**Researching Principles of the AR,VR,MR Applications Design for Education**

# Abstract

As the Chinese ancients saying goes for education: "读万卷书，行万里路", "Travel ten thousand miles is as important as to read ten thousand books. " One who wants to be successful, study only is not enough, study is wisdom, travel is experience, experiences can transform into wisdom. It may even be more practical and important than the wisdom gained from the book directly. However, if one has not enough knowledges gained by books, experience is only experience can’t be transform into wisdom. 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 reality of computer simulation can replace “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 it comes to biology, it is substituted into the local plant and animal life Environment, in the Chemistry class students can experience directly with chemistry, 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 UGC (user generated content) [1]. We are just beginning to see developers making huge breakthroughs in imaginative educational content for children and adolescents. Virtual Reality is a simulation technology that emphasizes the hands-on experience and engagement of user simulation. At present, there are many applications of virtual reality in many fields. The combination of virtual reality technology and experimental teaching is analyzed and the advantages compared with the traditional teaching mode are expounded. The basic principles of application design and interaction design are introduced, and the immersion of virtual experiment is enhanced for the application of virtual reality technology and augmented reality technology Feelings and improve teaching have provided a viable approach.

This thesis designed and developed four AR / VR education application implementation cases, they are respectively 1, AR Board game; 2 VR art show; 3, AR 3d Corloring game; 4, MR Chemistry Lab and introduced each application design Finally, through the actual experience of these applications, we analyze the implementation results respectively in educational effect, user experience and equipment, and get some experiences and methods of AR / VR education application design and development in some educational applications . That is, in the design and development of educational applications, the following principles should be followed ：. . .

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-computer interaction between the virtual environment generated by the human-computer interface, application development prospects are very broad.

1.1.1 Virtual Reality

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].

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. Lenovo introduced Mirage Solo. HMD + Mobile is represented by the Samsung Gear VR and in June 2014, at the Google I / O conference released Cardboard glasses box Fig.1 (b), in general, the glasses box is the phone into the VR case in watching VR display device. Although relatively rough experience, but such devices do not require complex electronic components, lower cost, and mobility and portability. VR all in one machine as shown in Fig.1 (c) need to display, computing, storage, power and other functional modules are fully integrated into the headset display device. If you want to achieve good performance, the display device is difficult to be compact. 2017 Millet and Oculus jointly launched the VR VR Miracle VR machine, PS VR relies on the PS4.

（a） (b) (c)

Fig.1 3 Kinds of VR devices

1.1.2 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. In entertainment, 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 floor, 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 the camera that comes with your phone to translate textual information in a portion of the real world into another language, Fig.5.



Fig.2 head-up display of the aircraft



Fig.3 Parking Assist System



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



Fig.5 [Google Translate](http://link.zhihu.com/?target=https%3A//media.nngroup.com/media/editor/2016/09/10/google-translate.jpg)[13]



Fig.6 The AR navigation system [30]

User experience AR applications, as long as the use of mobile phones (or with RGB camera PC) can be achieved, the principle is based on Marker identification and tracking, or can also be achieved through the SLAM technology. Marker can be 2D QR Code: The main function of the QR code is to provide a stable and fast identification. In AR, in addition to identification, the QR code also serves as a part-time function that provides easy tracking and positioning of the plane. For this reason, the two-dimensional code in the AR is simpler than the normal two-dimensional code in order to facilitate accurate positioning. Marker can be 2D Flat picture: Because the two-dimensional code itself is a two-dimensional image, the two-dimensional code method can be used directly on the two-dimensional image. Use two-dimensional pictures, such as banknotes, book posters, photo cards and more. The reason why the QR code is simple is that the design above it is designed so that the visual algorithm can quickly identify and locate. The general two-dimensional image does not have this good nature and needs a more powerful algorithm. And, not all 2D images can be used for AR positioning. For example, a solid image without any pattern can not be visually located. Marker can be a 3D Object: A natural extension of a two-dimensional 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, as is the case in industrial repair. However, for some specific irregular objects, such as faces, many algorithms have been able to perform real-time accurate alignment due to years of research accumulation and massive data support. However, how to deal with common objects is still a huge challenge. Finally, the latest Marker focused on 3D Envionment: 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 also can be aware of the current location of the device in space (depth information). Its optical display scheme has also become a waveguide, the lens thinner.



