Developing an AR Tutoring System to Support Maker Education

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Abstract. Maker education has been regarded by scholars as one of the most important topics, which is committed to turning ideas into reality. With the development of maker education, many makerspaces have been established to promote maker education. However, the number of teachers in makerspace is limited, so students can't learn how to use maker tools effectively. Thus, we found that the current challenge in maker education is the "lack of teachers" in makerspace. For this reason, we developed an AR system which can be used in maker education. This system can help teacher to guide students in maker education. In addition, we conducted a series of analyses. Based on the results of the analysis, we boldly assume that the system is helpful to students' learning in maker education. Finally, we have listed the problems and solutions encountered during the development process for future developers' reference.

Keywords: Augmented reality · Maker education · Unity

1 Introduction

Maker has been regarded by scholars as one of the most important topics [7], and itis committed to bringing ideas to life [8]. Maker, also known as "self-maker," is derived from the American garage culture in the 19th century [3]. The garage is a place where self-builders can give full play to their creativity. This visceral, non-profit-orientedculture is regarded as the origin of the third industrial revolution [17]. However, the word maker, it was proposed in 2005 by Dale Dougherty, the founder of Make Magazine in the United States [4]. Dougherty believes that as long as you do it yourself, the person who realizes the idea can be called a maker. In addition, former U.S. President Obama held the Maker Fair at the White House for the first time [15], and set June 18th each year as the National Maker Day [16]. Besides, the United States had more than 400 maker spaces in 2016, including maker spaces in schools, libraries, and universities [6]. Therefore, maker is one of the core concepts in the United States to cultivate talents for future generations, and it also redefines the public's view of learning. More importantly, students can learn creativity in the process of creation, thereby enhancing their 21st century abilities [9].

Due to the importance of maker, many scholars have applied it in education, and makerspace has been established one after another to promote maker education [11].

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Maker education is a teaching strategy based on creation, which emphasizes that studentsshould be immersed in the process of creation [19]. In other words, students should learn through hands-on experience, and connect the knowledge with life, in short, is unite knowledge and action. For example, some elementary school students use Scratch tocontrol Lego devices and use actuators to animate their puppets, and it also allows students to dvelop collaboration and communication skills, thereby enhancing their expressive skills [1]. Then we see another case, some elementary school students conducte an afterschool learning activity called "robot building", and the results show that this activity can improve students' knowledge of programming, thereby improving their problem-solving ability [2]. However, these teaching strategies of case are different from the traditional strategies, so they require a special teaching environment. Therefore makerspace was born, it can provide student with an environment based on creative learning [5].

However, the teacher in makerspace is quite limited, so students can't learn how to use the maker tools effectively [13]. Professor Zhu Zhiting said that the lack of teachers is an important problem in maker education [21]. He also said that in some schools,teachers must use their time after school to work on maker education, which means that they may not be experts in this field [21].In addition, the scholar said that the "lack of teachers" is a problem in maker education [14]. And he also said that schools should hire experts in the field of maker education to design the courses, this is the way to effectively train creative students [14]. Moreover, the scholar's study mentions that there are some problems in maker education, such as: lack of teachers and courses, incomplete teaching system, etc. [10]. Furthermore, USC Rossier and some teachers created the guide for maker education, and in the guide there is mention of an elementary school teacher who said that managing over 30 students at a same time for maker activitie is a difficult task [18].

Based on the above, we find that the current challenge in maker education is the lack of teacher in maker space. For this reason, we designed an AR animator teaching program that can be used for maker education, including AR system and animation machine. Specifically, students must use the system to complete the assembly of the animation machine. In other words, when students encounter problems in maker activities, they can use the system to solve them. Therefore, the problem of "lack of teachers" in maker education has been solved. In addition, we conducted a series of analyses. Based on the results of the analysis, we have made some suggestions for our system. Finally, we have listed the problems and solutions encountered during the development of the system for future developers' reference.

2 Application Development

2.1 Development Enviroment

Figure 1 shows the development environment of AR system, which contains four software. The first one is Unity 2020.3.0f1, which is a game engine developed by Unity Technologies, and it can be used to develop AR system, so we will use it as the development platform of the system. The second is Vuforia 9.8.8, which is an AR software toolkit developed by Qualcomm, it can support Unity, so we will use it as an AR development tool. The third is Illustrator, which is a vector-based drawing software developed by Adobe. It is not only easy to operate but also powerful, so we will use it to designthe

2D interface of the system. The fourth is Blender, which is a free 3D graphics software that can run on different platforms and has rich features, so we will use it to design 3D models and animations in the system.

