**Development and Evaluation of Mixed Reality Educational Applications**

# Abstract

As the Chinese ancients saying goes for education: "Travel ten thousand miles is as important as to read ten thousand books. " One who wants to be successful, only study is not enough, study get wisdom and knowledge, travel get experience, experiences can transform into wisdom and knowledge. It may even be more practical and important than the wisdom gained from the book directly. However. The wisdom of the ancients warned us that in education, knowledge and experience are mutually reinforcing and indispensable. However, the reality is that because of the implementation conditions, the education we receive focuses on the reading of books, and the lack of sensory and intuitive stimuli to enable us to experience and understand the knowledge we have learned. Immersive experience is very important in education. However, under the traditional education mode, because of the limitation of time and space, it can’t provide sufficient experience environment for students. Such experience in the actual implementation of teaching is very inconvenient. However, with the rapid development of computer technology, the highly immersive gaming experience that appears in the movie “Ready player one” is likely to become a reality in the near future. In education, the reality of computer simulation can replace the function of “Travel ten thousand miles” and help us to make up for the vacancy. For example, when it comes to geography, with the use of devices the students are brought into the local terrain where there is the terrain is being learning. When explain biology, it is substituted into the local plant and animal life Environment, in the Chemistry class students can start experiments directly, etc. And more importantly, these implementations are not limited by space and time. with the support of devices, learners can experience anywhere and anytime. These technologies have brought a revolution to traditional education and brought untold potential to development.

A new era of education is approaching, allowing students to move from a passive acceptance process to an autonomous learning process. This will be driven by Virtual Reality and Augmented Reality. At present, there are many applications of virtual reality in many fields. This thesis designed and developed four Augmented Reality and Virtual Reality education applications cases, they are respectively: an Augmented Reality Ludo game; a VR Art Exhibition application; an Augmented Reality 3D Coloring game; and a MR (Mixed with Augmented Reality and Virtual Reality) Chemistry Lab, introduced each application design. Finally, through the actual experience of these applications, we analyzed the implementation results respectively in educational effect, user experience and devices, and get some experiences and methods of Augmented Reality and Virtual Reality education application design and development in educational field. This article analyzes the combination of Virtual Reality technology and experimental teaching, expounded the advantages compared to the traditional teaching model, introduces the basic principles of application design and interaction design, it provides a feasible way to improve the immersion of Virtual Reality education and improve the teaching process.

Keywords: Virtual & Augmented Reality; Educational Application; Experiential & Interactive Learning, Game-based Learning

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# **Ⅰ Introduction**

This chapter presents a brief overview of the context under which the research was conducted. Background information regarding this study is provided in order to establish research objectives and scope. Then, the contributions are discussed. Finally, the structure of the dissertation is outlined.

* 1. Concepts

Virtual Reality (VR) and Augmented Reality (AR) techniques were proposed as early as the 1960s. Earlier, they have been classified as the development phase of cutting-edge science. Mixed-Reality (MR) is based on the development of AR and VR proposed by Ronald Azuma, both VR, AR and MR are human interaction with the virtual environment generated by the computer interface, the prospects are very broad.

Virtual Reality

**Virtual Reality** is a simulation technology that emphasizes the hands-on experience and engagement of user simulation. Virtual Reality immerses a user in an imagined or replicated world (like video games, movies, or flight simulation) or simulates presence in the real world (like watching a sporting event live). Example of hardware players in VR are Oculus, Sony PlayStation and Samsung Gear VR [24]. The world of VR has always existed. Comic books, games, and novels are all traditional VR. However, they are limited to the visual and auditory experience, which are two of the five human senses, the new Virtual Reality have far more immersion sense.

The VR systems are divided into three types: VR HMD + PC; VR HMD + Mobile and VR all in one. VR HMD + PC representatives are: Oculus Rift, HTC Vive Fig.1 (a) HTC introduced Vive Pro and Vive wireless adapter. HMD + Mobile is represented by the Samsung Gear VR and Google Cardboard which is released at the Google I / O conference in June 2014, show in Fig.1 (b), in general, the HMD + Mobile is put the phone into the VR box using the phone screen as the VR display device. Although relatively rough experience, but such devices do not require complex electronic components, lower cost, and better mobility and portability. VR all in one machine as shown in Fig.1 (c) need to fully integrated display, computing, storage, power and other functional modules into the headset display device. If you want to achieve good performance, the display device is difficult to be lightweight and compact. 2017 Millet and Oculus jointly launched the VR Miracle VR machine: Mi VR Standalone.

（a）HTC HMD[1] (b) Google Cardbord[2] (c) Dapeng All in one device[3]

Fig.1 3 kinds of mainstream VR devices

The core technologies of VR are tracking and CG (computer graphics). In the latest technology of VR, the Google Tilt brush that won the Cannes International Creative Festival digital process awards can be represented. Tilt brush is Google's VR drawing software, using HTC VIVE HMD and control handles, which can make you in 3D Create paintings in space. Artists use digital technology to create in the three-dimensional world, not just the 2D plane. This will certainly affect the creation of the entire art field. This means that in the future you may be able to enjoy a painting as if you were admiring a building. As shown in Fig.2 (a) you can draw a volcano. It is envisaged that this technology will be used in the field of education. To give a small example, the math teacher in high school will do your best he can to help us understand that the graphic he draws on a flat blackboard as a solid figure, not a flat figure. Draw a solid directly in the three-dimensional world. As shown in Fig. 2 (b), the education process will be more intuitive.

(a) Draw a volcano in VR (b) Teaching math using VR

Fig.2 Google Tilt brush and Math application

Similarly, World Brush is an application that lets you draw 3D shapes and designs in the real world. It's very similar to Google's Tilt Brush. The cool part is that no matter what you draw, it stays there (or until you delete it), and you can smear it with an application brush around it, as a sticker or art painting. Each painting is anonymous and saved at the GPS location created. You can draw something and share it Online, so that other people can see and appreciate your work on the phone. Since World Brush is integrated with the real world and belongs to the definition of AR, we applications using AR below.

Fig.3 World Brush

Augmented Reality

“Augmented” means improved or expanded or enhanced. Example of a general Augmented reality might be the ability to wear headphones that can allow you to hear sounds (higher or lower that the normal auditory spectrum) [7]. Augmented Reality overlays digital imagery onto the real world, Example of Hardware players on AR are Microsoft Hololens, Google Glass [24].

January 2015, Google launched Google Glass, 2016 Nintendo mobile AR game Pokmon Go swept the world, as shown in Fig.4, The user through the mobile phone camera in the real world to collect virtual animation characters. Augmented reality has also begun to open to ordinary users. On the entertainment side, AR camera application - FaceU, users can superimpose a variety of cartoon in their own photos in real time. On the military side, the concept of AR was first applied militarily and was first proposed by Thomas Caudell and David Mizell [27]. Its military application is also an important motivation for augmented reality. With AR technology, pilots can not bow their heads Look at the meter, you can read the HUD head-up display head-up display of the various states of the aircraft, such as heading, speed, fire control radar to provide enemy information. Similarly parking assist systems provide the system with the ability to proactively provide and make available information based on the current state of the vehicle (reverse gear) and relative position with surrounding obstacles without the user providing any additional information or instructions. Fig.2. At this year's CES showroom area, we saw Skully AR smart helmet, Civil Maps vehicle AR platform, and WayRay [25], which offers a solution for a car head-up display (HUD). Google Translate app uses your phone camera to translate textual information into another language and overlay display on the text.



Fig.4 [Pokemon Go Scenes【12】](http://link.zhihu.com/?target=https%3A//media.nngroup.com/media/editor/2016/09/18/pokemon-go-ar.jpg)



Fig.5 The AR navigation system [30]

As another example, IKEA has a new application that helps you to truly see how each piece of IKEA products is placed in your own home or office through augmented reality (AR) technology. The app currently has more than 2000 IKEA product options.

Fig.6 IKEA Place application

In the latest AR applications, the vast majority of measurement applications. Among those applications the Measure Kit is different and more feature-rich. It can provide us with different functions and measurement methods. The application provides a track mode that allows the user to draw and measure trajectories. It can also be used to measure angles, person heights, build cube models, and more.

Fig. 7 AR Measure Kit Application

User experience AR applications, as long as the use of mobile phones (or PC with RGB camera) can be achieved. It is based on Marker identification and tracking it can also be achieved through the SLAM (simultaneous localization and mapping) technology. Marker can be 2D QR Code: The main function of the QR code is to provide a stable and fast identification, in addition to identification, the QR code also serves as a part of function that provides easy tracking and positioning of the plane. For this reason, the 2D code in the AR is simpler than the normal 2D code in order to facilitate accurate positioning. Marker can be a 2D Flat picture: because the 2D code itself is a 2D image, the 2D code method can be used directly on the 2D image. Use 2D pictures, such as banknotes, book posters, photo cards and more. The reason why the QR code is simple is that it is designed to make the visual algorithm can quickly identify and locate. The general 2D image does not have this good nature and needs a more powerful algorithm. Besides, not all 2D images can be used for AR identify or positioning. For example, a solid image without any pattern cannot be visually located. Marker can also be a three-dimensional Object: A natural extension of a 2D image is a three-dimensional object. Some simple rules of Three-dimensional objects, such as cylindrical cans, can also be used as a combination of the actual vector. Slightly more complex three-dimensional objects can often be handled in similar ways or decomposed into simple objects. Finally, the latest Marker focused on three-dimensional environment: AR technology now focuses on the understanding and recognition of three-dimensional space and even interaction. Hololens is a bit more advanced, with the ability to repaint the entire real world with its own sensors and then superimpose digital content. But it also can be aware of the current location of the device in space (depth information).

Among the above-mentioned technologies, the identification and tracking technologies of 2D code and 2D images have basically been mature and have been widely used. The technical development goals are mainly to further improve the stability and broaden the scope of application. In contrast, there is still a lot of room for exploration in the identification of 3D objects and 3D environments.



1. QR code (b) Using Flat picture

Fig.8.QR Code and AR Application using Flat picture

At WWDC 2017, Apple brought AR Kit, a new Augmented Reality component for iOS 11 that works on iPhone and iPad platforms. AR Kit is Apple's augmented reality (AR) technology, delivers immersive, engaging experiences that seamlessly blend virtual objects with the real world. In AR apps, the device's camera presents a live, onscreen view of the physical world. Three-dimensional virtual objects are superimposed over this view, creating the illusion that they actually exist. The user can reorient their device to explore the objects from different angles and, if appropriate for the experience, interact with objects using gestures and movement [26]. The upper part of iPhoneX has a sensor that projects human invisible light to read the user's face 3D structure and instantly manipulate the data through the Apple Nerve engine to create a face model. This feature implements Face ID and cute Animoji show in Fig.9. The AR Kit uses the Visually Inertial Odometer (VIO) to track the surrounding environment with high accuracy and sense its movement within the room. For example, this application called AR ruler helps you to measure the precise size of an object without using any measurement tool. The AR Kit detects horizontal surfaces such as tables and floors, and tracks and places items at specific position. The AR Kit also uses camera sensors to estimate the amount of light available in the scene to apply the correct brightness to the virtual object.

Google also introduced Google Tango before it launched AR core in 2017. AR Core based on the original Tango made many improvements, such as real-time light rendering, the virtual object in reality looks more natural and true.

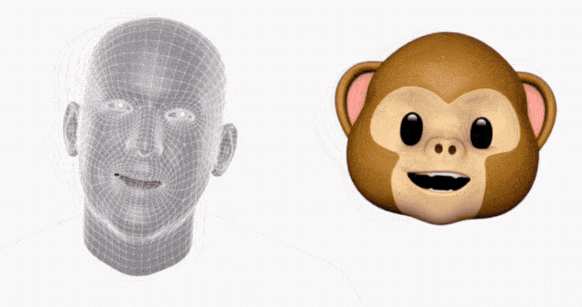


Fig 9. iPhone X to include animoji, emojis animated based on your facial expressions [31]



Fig.10 Apple AR light projection

Mixed Reality

There are two explanations about MR: Mediated Reality and Mixed Reality.

