. This feature is designed as a traditional marker-based AR application. Students in group use the camera to capture the marker of sun and earth. Then the application would guide students to arrange other cards of other planets in the solar system, as shown in Fig. 3.



Fig. 3. The application guide students to arrange the planets

Instant feedback would be given in the process of arrangement. When students completely arrange the eight

planets in the solar system, a complete solar system would be displayed on the screen. At the same time, the marker cards on the students' desktop were on the correct order.

3) Show the Solar System

In this feature, students could learn the order of eight planets and review their pronunciation again. Students could choose both AR and non-AR mode in this feature by their own using the “Camera” button on the device as shown in Fig. 4



Fig. 4. Show the solar system again (in non-AR mode)

4) Planets and their Descriptions

In the last feature of Solar Explore, students were asked to pair the specific planet with the description of the planet. For example, Earth is paired with the description: “The Earth is blue.”. Students should recognize the Earth in the 8 planets and drag Earth to the correct description.

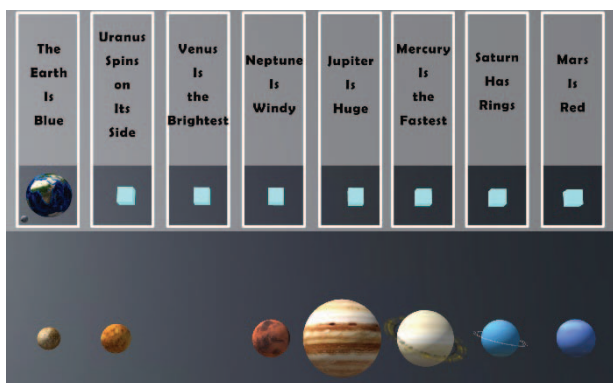


Fig. 5. Planets with their descriptions.

As shown in Fig. 5, if students could pair correctly, the planet would stay below the description. Instant feedback is also given in this feature to guide students to complete their learning activities.

C. Participants and Research Design

This study involved 45 students in the 6th Grade in China. For those students, English is their second language. They began to learn English on 3rd Grade in common. In the primary school level, the teaching and learning of English are mainly aimed their communication ability in English. This study paid attention to not only the learning of English but also the integration of English and science learning, students' ability in communication in second language and cooperating.



Fig. 6. Students with Solar Explore in the classroom.

In the learning activities, students were asked to cooperate with their desk mates and classmates as shown in Fig. 6.

After this lesson, interviews to both the teacher and students were taken to learn their view towards the teaching and learning with AR.

IV. DISCUSSION

When the lesson was finished, face-to-face interviews were taken with the instructor and some students. These feedbacks could help researchers to check the usability and acceptance of this AR application.

A. Interview with the teacher

In the interview with the teacher, questions mainly focus on the role AR playing in the lesson and classroom. The teacher took part in the design and development process of the AR application. The basic features in the application are designed for the activities in the lesson. And this teacher is the instructor of this English language learning lesson.

The first question is “*what is the first impression that AR gives you?*”, the teacher said some keywords: new technology, context-aware, real and interactive. “*This technology could bring students closer to the learning content*”, the teacher said. “*Through its ability on taking real and virtual things together and changing the environments or scenes in the classroom, AR could help students to solve the problem.*”

Though these advantages may be like Virtual Reality in some ways, the teacher thought that “*In second language teaching and learning, AR could make the context more realistic in low cost, comparing to VR*”. Indeed, in the classroom environment, AR has low cost in hardware and software comparing to VR headset. Then, “*AR could bring more interactive among students*”. Indeed, VR headset in the classroom may separate students from their peers. In AR learning activities, students could complete the task in cooperating ways.

As for the effect of AR in classroom, the first keyword the teacher mentioned is “*interest*”, along with the “*real context in communications*” and “*interactive in groups*”. In this topic, the teacher explained her views on these main features. The feature “*Say ‘Hello’ to Solar System*” was for the basic vocabulary and pronunciation learning. The next two features were for the inquiry-based learning in groups. And the last feature “*Planets and their Descriptions*” was for the instant feedback of students' reading comprehension. As described front, AR taking system and planets into the classroom students in, students could get closer to the planets they have never seen in the real life like Mercury, Uranus and so on. The teacher

believed that may help student to memorize and understand these vocabularies instead of memorizing and following the teacher. After the watching of solar system, students were asked to give a correct order of the 8 planets. The teacher considered this process as an inquiry-based group learning activity. Limited guides provided by the application led students to complete the work. After the reading comprehension, students use the application to check and get feedbacks, that could be seen as an assessment process. In the teacher's view, *"In the same lesson, the application turns from watching something to inquiring something, then to checking and feedback"*.