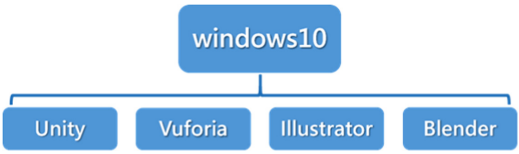


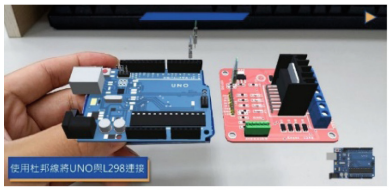
Fig. 1. Development environment

2.2 System Diagram

Figure 2 shows the schematic diagram of the system, which lists the most important five pages. Figure 2 (a) is the animation book page, which explains to the students how to draw the story. Figure 2 (a) shows the text description in the bottom left corner, the required tools in the bottom right corner, and the progress bar of the current work in the top. Figure 2 (b) shows the animator page, which shows students how to assemble the animator. below the AR movie are virtual buttons that students can touch to control theprogress of the movie. Figure 2 (c) is the motor page, which shows the students how

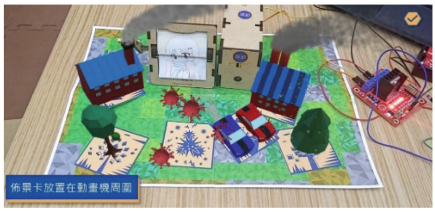
(a) Story

(b) Animachine machine



(c) Motor

(d) Integration



(e) Demonstration

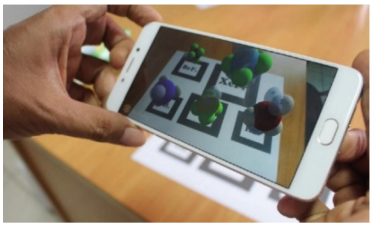
Fig. 2. System diagram.

to assemble the motor. The bottom right corner of Fig. 2 (c) shows the required parts. Students can place the parts in front of the camera of the phone and the system will show the assembly animation. Figure 2 (d) is the integration page, which shows students how to integrate the motor and the animator. Finally, Fig. 2 (e) is the display page where students can interact the animation machine with the system.

3 Discussion and Suggestion

3.1 System Analysis

Figure 3 shows the AR systems of other scholars, and we find two systems to discuss.Fig. 3 (a) is used to learn the geometric concepts of chemical molecules. Specifically,the student has to use the phone to scan the identification card of the molecule, and then the screen will show the model of the molecule, and the student has to view the model to learn the geometry of the chemical molecule. The results showed that the studentfound his system easy to use and would recommend it to other students [12]. In other words, it is very helpful for learning. Figure 3 (b) is used to learn the use of the sewing machine. Specifically, the student has to use the phone to scan the identification card and then an AR video is displayed on the screen and the student has to watch the AR video to learn how to use the sewing machine. The results showed that the AR video improved students' learning efficiency and understanding of complex tasks [20]. In otherwords, it is also useful for learning. In summary, their studies show that the AR system is useful for students' learning, so we boldly assume that our system is useful for students' learning.



(a) AR model

(b) AR Video

Fig. 3. AR learning system

3.2 Development Suggestion

Table 1 shows the problems we encountered in our development. First, the Windows user name and folders are named in English to avoid problems in Unity. Second, at present, the personal version of Unity can only be used if you get a license from Unity Hub, if you don't get a license to start Unity, it will not be able to run. Third, when compiling the apk, the API level should match the Android SDK version, otherwise it will not be compiled. Fourth, in the AR video, the virtual button should be placed in the center of the recognition card, if it is too far from the center, it will not work. Fifth, if you

want to display the expanded objects step by step, you can use SetActive to control the objects under the Target Image, but don't control the objects of Target Image or Vuforia, otherwise there will be problems. Sixth, if you want to develop a new teaching system, you can get familiar with all the functions of AR before you start designing the system.

Table 1. Suggestion list

Problem	Solution
Unity compiler	File naming in English
Unity license	Go to Unity Hub to get the license
Compiling the apk	Versions must match
Virtual button	Virtual button design in the center of the card
AR step-by-step guide	Program control to expand objects
How to design in the future	Familiar with all the functions of AR

4 Conclusion

We developed an AR system, which can solve the problem of "lack of teachers" in maker education. In addition, based on the analysis results, we boldly assume that our system will be helpful for students' learning in maker education. Moreover, we expect that the development proposal will help future developers. Finally, we propose to improve the recognition capability of the system, such as the speed or accuracy of recognition.

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