Mediated Reality: Digital reality + virtual digital picture. Mediated Reality is an older tradition, introduced by Stratton before more than 100 years ago, and he presented two important ideas: constructing special eyeglasses to modify how he saw onto the world, ecologically motivated admission to conducting his experiments within the domain of his everyday personal life [8].

Mixed Reality : also known as naked eye reality + virtual screen, on behalf of the 2015 Microsoft released AR Hollerns AR equipment and Magic Leap in 2015, is the virtual environment projected into the real environment.



Fig.11 [HoloLens by Microoft](http://link.zhihu.com/?target=https%3A//media.nngroup.com/media/editor/2016/09/18/hololens.jpg)

Professor Ronald Azuma at the University of North Carolina University summarized the Augmented Reality into three parts: virtual-reality integration, real-time interaction and three-dimensional registration [3]. Paul Milgram and Fumio Kishino proposed the reality-virtual reality continuum, And the virtual environment as the two ends of the continuum, and the middle of them is called the "Mixed Reality" (Fig.12). Which is close to the real environment is to Augmented Reality, close to the virtual environment is to expand the virtual environment.



Fig.12 Simplified representation of a “ virtuality continuum.”



Fig.13 Venn diagram of the focus of the work

The application fields of VR and AR are mainly in the fields of 1, Industrial manufacture and maintenance, displaying various auxiliary information to the user through the head mounted display (HMD), including the panel of the virtual instrument, the internal structure of the device, equipment parts map, etc. 2, Medical areas, using Virtual Reality help doctors diagnose the disease, treating the patients and training medical staff. 3, In the field of television broadcasting, the auxiliary information can be superimposed on the retransmission screen by the AR technology. 4, Entertainment, Games, VR Games, VR videos, movies and so on. 5, In the field of education, use VR for immersive teaching; 6, News report, through AR can make the text, pictures, to three-dimensional, increase reading interactivity and interest. 7, Tourism and exhibition areas. Through VR technology, we can create digital tourist attractions and exhibitions so that users can enjoy the beauty of the world without leaving their homes. The municipal construction plan uses AR technology to superimpose the planning effect on the real scene and obtain the planning results directly.

From the experience of the Last Jedi AR [40], a Google Pixel phone, to the impressive AR games presented at the Apple iPhone 8 conference, a variety of AR mobile applications can give us a highly immersive and realistic Augmented Reality experience. At the same time, Google Cardboard, such a simple VR device, priced at less than 20 dollars, significantly reducing the threshold of user experience Virtual Reality. In February last year, Cardboard completed two milestones: 10 million Cardboard shipments and 160 million app downloads. All of these changes make AR and VR appearing in our lives more and more frequent.

* + 1. Distinguish and apply fields of VR，AR and MR

Virtual Reality, Augmented Reality and Mixed Reality, there are differences between the three technologies to achieve, simply put: VR puts the user into the virtual world, AR puts the virtual world in front of the user. The difference between VR, AR, and MR is illustrated by the image in Fig. 14: VR is to create a completely virtual world that separates you from the real world, Fig. 14 left. The core problem is graphic computing and immersion. AR technology is the put the virtual things superimposed on the top of the reality world, used to enhance and augment the information in the real world, as shown in Figure 14 middle. The core issue is image recognition and tracking. AR is the augmented reality of human perception. Google Maps, for example, is an AR application [4]. MR is generated based on the AR of the virtual information and the real world to maintain the natural adaptation and interaction, the virtual objects and real objects are recalculated, put them together, hard to distinguish each other, as shown in Figure 14 right, the robot was blocked part. The core issue is the 3D scanning of the real world, as well as the perception of distance. MR in this article simply refers to the combination of AR and VR functionality in the application.



Fig. 14 The distinguish of VR, AR and MR [33]

* 1. Objectives and Scope

If we make an overview of the research content of this thesis, systematically introduces the development and application status of Virtual Reality, Augmented Reality, and Mixed Reality technologies. The use of Virtual Reality and Augmented Reality can enrich the existing teaching resources and make the existing educational resources presented in a new form. The static resources became dynamic and multi- dimensional, which is good for the students to understand the learning, stimulate students’ interest in learning, improve the effectiveness of education and teaching. Virtual Reality and Augmented Reality have begun tentative applications in the fields of military, medical, commercial, education, maritime training and have achieved some success. The Objective of this work is to advance the educational effects towards AR and VR educational applications.

* 1. Contribution

This paper presents several cases of Augmented Reality and Virtual Reality applied to education. By applying to education and teaching, evaluate each application by scientific methods and obtain the evaluation of each educational effects. Through the analysis of the results Get the design and development points for such educational applications. This study aims to obtain the best educational effect of Virtual Reality applications in education. Here are four applications introduced.

A Simply Ludo Board game

AR is the integration of digital information with the user's environment in real time [32]. AR is developed based on VR, unlike Virtual Reality, which creates a totally artificial environment, Augmented Reality uses the existing environment and overlays new information on top of it. In this paper, I made a Ludo game that can allow multiplayers to play in a combination of realistic and virtual space. In this game, there are 3 characters with different colors and several buttons to control the characters, each character goes steps according to the random number on the screen.

A VR Art exhibition application

Virtual Reality (VR) is widely used in various fields, and it is expanding game and movie toward health care, business Software, education, and web services. Especially various researches are actively conducted in the field of exhibition, utilizing smart phone based detachable HMD (Head Mounted Display). The VR exhibition solves addresses both temporal and special constraints overcoming the unilateral information transfer exhibitions. This paper presents a method to overcome the limitation of time, space, and unidirectional information transfer in offline exhibition, and also presents a new method that utilizes multimedia visual design artwork as VR contents.

AR 3D Color game

The development from "Virtual Reality" to "Augmented Reality" realizes the combination of the real world and the virtual world. " The magical brush"[41] is no longer a legend. Augmented Reality technology is constantly being applied to all fields of society, changing the way of life and production, and the electronic books designed and developed by using this technology also bring challenges to traditional paper books. Based on the application of Augmented Reality technology and Augmented Reality technology in education, this paper takes "Color the Earth" 3D interactive mobile handset as an example, from the aspects of enhancing the characteristics of application, product design and technology realization A more detailed analysis, and design and development of the "Coloring XiXi" application. In order to provide reference for the development of Augmented Reality mobile applications.

MR Chemistry Lab

This paper is based on a research of the conventional chemistry experiment education limitations, design and developed a "Virtual Chemistry Lab" propose a new method of assisting present teaching aids. Compared with the traditional chemistry experiment teaching, the application can simulate the experimental steps repeatedly and ensure the realism of experimental results because of the high probability of danger and waste of reagents caused by students that unfamiliar with reagent, equipment and experiment steps. Reduce the probability of dangerous occurrence and effectively improve the efficiency of learning. There are two ways to implement the program, one is using Leap Motion as the interaction tool, another is by using Oculus HMD and Controller devices. And through analyzing different interaction methods in the VR system, find a better mode for this application. By evaluation, implementation of this application achieved the education objective more effectively.

* 1. Dissertation structure

There are four cases in this thesis that involved in VR and AR application in education. The study structure is as follow.

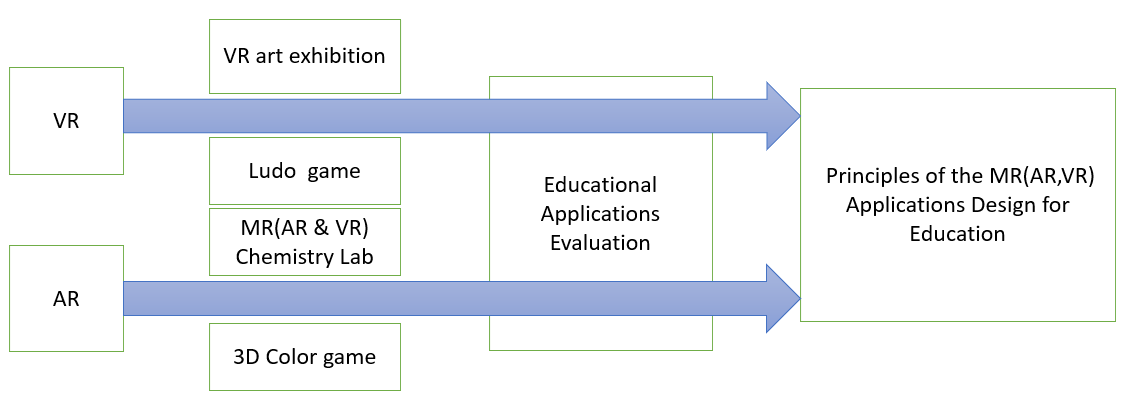


Fig.15 Research papers

# **Ⅱ** VR and AR Background

2.1 Researches

The famous investment bank Goldman Sachs Group in the investor report on the VR and AR market size and population size of the data analysis, including education K-12 stage and higher education stage of the current market size of 50 billion US dollars and 70 billion US dollars, only About 200 million primary and secondary schools in developed countries use VR / AR-assisted education. Goldman Sachs Group also predicted the population size and market size of VR / AR in education field: the number of users will increase to 7 million by 2020 and will reach 15 million by 2025; and the software revenue will reach 300 million by 2020, Rising to 700 million U.S. dollars in 2025 [17].

VR technology indeed has successful application cases in educational, here are some in the K12 classroom (K12 is the North American designation for primary and secondary education. The expression is a shortening of Kindergarten through 12th grade, the first and last grades of free education in the United States and English Canada). In China, more than 14 colleges and universities have their own VR Laboratory, many applications for Early Childhood Education were developed.

VR and AR are both technologies that can be used by college students' smartphones, and higher education has seen AR / VR as the wave of instructional technology. Goldman Sachs predicts that by 2025, about $ 700 million will be spent on AR / VR application development in education, from mechanical operations to building professionals to medical surgery simulations. Market research firm Gartner predicts that by 2021, 60% of higher education institutions in the United States will use virtual reality technology in teaching.

2.2 Educational Applications Typical types and Examples

Although VR / AR technology has not been applied for a long time, it is in accord with educational theory such as behaviorism and constructivism: 1. In behaviorism theory, learning is based on knowledge and the outside world to establish stimulus-response Link [18]. The learning environment created by VR / AR enables learners to be fed back while interacting with the environment and given the next action instructions so that the link between knowledge and response can be adequately built. 2. A large number of construction tools and performance areas provided by the VR / AR virtual learning situation, combined with the subjective initiative of learners, and Piaget's concept and practice of "moving labs to the classroom" and "learning is a Real experience "Constructivism is consistent. Compared with virtual technology, AR can not only simulate the learning object in time, but also put it in a real environment and manipulate the model. Allow students to use a natural means of interaction for independent exploration, cognitive. Its strength is the ability to present information that is difficult to express in a real world and seamlessly integrate that information with the real world so that learning interactions are as natural as interacting in the real world. This is very instructive for teaching abstract content and boosting learner interest.

The New Media Consortium, (NMC), a well-known organization in education, publishes a horizon report every year to introduce technologies that could have a significant impact on education. In the horizon report released in recent years, AR is listed as one of the six most promising technologies in coming years, as shown in Table 1, and the words from "augmented reality" to "augmented reality" Changes can be seen this technology is rapidly maturing. It is noteworthy that this report put VR and AR in parallel in 2016, which shows that the two VR and AR technologies will be used together in education. VR and AR in education in the application of the following types:

**1****. Three-dimensional virtual learning environment**

The current development trend of three-dimensional virtual learning environment: First, the user involved in the creation, that is, entirely by the user to create learning content. The second is to provide space for exploration and learning management system integration. Sloodle (Second Life Object-Oriented Distributed Learning Environment) [28] is a typical case, of course, it is still not perfect enough to three-dimensional virtual environment and learning management system to better heterogeneous two environments also need to have More research workers and practitioners efforts. Third, the virtual and real integration. The reality of the virtual environment depends on the development of graphics, but no matter how it develops, the virtual is virtual after all, and our learning activities are also occurring in the real physical world, "augmented reality" enables learners to carry out There is a better experience when learning activities, and the technology should be more widely used in education. 4. In-depth integration of 3D and AI technologies. Due to the complexity of learning, it is quite difficult for 3D virtual learning environment to be completely human-like, such as automatic answering, automatic paper-making, automatic paper-marking and so on. It needs a breakthrough in AI technology.