1. (b) (c)

Fig.7.QR Code and AR Application using Flat picture

Among the above-mentioned technologies, the identification and tracking technologies of two-dimensional code and two-dimensional 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 three-dimensional objects and three-dimensional environments. At WWDC 2017, Apple brought AR Kit, a new Augmented Reality component for iOS 11 that works on iPhone and iPad platforms. AR Kit, 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 iPhone X 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.8. 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 points. 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.

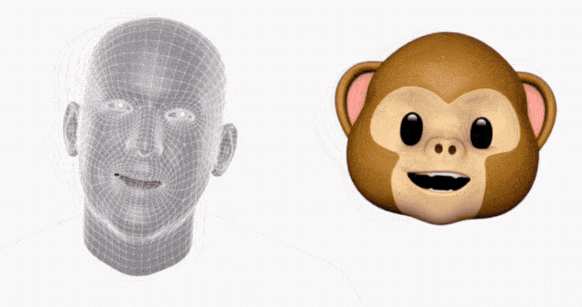


Fig 8. iPhone X to include animoji, emojis animated based on your facial expressions [31]



Fig.9 Apple AR light projection

1.1.2 MR

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

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.

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].

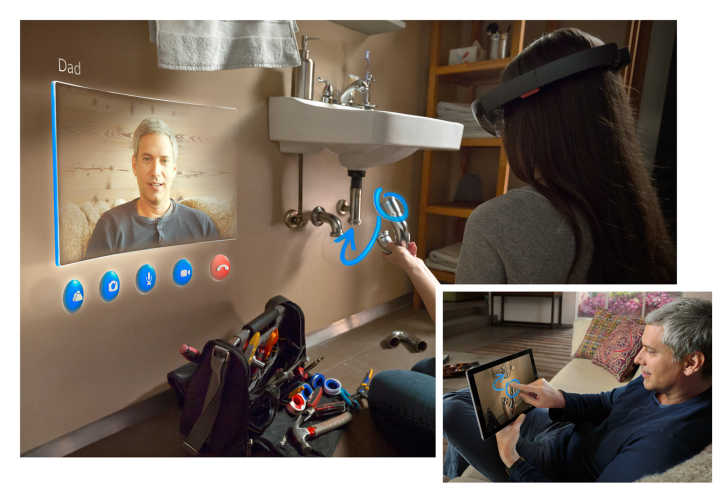


Fig.10 [HoloLens by MicroSoft](http://link.zhihu.com/?target=https%3A//media.nngroup.com/media/editor/2016/09/18/hololens.jpg)

Professor Ronald Azuma [3] at the University of North Carolina University summarized the augmented reality into three parts: virtual-reality integration, real-time interaction and three-dimensional registration. 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.11). Which is close to the real environment is to augment reality, close to the virtual environment is to expand the virtual environment.

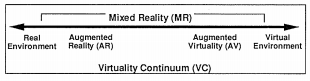


Fig.11 Simplified representation of a “ virtuality continuum.”