The teacher also mentioned that AR's effect in the classroom mainly focused on the knowledge and skill level. For example, the vocabularies and their pronunciation and meaning could be easily sent to students through this way.

In all the features, the inquiry-based learning was the key point the teacher imposed. *"AR in the lesson can make learning turn into inquiry-based learning and group learning. The AR could, in some extent, help students' personalized learning", "It could meet different needs of different level students. For example, high-level students may help his or her partner in the inquiry-based learning process while low-level students being a receiver. In this group, low-level students could use second language as a new way. That could help them to overcome the fear and be willing to speak out."* The help from each other in the group was highlighted. In the inquiry-based learning activity of giving the correct order of 8 planets, a single student could not complete the task easily so group work was necessary. As shown in Fig. 7, two students would help each other in the learning process. That might bring more gaining to both students in high-level and low-level on English achievements in school.

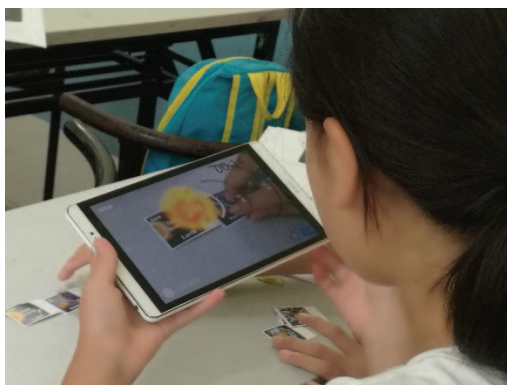


Fig. 7. Students were working together in the inquiry-based activity

The difference between different levels of students in AR-based second language learning had been noticed in previous studies. While both students with high and low prior English proficiency could gain achievement improvement through AR-based learning ways, students with high proficiency benefited more [18]. In the current study, students in high and low level were both considered, from the design process of the AR application to the teaching process in classroom. Individual differences of students were important points in this study. To some extent, AR application in classroom could meet the needs

of different students and make all the students get the most improvement.

In other words, the inquiry-based learning activity with AR application make the language learning lesson more interactive and personalized.

There were also some difficulties to make this type of AR learning application available in all the teaching and learning environment. At first, devices were needed in the classroom. Then, for students who were touching the AR technology for the first time, pre-training was required to make them familiar with the way of using AR application. That brought up a new question: a training version of the application was required. In the primary or secondary schools, teachers could not design and develop an AR application based on their own needs in teaching. So that could be a high-cost process to prepare a new course based on the AR education application.

Moreover, only teachers have basic knowledge of AR could choose appropriate learning content from the textbook to integrate with AR. Both teachers and the developer of the application should *"learn about the outline of this discipline"*.

B. Interview with students

Two different group of students were interviewed.

The main purpose of the interview with students was to learn about their attitudes towards the technology and the lesson with AR. In this interview, the most frequently mentioned word is *"happy"*. In students' words, *"we learn some about the planets and play games today"*.

In the first group of interviewers, when talking about the inquiry-based learning activity of place planets in correct order, students said they had *"communication"* and *"working together"* with their *"partners"* in this process. *"Interactive"* was also been mentioned. *"When two people gets together, they should communicate and work together, using language"*. Those feelings of students were at the same line with interview with the teacher. *"The AR could make things invisible visible"* was also mentioned by students. That was a main advantage of AR.

In another group of students, the way of learning in the classroom was discussed. Students considered group works make the lesson more interesting. They also thought that the ability of self-regulated learning, of collaborative learning and inquiry-based learning were improved with AR.

In sum, students' attitude towards the AR application was mostly positive. Key abilities in language learning were improved based on the analysis of face-to-face interview.

V. CONCLUSION

In this study, an ESL lesson integrated with science was designed. Moreover, a mobile-based AR application helping and guiding students in the learning activities in the classroom was designed and implemented.

The effect of this application was evaluated by the instructor and students of the lesson. In the teacher's view, the advantages of AR could create realistic language context in the

classroom environment. The AR application's design was for different activities in the instructional design, from basic cognition of concepts and vocabularies to inquiry-based activity and ended with students' self-checking and instant feedbacks.

Different individuals in the learning group were considered in the application, so that AR could do some on personalized learning in the large class teaching and learning.

However, there were certain requirements for both teachers and students if they took the AR learning environment into their education process. That may be a challenge for the designers and researchers of AR in teaching and learning.

For students, positive attitudes were demonstrated in this study, which was consistent with the results of some previous studies [8].

Further studies could design more strict experiment study with a larger sample and adopt some quantitative research methods on this topic. Some different individual characters of students, like self-efficacy and cognitive style, could be considered in the research questions. How the AR application helps students in the learning process is worth studying.

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