**2. AR book**

One of the earliest examples of augmented reality in education was the Magic Book by Bellinghurst [14]. It is based on the book content into 3D scenes and animation, and the use of a special glasses to allow children to see the combination of the actual situation and the background, after which the team has designed and developed a coloring book, the book picture is painted, you can display a painted 3D model with a flatbed [22].

**3. AR Science teaching**

A large number of scholars apply AR to science teaching so as to enhance learners' visual perception of real situations [19]. Clavula et al. [20] demonstrated an example of astronomy teaching in which teachers and students can explore the relationship between the Sun and Earth, day and night by rotating virtual Earth. Cai Su and others [21] combined AR and Kinect somatosensory devices to visualize the magnetic field. When students learn about magnetic fields, they can interact with the device in real time through gestures to understand the distribution and changes in the magnetic field. Researchers at Vienna University of Science and Technology have done specialized mechanical teaching demonstrations [22]. Through physical experiments in the field of simulation physics of AR physics engine, the parameters of mass, force and path of motion are analyzed. However, the use of the system teaching need to configure the more expensive helmets, glasses and other equipment. Magnetic Field Visualization: Visualize the invisible magnetic field using the AR + Kinect somatosensory device and explore the interaction of the magnetic field under different conditions through natural interaction, as shown in the figure, with the magnet moving with the movement of both hands, At the same time constantly changing.



Fig.15 Physical magnetic field visualization

The AR-based convex lens imaging experiment developed by Cai-Su team at Beijing Normal University explored the effect of AR technology on the effect of eighth-grade students' physics learning and deep-seated cognition [23]. The AR-based lenticular imaging aids simulate candles, lenticules, and fluorescent screens by using three different marking cards. When the camera captures a marker card, the 3D model of the lenticular lens with parameters such as the parallel axes used to mark the focal length and twice the focal length data will be displayed on the screen. The candle mark card and the screen mark card are respectively placed on both sides of the convex lens mark card. The screen will automatically present related images based on the distance between the candle and the convex lens. If the distance between the candle and the convex lens is adjusted, the image on the screen will be displayed according to the convex lens Imaging rules change in real time. Suppose the object distance u, like 1u 1 + = v 1f distance v, the focal length f. According to the formula of the convex lens imaging, when u <f, it becomes a virtual image; when u = f, the screen does not appear as an image; when u> f, the screen displays a real image. The experimental results show that AR has a greater impact on students who have lagged behind.

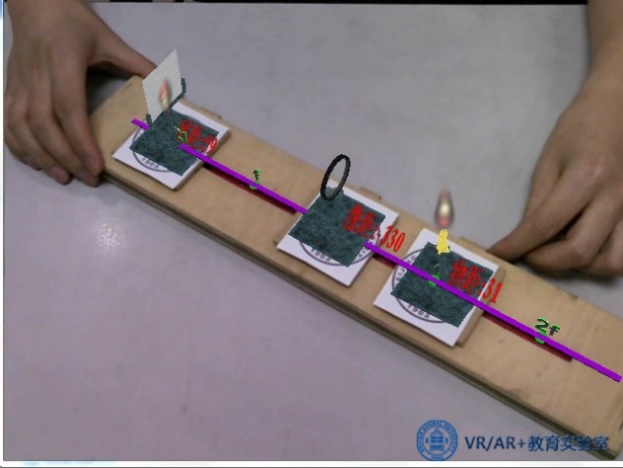


Fig.16 Simulated convex lens imaging



Fig.17 Chemical hydrogen peroxide

Combining PC or tablet teaching, using AR technology and naturally interacting to control conditions such as temperature, concentration, and catalyst, it explores how it affects chemical reactions.

Research shows AR tools can help students remember the structure of atoms better. In traditional classrooms, students' understanding of knowledge and persistence of memory are low only through simple instruction of the teacher. However, teaching based on AR software can mobilize the enthusiasm of students, prompting their attention more focused. After seeing and interacting with the simulation model intuitively, students are also more impressed with what they have learned. AR tools improve students' ability to operate in experimental exploration. Compared with the keyboard, mouse and computer operation, directly through the AR technology to improve activity sense of participation in this way the recognition of procedural knowledge better. At the same time, students also put forward some suggestions on this tool. For example, they hope that the simulation of material can be more realistic. In addition, cartoon or animation elements can be added to make the software more interesting.

The basic idea of virtual reality technology in VR teaching is to make people feel immersive in solving problems. In VR teaching, you can completely break the time and space constraints, the use of virtual reality technology, the boring the data becomes vivid graphics of virtual reality, so that vocational education into a new era of interactive participation.

The application of VR teaching in experimental education and practical education is the trend of educational technology development, and the cost of inputting is not very high. Its advantages are mainly reflected in the following points:

**Reduce funding.** Greatly reduce the investment in education funds to ease the educational institutions lack of funds to reduce the waste of resources and save a variety of experimental raw materials.

**The experiment can be repeated, so as to improve the skill level.** The use of virtual reality technology, you can do a wide range of skills training, and can be repeated. Such as surgical skills, teaching skills, sports skills, car driving skills, fruit tree cultivation skills, electrical maintenance skills and other skills training. Students can take the trouble to practice repeatedly until they master the skills. For example, in a virtual aircraft driving training system, students can repeatedly operate control equipment to learn to take off and land in various weather conditions, and through repeated training, achieve the purpose of mastering driving skills.

**To avoid the real experiment or operation of the various dangers.** In the past, dangerous or harmful to human health experiments, the general use of video recording instead of the experimental method, students can not directly involved in the experiment, access to perceptual knowledge. Using VR virtual reality for virtual experiment, you can avoid this concern. Students in the virtual experimental environment, you can safely do all kinds of experiments, will not appear outside. For example, a virtual chemical experiment can avoid the danger of burning, explosion caused by chemical reactions. Virtual surgery experiments to avoid mistakes due to student operation. Virtual car driving teaching system, students can be exempt from operational errors arising from accidents. The virtual airplane pilot system will not crash the plane.

**4. AR Language teaching**

Use your tablet or phone to scan a card to recognize the word, then render the corresponding picture or 3D model and pronounce it, which is good for children to learn spelling and pronunciation of words. The study shows that this learning combines tactile, auditory and visual features, which can stimulate children's enthusiasm more easily than traditional teaching methods and has significant effect on learning words of non-native English learners. Using a cell phone to scan words, render matching pictures and pronunciation is also consistent with children's cognitive rules, but the phone may distract children's attention. This type of teaching may be more suitable for one-on-one situations.



Fig.18 Happy to learn English interface

Chocolate company developed the VRCLASS chocolate interaction Starting from 2014 to develop a virtual reality immersive learning system, users can exposure to various scenes personally feel the charm of the future learning styles, and interact with remote teachers interact; teachers can give full play to the virtual The infinite possibilities of space, easy to achieve the traditional classroom teaching methods can not be achieved.

A class of 50 minutes, the first 30 minutes of traditional teaching, the teacher will recognize students spelling words, such as giraffes, tigers, lions, the last 20 minutes will allow students to use the VR head into the virtual world interaction, which can be consolidated. The effect of learning. Parents also generally believe that this teaching is very effective.

Fig.19 Cool fun ABC immersive children English learning [29]

**5. Location Based AR Learning**

During use, the user can find the campus related buildings according to the real scene captured in the camera, as shown in FIG. 11. Upon reaching the target building, the camera automatically recognizes the building information by capturing the image and presents it as a learning content to the user. The vast majority of subjects mentioned the use of mobile phones to obtain information anytime, anywhere, and the combination of positioning technology and augmented reality technologies made the search process and presentation more natural, eliminating the need for manual entry and seeing The vast majority of subjects mentioned the current waste of resources when using paper maps, and that the software is an alternative to paper media, one of the better means; most of the subjects are mentioned using mobile phones The way in which the camera interacts with the real physical environment is very new and interesting, has not been exposed before, and the quick, instant presentation of information has made campus culture readily available. Users also made a lot of constructive comments on the software. Some opinions are limited to the current hardware technology capability. For example, the slow speed of campus wireless network results in too slow loading information, the time required for GPS positioning of the mobile phone is too long and sometimes it is not located Accurate and so on.

**6. Other applications**

Chin AR: Facilitating Chinese Guqin Learning through Interactive Projected Augmentation,Yingxue Zhang, Siqi Liu, Lu Tao, Chun Yu, Yuanchun Shi, Ying-Qing Xu, CCHI2015. Lower the threshold of Guqin learning, is conducive to the most ancient Chinese instrument to flourish. Guqin is good, but I learned from my classmates teaching Guqin at school that most people chose to give up after learning Guqin for a month. Different from other musical instruments, Guqin has its own set of music system. The entry requires learning and adaptation of many new concepts and methods. In this respect, the threshold of entry is higher than that of other instruments. This essay, by enhancing learning techniques, gives beginners a lot of "hints," greatly reducing the threshold for entry learning, and combining Chinese and foreign related musical theories to design a complete set of interactive methods.



Fig.20 Chinese Guqin Learning Application

2.3 Interaction Design

2.3.1 The develop of Human-centered Interaction Design

Human-computer interaction refers to the exchange of information between a person and a computer, including a computer providing information to people through an output or display device, and a person entering information into the computer through an input device. The purpose of human-computer interaction is to discuss how to make the computer designed to help people to be more safe and reliable, more efficient to complete the task to be completed. Mainly experienced in three stages.

**Multi-language User Interface****.** Inefficiency. Human-computer interaction began with the emergence of the world's first computer ENIAC, the operating system is the way to complete the order is, then bring more people to the computer's mystique, language barriers give a strong professional sense. Need to master a computer language proficiency, otherwise the interaction process is inefficient.

**Image User Interface****.** Operational, graphical user interface is the mainstream of the current user interface, represented by the United States Microsoft, which fundamentally changed the situation in the past to remember a large number of language forms. A common feature of current GUIs is that they convey and display information through windows. In addition, they are operated by using keyboards and mice. Because image-based user interfaces rely heavily on visual Recognition and manual control, so this interface is easy to operate.

**Multimedia User Interface****.** Multimedia technology is a transitional technology before the emergence of naturalized interactive design technology. Before the advent of the multimedia user interface, the user interface design had completed the transition from language to graphics. However, with the development of multimedia technology, the introduction of animations, audio and video media into this technology, especially the introduction of audio media, has greatly enriched the computer's expression of information to better serve people Control and communication of information to create a very good condition, greatly improving the efficiency of human-computer interaction. The main advantage of the multimedia user interface in human-computer interaction is that it can improve people's recognition of information and its choice, as well as the ability to control the information. In addition, the interaction between the computer's representation of information and human recognition Great improvement.

2.3.2 Interaction Design for VR and AR

Since 2014, the advent of virtual reality entertainment devices such as Oculus, Gear VR and HTC Vive has enabled VR technology to serve ordinary consumers, thus detonating a world-class VR industry revolution. People enter a new era of human-computer interaction: the computer constructs a real-world three-dimensional world for the user to use the sensory interaction directly through the sensory simulation technologies such as vision, hearing and touch. The user is no longer an isolated individual but a virtual Part of the environment, people and machines to establish a natural link between. This natural interactive nature of the failure of the two-dimensional screen-based design rules, designers must find a reasonable interaction design method to eliminate the gap between human and computer virtual environment, to create a more natural VR experience. [10]

VR interacts in various ways, but in terms of current interactions, it is neither eye-tracking nor gesture-based tracking. Instead, in the form of a handle, tactile feedback acts as the main method of interaction. The interaction of virtual reality is divided into input part, output part and virtual environment information. The virtual reality system accepts information from the user through the input part. The basic signal of the user includes the position and direction of the user's head and hands. Common input devices have data. Gloves, space seeking, three-dimensional floating mouse, biosensor, head tracker and voice input device. At present, VR has the following interaction modes:

**Motion capture.** Full-body capture is not necessary in many situations. Another problem is that there is no feedback. It is difficult for users to feel that their operations are effective. This is a major pain point for interaction design.