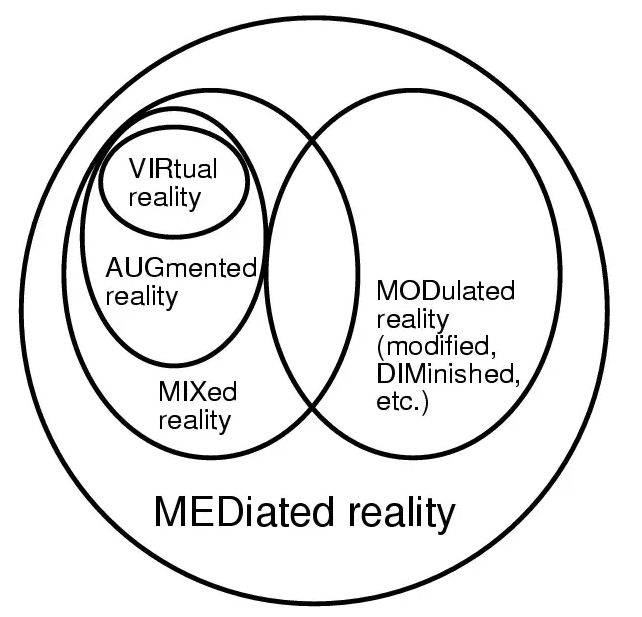


Fig.12 Venn diagram of the focus of the work

Virtual reality, augmented reality and mixed reality, there are differences between the three technologies to achieve, simply put: VR put the user into the virtual world, AR virtual world in front of the user. The difference between VR, AR, and MR is illustrated by the image in Fig. 13: VR is to create a completely virtual world that separates you from the real world (Fig. 1). The core problem is graphic computing and immersion. The VR world has always existed. VR, which is the traditional meaning of comic books, games and novels, is limited to visual and auditory feelings, that is, two of the five senses of human beings come out from the computer After that, the game appeared as a powerful virtual world, because it can participate in which play a different outcome, but also many people together to create unpredictable results, but also have a sense of participation than the movie; AR technology is the virtual reality superimposed on reality The top of the world image, used to enhance and augment the information in the real world, as shown in Figure 2. The core issue is image recognition and tracking. The AR is the augmented reality of human perception. The content of the virtual world is overlaid by the device into the real world. This includes Google Maps as an AR [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 3, the robot was blocked part. The core issue is the 3D scanning of the real world, as well as the perception of distance.

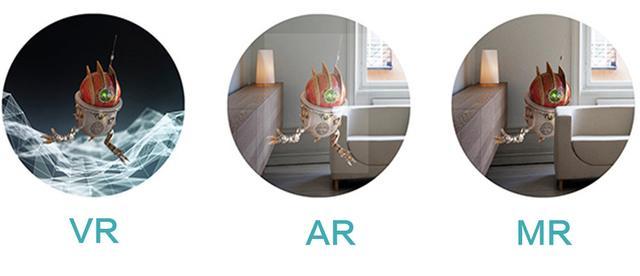


Fig. 13 the distinguish of VR, AR and MR [33]

Summarizing the development characteristics of VR and AR, it can be seen that the application fields of VR and AR are mainly in the field of industrial manufacture and maintenance, displaying various auxiliary information to the user through the head mounted display, including the panel of the virtual instrument, the internal structure of the device, Equipment parts map. Medical areas, using VR virtual reality methods to help doctors diagnose the disease, treatment of patients and training of medical staff. In the field of television broadcasting, the auxiliary information can be superimposed on the retransmission screen by the AR technology. Entertainment, Games, VR Games, VR Videos, Movies and more. In the field of education, the use of VR for immersive teaching; through the AR can text, pictures, three-dimensional, increase reading interactivity and interest. 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, 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 more immersive and realistic augmented reality experience. At the same time, Google Cardboard such a simple VR glasses, priced at less than one hundred yuan, significantly reducing the threshold of user experience virtual reality. Last February Cardboard accomplished two milestones: 10 million Cardboard shipments and 160 million application downloads, all of which make AR / VR more and more appearing in our lives.

* 1. Objectives and Scope

If we make an overview of the research content of this thesis, this paper systematically introduces the development and application status of virtual reality, augmented reality, and mixed reality technologies, and the technologies involved. The use of virtual reality and augmented reality can enrich the existing teaching resources and make the existing educational resources appear in a new form. The static resources are dynamic and multi- dimensional, which is good for the students to understand the learning resources, Stimulate students interest in learning, education and teaching effectiveness. 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 examples of augmented reality and virtual reality applied to education. Through the application of these practical applications to education and teaching, we evaluate each application by scientific methods and obtain the evaluation of their respective 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.

1.3.1 A Board Game - Design of Simple Board Game for Augmented Reality

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, 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.

1.3.2 A VR Art application - Development of Multimedia Design Contents using Mobile Virtual Reality

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.

1.3.3 AR 3D Color games – Design and Development of Coloring Game based on Augmented Reality Technology by a case study

The development from "virtual reality" to "augmented reality" realizes the combination of the real world and the virtual world. "Supernatural" is no longer a legend. Augmented reality technology is constantly being applied to all fields of society, changing people's 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.

1.3.4 MR Chemistry Lab - A Virtual and Augment Reality Application for Chemical Experiment Education and Practice

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 unfamiliar students' reagent, equipment and experiment steps. Reduce the probability of dangerous occurrence and effectively improve the efficiency of learning. In extended applications, the microscopic molecular combination and arrangement structure of the microscopic management system of an augmented reality management system can be applied. Virtual reality (VR) and Argument reality(AR) technology have open a vast opportunity to be applied in many fields include education. This paper is based on a research of the conventional chemistry experiment education limitations, we design and developed a "Virtual Chemistry Lab" propose a new method of assisting present teaching aids. And through analyzing different interaction methods in the VR system, find a better applicable interaction mode for this application. By evaluation, implementation of this application achieved the education objective more effectively.