**Tactile feedback.** Here is the main button and vibration feedback, which is a large class of virtual reality handles that will be mentioned below. At present, the three major VR head-display manufacturers Oculus, Sony, HTC Valve all use virtual reality handles as standard interactive modes: two-hand discrete, 6-DOF space tracking (3 rotational degrees of freedom, 3 translation degrees of freedom) , handle with button and vibration feedback. Such devices are obviously used for some highly specialized game applications (as well as light consumer applications), which can also be considered as a business strategy, because the early consumer of VR headsets should be basically a game player. However, the advantage of such a highly specialized/simplified interactive device is obviously that it can be used very freely in applications such as games, but it cannot adapt to a wider range of application scenarios.

**Eye tracking.** When it comes to the most important technology in the VR field, eye tracking technology is definitely worth paying close attention to practitioners. The founder of Oculus, Palmer Rudge, once called it “the heart of VR” because it detects the position of the human eye and provides the best 3D effect for the current viewing angle, making the VR head appear as an image. More natural, less delay, which can greatly increase the playability. At the same time, because the eye tracking technology can know the actual fixation point of the human eye, the depth of field of the viewpoint position on the virtual object can be obtained. Therefore, eye tracking technology is considered by most VR practitioners to be an important technological breakthrough in solving the problem of virtual reality helmet vertigo. However, despite the fact that many companies are researching eye tracking technology, there is still no satisfactory solution.

**Gesture tracking.** The use of gesture tracking as an interaction can be divided into two ways: The first is the use of optical tracking, such as depth sensors such as Leap Motion and Nimble VR, and the second is the use of data gloves on the sensor. The advantage of optical tracking is that it has a low threshold for use and the scene is flexible. The user does not need to put off the device on his/her hand. In the future, integrating the optical hand tracking directly on the integrated mobile VR head tracking as the interactive mode of the moving scene is very feasible. thing. But its disadvantage is that the field of view is limited, as well as the two basic problems we mentioned before: The interactions that require the user to make mental and physical efforts are unsuccessful. Using gesture tracking can be tiring and not intuitive, and there is no feedback. This requires good interaction design to make up for.

**Data gloves.** An inertial sensor is generally integrated on the glove to track the movement of the user's finger or even the entire arm. Its advantage is that there is no field of view limitation, and it is entirely possible to integrate feedback mechanisms (such as vibration, buttons, and touch) on the device. Its drawback lies in the high usage threshold: the user needs to wear off the device, and its use scenario as a peripheral is still limited: it is like saying that it is unlikely to use the mouse in many moving scenes. However, these problems have no absolute technical threshold, and it is entirely conceivable that highly integrated and simplified data gloves like the ring will appear in the VR industry in the future, and users can carry it with them at all times. These two methods have advantages and disadvantages. It can be imagined that in the future, these two kinds of gesture tracking will coexist for a long time, and users will use different tracking methods in different scenarios (and different preferences).

**Direction tracking.** In addition to direction tracking, aiming points can also be used to control the user's direction of advancement in VR. However, if you use direction tracking to adjust the direction, you may not be able to transfer because the user does not always sit on a swivel chair that can rotate 360 degrees, and may be limited in many cases. For example, if you turn your head 90 degrees and then turn your body, it's hard to turn 180 degrees together... So here's “Space Constraints Can't Turn Around Is a Demand,” so the interaction designer gave a solution—pressing the mouse Right-clicking can return the direction to the original frontal direction or the direction to reset the current gaze (that is, the direction you originally faced), or you can use the joystick to adjust the direction, or press the button to return to the initial position. However, the problem still exists, with the direction of the user facing the direction of walking compared to the keyboard and mouse and the gamepad, the matching of steering and vision greatly enhances the sense of immersion, but it may be very tired and the comfort is weakened.

**Voice interaction.** Voice interactions drown users with VR's massive amount of information. He does not care about the visual center's instructions, but looks around and discovers. If you give some graphic instructions at this time will interfere with their immersive experience in VR, so the best way is to use the voice, and they are watching the surrounding world without disturbing each other. At this time, if the user interacts with the VR world by voice, it will be more natural, and it is everywhere and at all times. Users do not need to move their heads and look for them, and they can communicate with them anywhere in any direction.

**Sensor.** Sensors can help people interact naturally with multidimensional VR information environments. For example, people enter the virtual world not only want to sit there, they also want to be able to walk around in the virtual world, such as universal treadmill, Virtuix, Cyberith and domestic KAT are developing this product. However, experienced people have reacted that such a treadmill is not actually able to provide a feeling close to real movement, and the current experience is not good. Another idea is to use the inertial sensor on the foot instead of going forward, such as Stompz VR. Also, for example, the full-body VR suit Teslasuit, wearing this equipment, you can feel the changes in the virtual reality environment, such as blowing the breeze can feel the breeze, and even feel the shot in the shooting game feel. These are generated by various sensors on the device, such as smart inductive rings, temperature sensors, light sensors, pressure sensors, visual sensors, etc., which can make the skin produce a corresponding feeling through pulsed current, or touch and sense of smell in the game. Various kinds of perceptions are transmitted to the brain. However, there are currently not many high-end devices that use sensors, and there are still many technical breakthroughs that need to be made.

**Virtual Reality Theme Park.** The virtual reality theme park The Void uses this approach. It is a mixed-reality experience that builds the virtual world on top of the physical world, allowing users to feel the surrounding objects and use real-world props, such as portable lights, swords, guns, etc., Chinese media called it "the strongest surface recreation facility."

2.3.3 User Interface Design for VR and AR

Augmented reality achieves enhanced results by providing timely feedback on real-world dynamic changes. This is different from virtual reality. Virtual reality isolates the user from the real world, presenting the user with a virtual environment consisting mostly of elements created by. However, virtual reality and augmented reality are both real-time and provide timely feedback on the user's behavior and interaction in the environment. The user interface is a connected window.

Now the Unity development environment mostly uses the original screen interaction, which is divided into interface interaction and model interaction. The model interaction is more of a kind of gesture interaction, which is the screen-aware gesture that we can use now and then make feedback interaction. the way. And the feedback effect Unity can achieve is far less than the designer wants to do, including model effect feedback and interface feedback. It is too early to discuss the future of virtual interaction because the way of interaction not only changes with the improvement and development of technology, but also changes with the changes brought about by the development of technology. Now people are more accustomed to the interaction on the screen, so even if there are new technological drivers, it's a process that people accept. Now that AR technology has developed to such a level, Ali’s AR red envelopes and AR scans are “blessings”. They are all relatively elementary ARs. He is slowly promoting people’s perceptions and living habits. At the same time, it is also a look at people's reactions and attitudes towards this, so talking about future AR/VR interactions is nothing more than a vacuum.

The flat interface design can be used along the AR/VR interface. The AR technology can superimpose virtual objects onto the real world, fuse and interact with each other. However, in order to use a complex real environment as the “background canvas”, the design of the GUI must focus on how to better present information and facilitate browsing and interaction. Then the advantages of Flat Design are reflected: 1. Better presentation of content and data, avoiding too many visual elements to interfere with information identification; 2. Applicable to the effects of transparency, allowing users to observe the external environment. Take the Google tilt brush example. This is the Color picker provided in the software, which is similar to what we usually use in desktop software (flat style), instead of giving you a box of "pigment" to color slowly.



Fig.22 Flat Design User interface in Google tilt brush

2.4 Summary

Using AR and VR for education has enriched educational resources and improved the way of education. To a certain extent, it can supplement the existing shortcomings of traditional education. However, each application must find a suitable binding point, according to the needs of reagents, custom design programs in order to achieve the best educational results.

First of all, VR + Education, in terms of product content, the hardware configuration and subject education is low, and the development of VR education curriculum lacks the participation of subject education experts and teachers. Compared with pure virtual reality environments such as Oculus and HTC Vive, the augmented reality environment does not need to wear a heavy helmet and does not need to place a dedicated locator to capture user space locations and a specific activity range space. It only requires a computer to work with a normal camera, or just a tablet or mobile phone (it comes with its own camera), and it can achieve the integration and interaction of the real environment and virtual objects. Therefore, this kind of learning technology with less demanding hardware conditions is easier to land at school and has more audience users. More importantly, the augmented reality environment has meaningfully linked virtual learning content with the real world. Therefore, AR technology as a branch of VR technology, one of the current research hotspots, can create a scientific inquiry environment for students [14]. The famous publication “The Economist” wrote an article in early 2017 predicting that AR is more promising than VR [15].

 Secondly, AR + Education is still in the initial stage of simple presentation and immature interaction. There are still many parts that need to be developed for the study of AR empirical research topics. It is worth mentioning that the team of the Institute of Modern Education of Beijing Normal University has conducted long-term empirical research on key technical problems such as 3D modeling and virtual behavior interaction in augmented reality education applications, and has achieved breakthrough results.

Through its empirical research, it can be seen that most students show a positive attitude towards VR/AR teaching tools or environment, which is also consistent with the results of Núñez et al. [23]. Therefore, in the future education, we should dig deep into the laws of education, use the VR/AR learning environment, and build a new teaching model supported by the technology platform to explore how the VR/AR learning environment supports learning and teaching so as to improve students’ classroom teaching. The effect of learning returns to the essence of education by reshaping the learning style and provides support for cultivating innovative talents and education.

# Ⅲ. **A Ludo Game**

Ludo game is a common toddler game, which is of great significance to the physical and mental development of young children. It consists of three parts: chessboard, chess pieces, and dice. Ludo games are designed from the perspective of the main purpose of the following aspects: involving logical ability training, strengthen attention and observation, but social development, including awareness of rules, competition and cooperation, and the relationship between winning and losing. The third is mathematical logic training.

3.1 Implementation Method

Through the previous introduction, we learned that there are many ways to achieve AR technology, one of which is the three-dimensional registration technology, three-dimensional registration technology is to obtain the precise coordinates of an object in three-dimensional space, and then according to the coordinate information obtained will be placed in the corresponding virtual information In the three-dimensional scene, the virtual reality is used to enhance the real scene. Three-dimensional registration is a key technology in augmented reality. The accuracy of the registration is related to whether it can achieve an effective enhancement of the real scene, but also to judge whether the augmented reality technology can The most widely used and most intuitive standard, the integration of virtual information is the final link of an augmented reality system, and is the ultimate result of augmented reality. At present, three-dimensional registration can be divided into registration-based registration technology and registration technology based on natural features. The two AR applications studied in this paper are based on identification, and registration technologies based on natural feature points can be roughly divided into two categories: hardware-based Three-dimensional registration technology and vision-based three-dimensional registration technology, hardware-based three-dimensional registration technology requires higher hardware facilities, resulting in expensive registration, and based on that three-dimensional registration technology is less call charges, and registration accuracy is acceptable, such as:

**Through the identification map.** The way to display the model by recognizing the map can be done by uploading the image to the Vuforia website. The resource package can be downloaded and imported into the unit. In the AR development process, many people will feel that uploading the identification map to the official website database and then downloading it from the database is inevitably complicated. The second way is to create a recognition map in real time when used, that is, a custom target recognition map. After opening the camera to start scanning, using a fixed scene as a recognition map, the method to achieve this step is to use the camera to take a picture. At this time, an instruction to trigger the photographing is needed and a button is used to implement the photographing. When we scan to the identification map that we want to customize, press the button, and then the identification map is created, scan the identification map, and the model appears. In addition, custom identification maps do not support virtual keys. Since flying chess requires a standard board, this method does not guarantee the standardization of the scanned board. Since this game requires a checkerboard with a standard aspect ratio, this application uses the method of uploading to the Vuforia database and then downloading the resource pack to identify custom images.

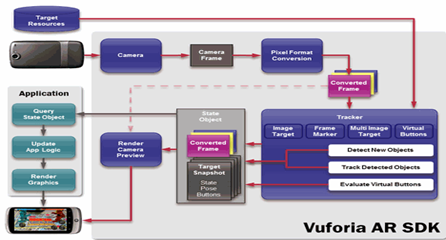


Fig. Data flow diagram of Vuforia SDK [ ]

The data stream of Vuforia SDK is divided into four modules: inputting, database, tracking and matching and render output [32].

**Through the use of AR SDKs to identify planes.** Current mainstream development tools include Google’s Project Tango and AR Core, launched in December 2017, and Apple’s AR kit. Tango's hardware requirements are too high, and ARCore does not use software to achieve AR effects. Tango's AR effects are mainly achieved through special hardware such as depth cameras and sensors. Because of this, to run Tango, the received hardware must reach a certain level of technology. . So far, only ASUS, Lenovo and the two companies have withdrawn enough to support Tango mobile phones. So, ARCore came into being, he does not need dedicated hardware, does not require expensive mobile platforms, just to rescue Google from the hardware's plight, compared to Tango's two models are very poor, was born in Andrews this huge ARCore in the hardware world can say no hardware at all. At present, Google AR Core only supports Google Pixel and Samsung Galaxy S8 devices. Google said that they are actively working with Samsung, Asus, LG, Huawei and other vendors. It is expected that in November 2018, there will be more than 100 million. Users can access ARCore's applications. On the developer side, ARCore supports most of the development platforms, including Unreal, Unity, Vofuria, Java, OpenGL, and even Web.

3.2 Game design

Remember the flying chess that I played when I was young? Now we have moved it to the phone. Based on AR augmented reality technology, "AR Flying Chess" bid farewell to the old messy parts, just a recognition map, pick up the mobile phone swept, you can integrate the virtual chess board into the real world, let you experience through the mobile phone based on Real-world virtual interaction.

The characteristics of the AR flight chess: AR combined with virtual reality technology allows you to be anywhere. The following figure shows the chess board for flying chess.

AR is the integration of digital information with the user's environment in real time [32]. AR is developed based on VR, however, unlike virtual reality, which creates a totally artificial environment, augmented reality uses the existing environment and overlays new information on top of it. In this project, we made a board game that can allow multiplayers to play in a combination of realistic and virtual space. In this Board Game, there are 3 characters with different colors and several buttons to control the characters.

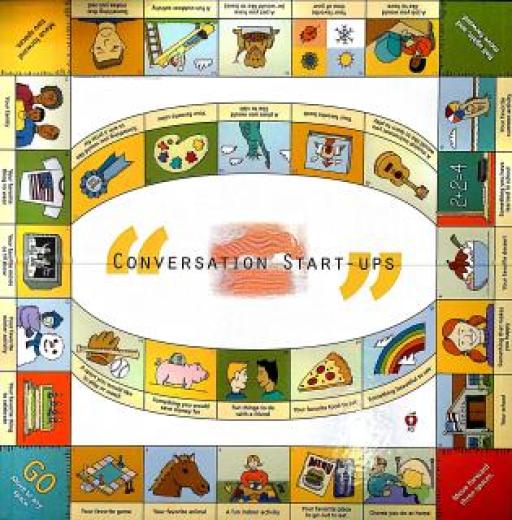


Fig.23 The board of the game（Identification pic）

In this project, we made a board game that can allow multiplayers to play in a combination of realistic and virtual space. In this Board Game, there are 3 characters with different colors and several buttons to control the characters.

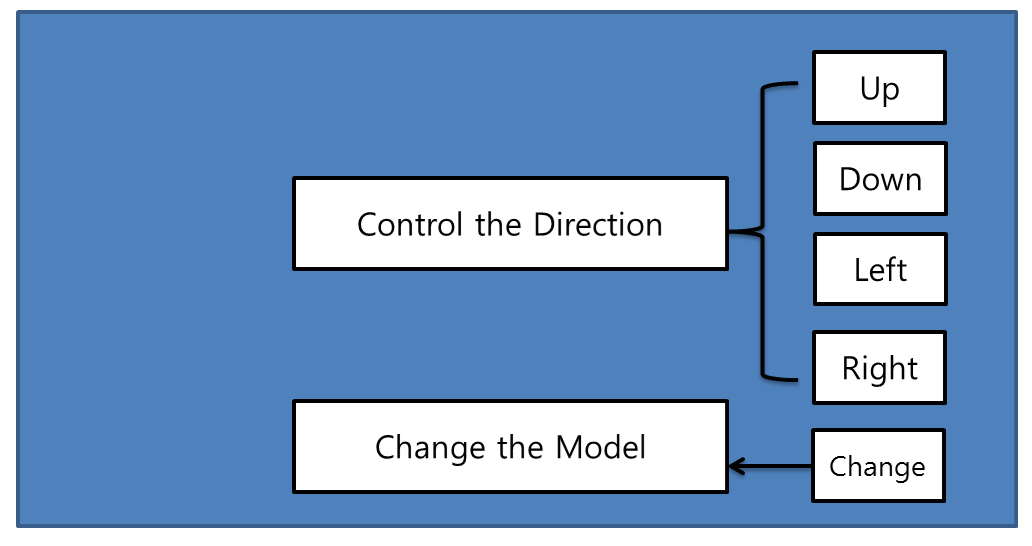
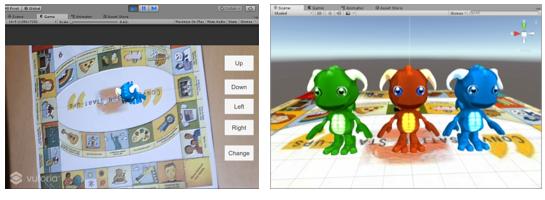


Fig.21 the board game Flowchart

A player has played on a specially designed board. The games have been played in most societies and cultures throughout history [4]. Especially the games that are based on strategy placed on a pre-marked surface according to a set of rules [4]. Molla et al. have been studies how to transform actual game into game of Augmented Reality by using a simple webcam [5]. For mobile AR games are several interaction studies like the potential of interaction based on finger movement via camera [6]. The Sphero [7] focuses on both tangible interfaces and physical around players and increases enjoy ability and immersion. Vancouver Maneuver [8] has created a cooperative board game experience by using Augmented Reality for mobile devices. The game provides both digital and analogue board game design like hybrid game design approach.



(a) Beginning the game (Game Scene) (b) Game Models

Fig.25 Result of designed Game

3.3 Project Implementation

The Experimental environment for this development is Intel(R) Xeon(R)CPU E3-1240 v3 @3.40GHz 3.40GHz, RAM 8GB with window 10 and using software include version 5.5.2f1 personal (64bit) of Unity3D and Vuforia unity-6-2-10 unity package for AR. We have implied the game in a mobile device such as an android. Fig. 2 shows the result of designed game.

(Qualcomm) is an AR company that provides the Unity plug-in to develop AR products. Use the upload identification map to the Qualcomm Vuforia repository.

1. New project and import Vuforia plugin into Unity

2. Upload the picture to the official website, download the corresponding picture data package, Qualcomm (Qualcomm Vuforia) will identify the degree of recognition for the recognition map (star), identify the figure in the project at least Samsung.

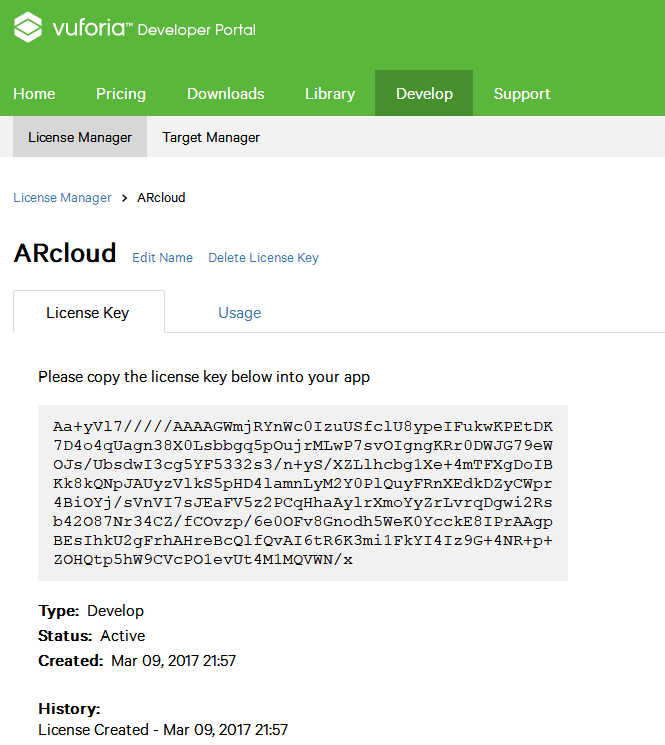
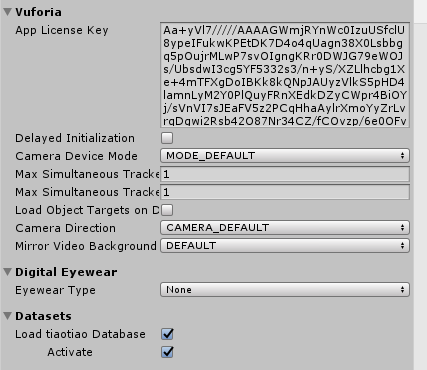


Fig.26

3. Delete the MainCamera in the original scene and drag it into the ARCamera in the vuforia prefab, ImageTarget

4. Import three models into hierarchical view Hierachy

5. Click OpenVuforiaConfiguration under VuforiaBehaviour under ARCamera and enter LicenseKey.

1. (b)

Fig.27 add key

Then set the ImageTarget type to Predefined (UserDefined if it is user-defined).

6. Write the script. In the default script named Default Trackable Event Handler.cs on the ImageTarget, you can use state + control to complete the switch after recognition. If you want to identify multiple images, you can create multiple ImageTargets.

TrackableBehaviour.Status.DETECTED//检测到TrackableBehaviour.Status.EXTENDED\_TRACKED//延伸跟踪

TrackableBehaviour.Status.NOT\_FOUND//未找到

TrackableBehaviour.Status.TRACKED//跟踪中

You also need to have a script that controls the character name Move.cs, hang it under player, and then drag the three model prefabs to the script variable.

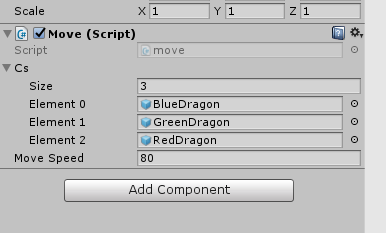


Fig.29

for (int i = 0; i < 3; i++)

{

Cs[i].SetActive(false);

}

modelId\_ = ran.Next(0, 3);

C\_now = Cs[modelId\_];

C\_now.SetActive(true);

C\_now.transform.parent = this.transform;

Set up the UI

There are buttons and reality in the UI section of this game. There are 5 buttons in this game screen to adjust the direction, and a text display box is used to display the number of steps.

Fig.30 game scenes

3.4 Conclusion

AR technology was released in 2018 from Apple's ARKit and Google Android's ARCore. Millions of smartphone users can only perform software updates to enhance their performance. So the AR application, through the camera lens, allows virtual objects to be displayed in superposition in the real world. Snapchat and Facebook have enhanced their application's camera capabilities to augment things in the real world. In 2018, there will surely be a large number of AR applications in the market that will be accepted by the general public. At this year's CES, AR technology demonstrated the potential of holographic displays to enter people's daily lives in large and small ways.

# **Ⅳ**. **VR Art Exhibition**

The virtual art display application can allow users to appreciate and analyze art works at any time without leaving home, which breaks the time and space constraints.

4.1 Implementation Method

Virtual Reality (VR) is widely used in various fields, and it is expanding game movie towards health care, business software, education and web service. Especially various researches are being conducted in the field of exhibition, and methods for implementing Attachable-removable HMD (Head Mounted Display) VR contents using a smart phone are being presented. The VR technology in the field of exhibition solves both the time, space constraints and the unilateral information transfer to the exhibitions displayed in the offline exhibition. The advantage has that this can overcome the quantity, time and the geographical constraints that should be met by direct visits. This paper presents a method to overcome the limitation of time, space, unidirectional information in offline exhibition, and also presents a new method that utilize multimedia visual design works as VR contents.

In the Mobile +VR device, the Samsung Gear VR is indeed much more closed, but you must have one of the newer phone models such as the Galaxy S6, Galaxy S6 edge, Galaxy Note4, Galaxy Note5, and Galaxy S6 edge+. Google Cardboard is a good choice as a VR entry-level experience, mainly because the cost is relatively low and most people buy it. And Android and Apple's most mobile phones can be used. In the Google Cardboard introduction page, there is such a sentence "Experience virtual reality in a simple, fun, and affordable way" summed up Google Cardboard has the following advantages compared to other mobile VR products: 1, cheap, 2, easy to carry, 3, while supporting all Android screens and IOS phones with appropriate screen size. Therefore, this game selects Google Cardboard as a game device.



Fig.32 According to the guideline, users can personally do Cardboard

4.2 Game Design

This application is a multimedia mobile visual VR application using Google Cardboard's multimedia visual design. Users can experience the virtual art exhibition from the first viewing angle after being worn by the user. Because Google Cardboard and mobile phones support simple interaction, we have used the line of sight here. Control the way to move. After the application starts, the user's line of sight follows the character and moves toward the user's direction. When the user enters the painting or the obstacle in front of a certain distance, the user can stop the painting. When the line of sight changes, the user continues to move.

4.2.1 Composition of contents

Fig.32 Work of Arts

4.2.2 Immersion for VR exhibition

Basic HMD devices all have basic experience and immersion, but the factors that hinder immersion are defined in [33] as follows: The smaller the screen size is, the smaller the stereoscopic effect is, and the movement is not able to react well. The lower the resolution of the picture, the lower the immersiveness. From the aspect of experience, HMD is also one of the factors that hinder the immersion. The result of the user's free movement and the reality are different. Therefore, the immersiveness is raised in the following table. The solution:

Table 1: Influencing Factors of Sense of Experience and Immersion in Virtual Reality Display

|  |  |
| --- | --- |
| Distinguish | factors of experience and immersion |
| Display Performance | Shading ratio, color reproduction rate, color temperature, grayscale |
| Image Resolution | The difference between the entity comics and the digitized image. |
| Image Size | The difference in the picture size of the HMD system was used. |
| Displaying the layout of the work | When a three-dimensional virtual reality environment is composed, effects such as “shadow” with lighting as background |

4.2.3 Interaction Design and Operating Mode

In terms of user interaction, in order to use Google Cardboard as a tool to watch multimedia exhibits, the interaction mode is particularly important, especially if you want to approach the actual exhibition, the interaction mode must follow the natural interaction as much as possible, through analysis of the hardware conditions of Google Cardboard, Using the way of the user's line of sight to interact, the user in the virtual world automatically advances toward the line of sight defense at the first viewing angle, and stops when entering a certain range near the obstacle. At this time, the user may stop to view the painting or pass through. Change the direction of the line of sight to change the direction of movement.

4.3 Project Implementation

This application uses Unity 3D 5.1 as a development tool. Unity has built-in support for virtual reality from 5.1. Download CardboardSdkForUnity. Packadge and import it into Unity project. In game level hierarchy panel, use Cardboard Main Prefab instead of standard camera in project setting. Check the Virtual Reality Supported option and the game can be switched to VR mode preview.

The following is the main code for the user to move and determine the obstacle part:

float walk\_speed = 2;

void Update() {

Ray ray= new Ray(); // Create ray

RaycastHit hit; // Collision

if(Raycast) //Collision check

{ Transform.translate(forward, walk\_speed); // forwarding

float distance = vector3(position.hit, position); // calculate distance

if(distance < 3) { // check distance to wall walk\_speed = 0;}

else { walk\_speed =1;

}

}

}

The application development environment is Windows 10 64bit, Unity3D 5.1, and the development language is C#. The hardware devices used include Google Cardboard and Samsung S4 smart phones. The following figure shows the program execution screen and various visual design contents in a virtual environment. The viewing effect and experience are not inferior to those in the real world exhibition hall.

（a） (b)

Fig.33 Game Scnens

4.4 Conclusion

Nowadays, smart phones have become popular and become our daily necessities. Through smart phones, various applications can be easily used. Using Google Cardboard also allows users to have a better experience. For those who are keen on appreciation of works of art Say, you can visit art exhibition anytime and anywhere. This study analyzes the factors that affect user experience and immersive in this trend and proposes ways to improve user experience and immersion based on existing conditions.

# **Ⅴ. AR 3D Coloring game**

Through the development of this AR educational game, the flat object can be “moved on the paper” by a simple and portable scan of the mobile terminal. The multiple forms of interaction stimulate the interest of the learners and enable them to interact with the three-dimensional “partners”. Learn knowledge and understand the world. Break through the limitations of the paper book, promote the acquisition and absorption of knowledge, improve the interactive effect of teaching, and fit in with the concept of entertaining, improve the students' ability to operate, recognize the ability of literacy and identify colors. In the future, through further improvement, with the advancement of smart classrooms and digital learning, augmented reality e-books as emerging learning media will have a disruptive impact on classroom environment, teaching model, and even education.

5.1 Implementation Method

At present, augmented reality technology has begun trial application in military, medical, commercial, education, and maritime training and achieved certain results. The combination of education and AR technology has created a spatial three-dimensional material for learners while at the same time promoting the deep integration of technology and teaching, so that both as a teaching content or as a teaching tool can promote the internalization of knowledge absorption and bring about innovation and development in education [5]. At present, the application of AR technology in the field of education is mainly reflected in the following aspects: AR-based classroom teaching; AR-based skills training; AR-based mobile learning.

AR technology is a combination of virtual image and reality. Interaction should be the main focus of AR. However, due to the fact that smart glasses are not formally listed, AR technology still stays on the screen of mobile devices. This results in many AR technologies. As a kind of gimmick, taking the acceptance visual experience as the mainstay, coloring AR products are a few successful products in the current AR market. They have the following characteristics: high interactivity and entertainment; they can be used independently or as part of the system. , less investment than traditional games; collaboration between different areas, mapping UV matching requires a higher calculation. In the market for some color AR applications, the main feature of the colAR Mix is ​​that the models and animations are more complex and interactive, AR TuTuLe. Color rendering AR two ways of expression: 1, real-time rendering model texture content; 2, only once the model texture is not real-time rendering content.

5.2 Game Design

In this article, according to the knowledge and methods of AR painting application development, a fun cartoon character painting and dressing application suitable for young children was developed. This application can be run on the mobile device with simple operation and strong mobility. Need a few pieces of paper or cards to experience anytime, anywhere. The design motivation of this application is to help children recognize colors and express their desired combinations through coloring and collage. Young children can also observe their designs and collocations from all angles.

This game consists of two parts: AR and AR+ as shown in Fig. 35.



Fig.35 Start Scene

1. (b) (c)

Fig.36 The AR Scene(a)and (b); the AR+ Scene (c)

Three characters correspond to three recognition maps, and the model of each character is not static. When the three-dimensional rendering has a simple dynamic effect, when the user covers the original picture with a piece of paper with a different color, the character It will also change its color in three dimensions. The following figure is the scene of one of the characters when running: (a) Coloring the child's contrast picture; (b) Running the game with a mobile device, aiming at the picture, and displaying a 3D dynamic model at the top of the picture; (c) Using the child The other colors replace the corresponding parts of the recognition map; (d) The model displayed after the operation is changed is the model after the color change.

5.3 Project Implementation(Programing)



Fig.37 Application Development Steps

Get the world coordinates of the four points on the screen and save them in four variables

halfSize = new Vector2(gameObject.GetComponent<MeshFilter>().mesh.bounds.size.x,

gameObject.GetComponent<MeshFilter>().mesh.bounds.size.z) \* 50.0f\*0.5f;

targetAnglePoint1 = transform.parent.position + new Vector3(-halfSize.x, 0, halfSize.y);

targetAnglePoint2 = transform.parent.position + new Vector3(-halfSize.x, 0, -halfSize.y);

targetAnglePoint3 = transform.parent.position + new Vector3(halfSize.x, 0, halfSize.y);

targetAnglePoint4 = transform.parent.position + new Vector3(halfSize.x, 0, -halfSize.y);



Fig.24 Corloring XiXi papers

5.4 Conclusion

The application of augmented reality technology in education has provided new ideas for teaching and learning. As a representative product, AR 3D e-book breaks through the limitations of paper books, provides learners with realistic and intuitive learning materials, and promotes knowledge. Get and absorb. "Color the Earth AR" allows the planarized object to "move on a piece of paper" through a simple and convenient scan of the mobile terminal. The interactive form stimulates the learner's interest in learning and enables them to learn knowledge and understand the world in communicating with the concept of three-dimensionality. Of course, AR 3D e-books are in the development stage. Whether it is the fidelity or interactive effect of 3D models, there are deficiencies, which need to be further improved in the later research and production. With the advancement of smart classrooms and digital learning, AR 3D e-books, as emerging learning media, will have a disruptive impact on the classroom environment, teaching model, and even education.

# **Ⅴ**. **MR Chemistry Lab**

Through virtual chemical experiment equipment, students can perform simulation experiments in a high immersive environment, familiarize themselves with experimental procedures, observe and record experimental phenomena, save reagents, reduce danger, and achieve the goal of learning at any time.

The conventional education system modes are primarily passive or receptive learning style, many teachers think that students learned the experimental principle and method is important and enough, so they no need to do many experiments, according to our research, present teaching methods have limits shows as below: First: Lack of motivation and of activity, students are shown the experiments results instead of probing the results. Second: Temporal and spatial constraints; students cannot do the experiments anytime and anywhere for the limits of objective conditions and cannot repeat the experiment steps. Third: Wasted reagents and danger, some of the reagents are dangerous, therefore many practices are requisite before using the real ones. In this way can save the reagents and lessen the danger. To break the limits as we build up this application, use this can let the users practice the experiments wherever and whenever they need in a more active and probing learning way, and can also can save the reagents and lessen the danger probability. Meanwhile compare to the general 2D chemistry applications it guarantees the immersion almost alike the real world, in addition we also design a feature that users can see the microcosmic things like molecular structure using mark AR. All the solutions are confirmed Improved learning efficiency.

6.1 Implementation Method

The chemical knowledge involved in this application is a simple chemical experiment. Observe that one substance can produce other substances through chemical experiments. Through this experiment, we first understand what chemical experiments are. The experimental phenomenon: intense burning, emitting dazzling light, taking a lot of white smoke, generate white solids. The effect of the dazzling white light emitted when the magnesium bar burned was achieved by a particle system. The burned magnesium bar was placed in a beaker containing acetic acid. The magnesium bar was gradually dissolved without bubbles; the unburnt magnesium bar was put in the same package. In beakers with acetic acid, magnesium strips were observed to gradually dissolve, and bubbles were generated in the beaker.

The experimental principles and reaction equations involved are as follows: The combustion reaction of the magnesium strip changes the arrangement of the atoms.

2Mg+O2——ignite——2MgO

Mg + 2CH3COOH ——(CH3COO)2Mg + H2（ ↑ ）

2CH3COOH+MgO=(CH3COO)2Mg+H2O

According to the education content described above, two implementation methods are adopted: Mobile + PC + Leap Motion and PC + Oculus HMD. When running on Android phones, you need to use Leap Motion's gesture recognition to interact and implement the experiment process. However, since Leap Motion doesn't yet support running directly on the phone, we use Unity 3d Engine + Remote, which is the Unity Remote function that runs on Unity in the PC and is displayed on the phone screen. In order to achieve the combination of virtual reality and Leap Motion. it is divided into AR part and VR part, VR part is virtual chemistry experiment, and there are three experiments designed. Due to the model and some experimental effects, we only test the first experiment, which is the “burning of magnesium bar” experiment. In the AR section, the atomic card is scanned to show the model diagram inside the atom. Under the condition of PC and Oculus, the experiment was performed through the Oculus handle Controllers, and the virtual reality screen was displayed through the HMD. The detailed design are as follows.

6.1.1 PC+ Leap Motion +Mobile Phone



Fig. 39 The Design Flow

The program has three scenes, Main scene, Virtual Reality scene and Augmented Reality scene. Experiments are carried out in a virtual reality scene. In Experiment 1, there is an experiment table with experimental information cards, alcohol lamps, beakers, and magnesium bars. Wait. As shown in Fig 40.



Fig 40.

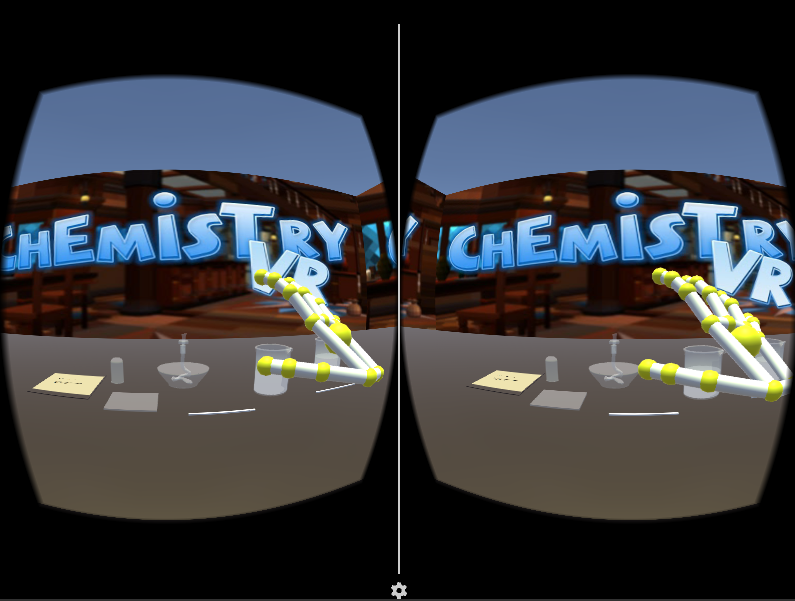


Fig. game scene

Oculus HMD +PC

In the case of using the Oculus HMD and Controllers, it is divided into the Main scene and the ChemVR scene. In the Main scene, the main function is to select experiments and recognize the atomic structure model of the necessary elements in the periodic table, as shown in Fig. the middle of the scene. Periodic table of elements, the user can use the handle to control the cursor to select the experiment in the left menu bar, the corresponding experimental information and description will appear on the right display box, at the same time, the elements involved in the experiment will be highlighted, the user through the operator The handle on the handle can be pointed at the element to handle the element's atomic structure model with the handle pulled to the eye, as shown in Fig.



Fig. Main scene



After you have finished observing the experiment information, select the experiment to be performed. Click the Go button to jump to the lab scene ChemVR under the ChemVR scene. The same UI layout, the left is the experimental information menu, click, the corresponding information appears in the middle panel. The user is in front of the experiment console, as shown in Fig. The user can refer to the displayed experimental procedure to start the experiment and observe the phenomenon.



Fig. ChemVR Scene



Fig. the Experiment desk

6.2 Game Design

Experiment 1 ：Burning of magnesium strip

Before the experiment, it is necessary to perform the following operations: Since the magnesium strip has a layer of oxidized MgO on it, the melting point is very high and the magnesium strip is not visible. Therefore, the surface of the magnesium strip needs to be sanded before the experiment to remove the oxide film. The silvery white magnesium bar; the asbestos mesh on the lab table to prevent the product from splashing down after burning, and the asbestos web is also provided on the test bench in the scene. According to the two implementation methods used in this application, the operation steps are slightly different.

1，The experience1 process using Leap Motion + PC + Mobile

* Read the guidelines or videos on the desk (mark AR)
* Grab the match on the desk and Lighting alcohol lamp
* Use a pair of tweezers to clip one of the two magnesium strips on the table and burn one on the alcohol lamp
* Watch and record the phenomenon
* Put the burned magnesium strips in a beaker containing vinegar, Put the other(unburned) magnesium strips in a beaker containing vinegar
* See and record the phenomenon
* Extinguishing alcohol lamp

2，The experience1 process using Oculus HMD

* Choose the experience1 in main scene.
* Read the guidelines or videos on the desk
* Grab the match on the desk and Lighting alcohol lamp
* Use a pair of tweezers to clip one of the two magnesium strips on the table and burn one on the alcohol lamp
* Watch and record the phenomenon
* Put the burned magnesium strips in a beaker containing vinegar, Put the other(unburned) magnesium strips in a beaker containing vinegar
* See and record the phenomenon
* Extinguishing alcohol lamp

6.2.1 Interaction design

When use Leap Motion as the interaction tool, users’ hand is recognized as Fig below.



Fig.28 Hand control with Leap Motion

Although Leap Motion currently does not support the direct link to the PC, the way to achieve Leap Motion and PC link is through the wireless network protocol linking the PC side as the server side, the mobile side as the client, running the program on the PC and the mobile phone at the same time, gesture recognition information passed The network protocol is transmitted to the PC for processing. Although this method realizes wireless connection and the mobile phone has certain mobility, it still cannot get rid of the PC. Therefore, the application is directly run in Unity, and the virtual mobile phone screen is used to implement virtualization. Real mode shows the game operation screen and the operation of leap Motion.

When use Oculus as the interaction tool. Oculus uses the Oculus as the interaction tool. Oculus controls the input by the handle, the left and right handles each have two buttons, a remote controller, a touch panel, and two trigger buttons. The left controller has a menu button, which is used to pause the game. In the game, the right controller has a main interface button, which is used to exit the game interface and return to the Oculus main interface. Each key corresponds to the following name.



6.3 Project Implementation(Programing)

1, Leap Motion + PC + Mobile

First, set up three scenarios and switch between scenes with the following code.

public class UIManager : MonoBehaviour {

public Button btn\_Ar;

public Button btn\_Vr;

// Use this for initialization

void Start () {

if (btn\_Ar != null)

btn\_Ar.onClick.AddListener(OnClickAr);

if (btn\_Vr != null)

btn\_Vr.onClick.AddListener(OnClickVr);

}

void OnClickAr()

{

SceneManager.LoadScene("ARPlayer");

}

void OnClickVr()

{

SceneManager.LoadScene("LeapVR");

}

}

LeapMotionMain.cs

private void SpawnManesiumRod()

{

if (magnesiumPrefab != null)

{

GameObject ma = Instantiate(magnesiumPrefab) as GameObject;

MagnesiumRod = ma;

MagnesiumRod.name = "MagnesiumRod";

MagnesiumRod.transform.localScale = Vector3.one;

MagnesiumRod.transform.localPosition = new Vector3(0.094f, 0.7f, 0.33f);

MagnesiumRod.transform.localRotation = Quaternion.Euler(Vector3.zero);

MagnesiumFire = MagnesiumRod.transform.Find("FlareMobile").gameObject;

InteractionManager.instance.RegisterInteractionBehaviour(MagnesiumRod.GetComponent<InteractionBehaviour>());

}

}

Download and install Leapmotion. I currently use the Leap Motion Unity package LeapMotion \_CoreAssets \_4.1.6.unitypackage, unity version 2017.1.1, using the latest Unity development kits need to use Unity version 5.5 or later, otherwise it will give an error. In our project, import the LeapMotion SDK. Next we can create a hand, find LeapMotion-Prefabs-LeapHandController to drag it to the scene (this is the hand controller), find LeapMotion-Prefabs-HandModelsNoHuman drag both CapsuleHand\_L and CapsuleHand\_R to the scene (this Is not with physical properties), then the hand with physical properties should be placed in the scene, there is a HandModelsPhysical folder under the HandModelsNoHuman file Drag RigidRoundHand\_L and RigidRoundHand\_R inside the scene, so that the hand is created In order to facilitate management, we create an object in the scene to manage the four hands we just created, create an empty object named HandModels in the scene, and use the hand we just dragged into the scene as its child. Object can be. As shown. You also need to set the LeapHandController, find it in the scene, and then in the Inspector panel, find the HandPool component, assign HandModels to ModelsParent, and find that ModelPool\_size is set to 1. A hand with no physical attributes is assigned to the corresponding variable in Element0, and a hand with a physical attribute is assigned to the corresponding variable in Element1. This way we can configure our hands and run the program to test your hands.



Fig

[Define some gesture](javascript:;)s that can interact with the object more accurate, such as lighting the alcohol lamp by pointing (with one index finger) the top of the alcohol lamp.

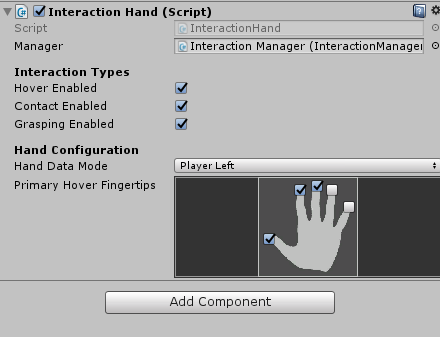
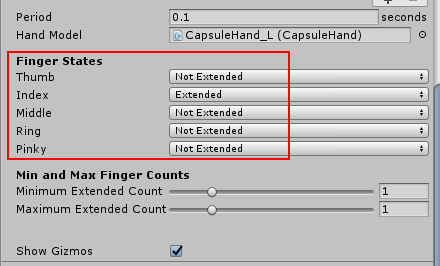
 

Fig. 29 [Definition of hand gesture](javascript:;)s: Lighting the alcohol lamp by pointing with the index finger



Fig. 点燃手势

TriggertEnter () detects the contact between the magnesium bar and the alcohol lamp to burn.

private void TriggertEnter(GameObject arg1, Collider arg2)

{

if (arg2.transform.parent.tag == "GameObject")

{

//if (arg2.transform.parent.gameObject == LampShade)

//{

// lampshadeState = true;

//}

if (arg2.transform.parent.gameObject == MagnesiumRod)

{

if (MagnesiumState == false && MagnesiumIsFire == false && alcoholLampIsFire)

{

MagnesiumState = true;

this.ExecuteLater(() =>

{

if (MagnesiumIsFire == false && MagnesiumState == true)

{

MagnesiumFire.SetActive(true);

MagnesiumIsFire = true;

DOTween.To((float scaleX) =>

{

Debug.Log(scaleX);

//MagnesiumRod.transform.localScale = new Vector3(scaleX, MagnesiumRod.transform.localScale.y, MagnesiumRod.transform.localScale.z);

MagnesiumRod.transform.GetChild(0).GetComponent<MeshRenderer>().material.mainTextureOffset = new Vector2(1-scaleX / 2, 0.0f);//SetTextureOffset("\_MainTex",new Vector2(scaleX/2, 0.0f));

}, MagnesiumRod.transform.localScale.x, 0, 10).OnComplete(() =>

{

MagnesiumIsFire = false;

InteractionManager.instance.UnregisterInteractionBehaviour(MagnesiumRod.GetComponent<InteractionBehaviour>());

//Destroy(MagnesiumRod);

//SpawnManesiumRod();

MagnesiumFire.SetActive(false);

});

}

MagnesiumState = false;

}, 1.0f);

}

}

}

}

Experiment process screen:



Fig.



Fig. 40 main game

2，Oculus + PC

Download the corresponding components on the Oculus Developer Center website, Oculus Utilities for Unity, Unity 4 Legacy Integration, Oculus Avatar SDK, and Oculus Platform SDK to import these four components into Unity and find the OVRCameraRig prefabs to drag into the hierarchy view.

6.4 Conclusion

# **Ⅶ Evaluation**

Educational games are electronic games that have game features and educational functions. They are essentially computer games created by game design and production personnel and carry concrete educational and entertainment purposes. Educational game evaluation is the process of design and development. The important links have a certain guiding role. Evaluating educational games in a timely and effective manner is a powerful guarantee for the development of educational games. For developers, there is a standard that can be used for reference. Can we not only develop targeted educational games but also save them? Time and cost, for teachers and students, can quickly find a game that assists teaching and mobilizes students' interest in learning. For parents and schools, it can effectively eliminate the traditional prejudice of the game and establish a scientific education attitude. Warren Buckleitner, a child and technologist in the United States, believes that gamified learning software is three-dimensional, in addition to evaluating the number of tasks (number of tasks) and quality (story, animation). The evaluation staff also has to control the levers of children in the use of software, menu design. The judgment of the clarity, etc., to evaluate the software experience is like evaluating teacher-student interaction. Warren Buckleitner's point of view actually coincides with the constructivist learning theory. Constructivism emphasizes the role of meaning construction and social-cultural interaction in learning, emphasizing learning, only with the contextual situation of wisdom, and the situation is synthesized through activities only, so that learning It should happen in a similar situation to the actual situation. Virtual reality and augmented reality educational games can provide learners with a real and open situation. Students can actively explore and solve various problems.

The goal of educational game evaluation is to judge its role as a learning tool for the promotion of learning, that is, to fully exploit the educational value of educational games. Alvaro, the chief research institute of non-profit education research and development organizations in the US, and Babette, a researcher of the Center for Children and Family Studies, combed the game-based learning environment. The evaluation literature provides a gradual process for evaluating the digital gaming learning environment, including the following five steps:

Table 2: Five Steps for Digital Gamification Learning Environment Evaluation [33]

|  |  |
| --- | --- |
| Steps | Specific description |
| Step 1 | obtain the software, may need to buy, or get demo and account, get evaluation allowed |
| Step 2 | satisfy the running hardware conditions of the software, clarify the purpose of education, target users, and the completed non-gaming learning environment that can help achieve learning objectives. |
| Step 3 | analyze how other organizations evaluate the software and can be used as a reference |
| Step 4 | Target users try out the software and conduct surveys and interviews with them after the end of the experience |
| Step 5 | Use evaluation gauges for further analysis |

It can be seen that the evaluation mainly used the comparative method, the questionnaire survey method, the interview survey method, and the gauge measurement.

The evaluation of educational games by the 80days digital educational game project team is not limited to games that have already been developed and put into use. They combine the formative evaluation and summative evaluation of the educational game from the design and development to the application at each stage. First of all, a questionnaire survey on game design concept prototypes is used to obtain children's acceptance of the game design; then expert review on game usability and playability is carried out when the game development is successful and can be run, and various issues in game design and development are excluded; Then select a school in the United Kingdom and Australia as a user group for testing, including usability, user experience, and teaching effectiveness. Finally, draw questions from the conclusions and conduct focus group interviews. [34] The questionnaire survey method, expert review method, experiment method (pre-test and post-test of user's learning content) and interview survey method were used in the evaluation process, and the quantitative evaluation method was combined with the qualitative evaluation method.

Educational Game Evaluation Gauge

Evaluation gauge is a tool for authenticity evaluation. It is composed of a series of indicators. He is a set of criteria for evaluating or registering the characteristics of educational games. It is also an important bridge between the development of connected educational games and the application and evaluation of educational games. The use of gauges to evaluate educational games actually belongs to the indicator quantitative evaluation method. In the following table, evaluation gauges used by teachers' parents or game developers and designers, which have relatively high correlation with educational games, are sorted out.

Evaluating educational games using evaluation scales is simple and easy. It has changed the general and ambiguous evaluation content of some educational game evaluation methods. It decomposes the evaluation content into specific projects, and has strong operability and short duration.

Table 4: Educational Game Evaluation Rubric Study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Author | Essay topic | Gauge dimensions | | Applicable people | Gauge features |
| Alvaro&Babette [36] | Rubric for Assessing or Designing Digital Playful Learning Spaces(2001) | 7dimensions | Fantasy space | Decision makers: parents, teachers, businesses, educators, developers | Emphasis is placed on the learning needs of users and less attention is paid to gameplay and entertainment. In the form of questions, it is a qualitative assessment |
| Feedback |
| Sense of control |
| Gamification learning curve |
| Special needs adaptability |
| Learning opportunities |
| Various educational opportunities |
| TEEM Teacher Evalution Framework British Teacher Evaluation Education Media Organization [37 ] | TEEM Teacher Evalution Framework(2002) | 6dimensions | Use profile | teachers | There are a total of 37 questions, each of which must be enlarged with a complete sentence. This evaluation is more rigorous. Focuses on teachers’ teaching applications and is a qualitative assessment |
| Course relevance |
| Design and navigation |
| Ease of use |
| Recreational |
| Installation |
| RICAR\_DO JAVIER RADEMA CHER MENA | E/E Grid (EDU Grid &ENT Grid)(2010) | 2dimensions | Education (as a specific indicator of the "" knowledge" dimension in Gardner's Multiple Intelligences and the 2001 Anderson Educational Target Classification) | Game Designer, Teacher, Educator | Taking full account of the balance between educational and gameplay, using Caillois's game type classification is not very suitable for the types of games in modern educational games, and it is a qualitative evaluation. |
| Gameplay (as a specific indicator of the Battle virtual world player type and Caillois game type) |
| LEONAR D A. ANNET\_TA, RICHAR DLAMB &MAR\_CUS STONE[] | Serious Educational Game Rubric [SEGR] (2011) |  | Preface | Teachers, game developers, etc. | The integration of education and playability, using Kappa coefficient to test the various factors of the rating scale, improved reliability and validity. Really combine education games with classroom teaching and student's heart characteristics to formulate evaluation indicators, and more fully consider the teaching needs of teachers. Each indicator (0 points, 1 point, 2 points...) is a quantitative evaluation |
| Tutorial |
| Interactive |
| Feedback |
| Identity |
| Immersive |
| Happy / depressed |
| Sense of control |
| Degree of difficulty |
| rule |
| Learning Content |
| learning target |
| Teaching effect |
| Communication channel |
| Wang Wei[37] | Multi-intelligence-based electronic game education comprehensive evaluation index system（2009） | 3dimensions | task | Teacher, user, educational game development company | 11 task boxes, 27 scene indicators and 25 interaction indicators. The indicators are very subtle and have the right to restate, which helps to evaluate the accuracy of the results. It belongs to quantitative evaluation. |
| Scenes |
| Interactive |

7.1 Evaluate system

AR technology can superimpose the virtual information into the features of the real world, which can make the original boring knowledge in teaching into a vivid image, which can improve students' interest and enable them to learn better. Events such as special geographical features, historical events, and things that are not easily accessible can be presented to students through AR technology. As can be seen from the AR game Pokemon Go, which was popular around the world some time ago, AR is more easily commercialized than VR. According to the application of AR in the education field, it is the concept of inquiry-based education that attracts children to participate in teaching from the standpoint of expression. The interests of things, so as to explore and research deeper content in an interactive way. The multi-media approach is more expressive. After being integrated into augmented reality technology, the content of the teaching is expressed in pictures, videos, animations, and other ways. It is easier to understand and understand. The new interactive experience, augmented with the unique interactive experience of real life, allows children to use their eyes, ears, hands, and brains to truly realize diversified education.

According to the evaluation, the performance, cost, and portability of the device, as well as the user's experience, educational effectiveness, etc., are performed. Among them, the cost performance and portability are inherent attribute characteristics of the device itself. The user experience and the educational effect need to be verified through testing. The experience sense and the educational effect are interviewed through oral questions. Combined with the characteristics of each evaluation system summarized in the previous section, and the characteristics of virtual reality educational games, the following table is based on the evaluation system:

Table 5. Educational purposes and target audience for each game in this application

|  |  |  |
| --- | --- | --- |
| Game | target | Educational goals (effects) |
| Ludo Game | 6 year;  Pre-school | Develop students’ ability to diverge thinking and solve problems |
| AR 3D Coloring Game | 6 year;  Pre-school | Develop children's color recognition and hands-on skills. |
| VR Art Exhibition | 20 year; college | Watching works of art |
| MR Chemistry Lab | 20 year; college | Get rid of the time and space limitations of doing chemical experiments |

The highly innovative Wang Wei (2010) researched a multiple-intelligence-based electronic game evaluation scale. Based on the influence of video games on the multiple intelligence of young people, electronic games were divided into eight types: language-based and music-based. Give each type an evaluation gauge and assign weights to it. At present, there are many types of educational games. They have their own distinct characteristics. It is difficult to align these features with the same gauge to make a correct evaluation. The same type of games is comparable. The four models in this study all belong to virtual reality, augmented reality educational games. One of the hallmarks of virtual reality is immersion because of the need to experience immersions and senses of control. The other way of interacting that directly affects the sense of control of experience is One of the decisive factors.

Table 6: Evaluation of Stone's Gauge Dimension Design in this Application

|  |  |  |
| --- | --- | --- |
| Gauge dimensions | Evaluation method | |
| The first category | The second category |
| hardware equipment | record | record |
| Immersive | Interview | Interview |
| Educational effect | Interview | Questionnaire |
| Interactive | Interview | Interview |
| Sense of control | Interview | Interview |
| Degree of difficulty | Interview | Questionnaire |

However, just using evaluation scales to judge the application value of educational games is not comprehensive enough, and the evaluator still needs to examine the changes in learning behaviors and learning results after learners use educational games in order to make in-depth, comprehensive and reasonable evaluations.

7.2 Evaluations for the 4 cases

In the previous section, we introduced that we divided the four games into two categories for evaluation. The four applications were targeted at different ages. Board games and AR 3D coloring games targeted preschool children. The average age was 10 years old at 6 years old, including 5 in the experimental group 5 and 5 in the comparison group. The selected subjects were familiar with the basic operation of the mobile phone, while the VR art Show and the VR Chemistry Lab focused on the subject of extended education and the choice of subjects. There are 10 undergraduates in art and undergraduates in science. There are no gender restrictions. The test tasks are divided into four groups. Each game has an experimental group and a comparison group. The subjects of the experimental group implement the projects developed in this thesis and compare the group's object experience with the traditional group games with the same function as the experimental group. As shown in the table below.

Table 7 Number of subjects and grouping

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Game | Ludo Game | | | AR 3D coloring game | | | VR art exhibition | | | MR Chemistry Lab | | |
| AR | 非 AR | Normal | AR | 非 AR | Normal | VR | 非 VR | Normal | MR | 非 MR | Normal |
| Number | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total | 15 | | | | | | 15 | | | 15 | | |

It is mainly the theoretical analysis of qualitative analysis, which confirms the lack of quantitative analysis. Based on the above introduction and the features of virtual reality, augmented reality program and two types of target population, this paper has designed the following evaluation gauges:

The first category

The evaluation included Ludo game and 3D coloring game, two puzzle virtual reality and augmented reality games developed for preschool children. The participants of this category included game developers (game developers) and game targets. The results of the population (preschoolers) are as follows:

Table 8 ：The first category Evaluation result

|  |  |  |
| --- | --- | --- |
| Gauge dimensions | Evaluation method | Evaluation result |
| hardware equipment | record |  |
| Immersive | Interview |  |
| Educational effect | Interview |  |
| Interactive | Interview |  |
| Sense of control | Interview |  |
| Degree of difficulty | Interview |  |

The second category

This review includes VR Art Exhibition and MR Chemistry Lab. These are two types of virtual reality augmented reality games developed for college students. Participants in this category include game developers (game development practitioners) and game target audiences (college students). The results are as follows:

Table 9 ：The second category Evaluation result

|  |  |  |
| --- | --- | --- |
| Gauge dimensions | Evaluation method | Evaluation result |
| hardware equipment | record | … |
| Immersive | Interview |  |
| Educational effect | Questionnaire |  |
| Interactive | Interview |  |
| Sense of control | Interview |  |
| Degree of difficulty | Questionnaire |  |

7.3 Evaluation Result

7.4 Summary

# **Ⅷ Conclusions**

This chapter reviews the achievements of the research objectives. Then, the

conclusions and contributions of the research are discussed. Finally, some

possibilities of future researches are outlined.

8.1 Review of Objectives

8.2 Discussions

8.2.1 Limitations

8.3 Recommendations for future work

Appendix I: Virtual & Augmented Education Scenarios

Appendix II: Questionnaire for Subjective Evaluation

Appendix III: Paper Based Examination

Appendix IV: Comparison of use of VR and AR system with traditional whiteboard based lecture

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