1.4 Dissertation structure

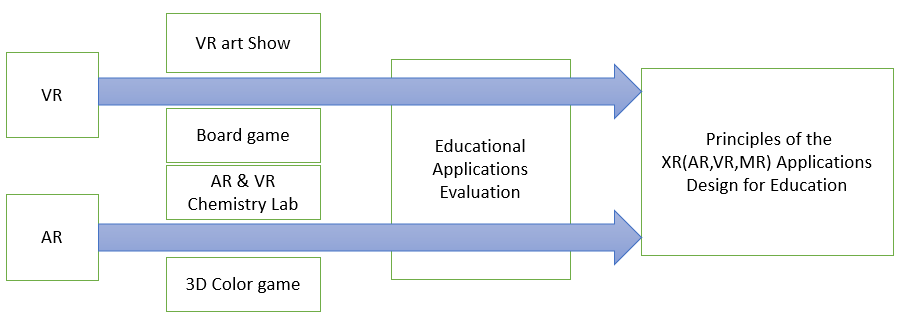


Fig.14 Research papers

# **Ⅱ Related Work**

2.1 Background

The famous investment bank Goldman Sachs Group in the investor report on the VR / 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.

2.1.1 VR and AR Educational Applications Typical types and researches

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.

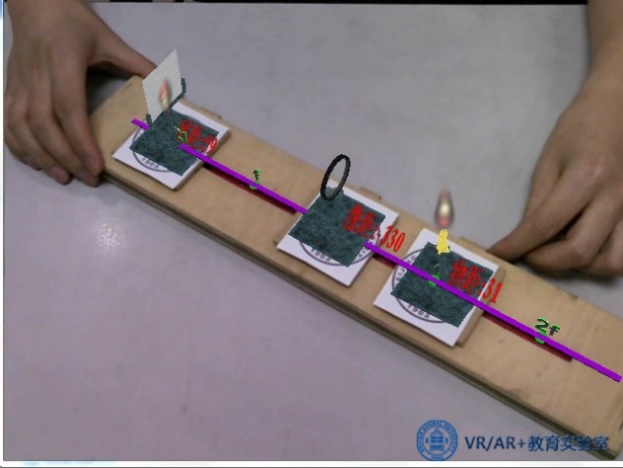


Fig.16 Simulated convex lens imaging

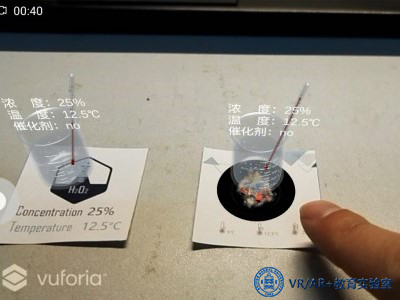


Fig.17 Chemical hydrogen peroxide

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:

1, 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.

2, 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.

3, 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**

ChinAR: 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.

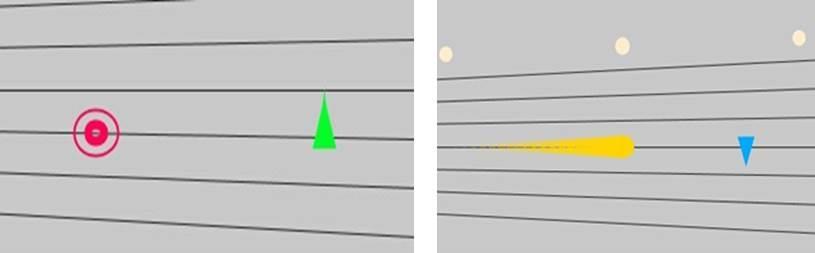


Fig.20 Chinese Guqin Learning Application

**Summary**

In the traditional mode of education. Mainly "accepted learning", manifested in chemical education, many teachers and humanities as long as students understand the basic experimental steps and the final experimental results are sufficient, has the following limitations: 1, the lack of initiative, students are more Passive observation teachers demonstrate the experiment, but for the students to do the experiment led by their own few, resulting in passive acceptance of the students, the memory of knowledge is not very profound. 2, experimental demonstration time is limited, students can not repeat the experiment. 3, lack of reagents and the risk of some chemical reagents and instruments of a certain experimental laboratory risk, experimental procedures for this dangerous and experimental students need to be repeated before the experiment to be familiar with the experimental procedures and steps. The above limitations to a certain extent in time and space limit the effectiveness of student learning, we should use new technologies to change the traditional mode of education, change the mode of learning for the initiative to explore sexual inquiry education.

"VR + Education" First of all, enriches education resources and improves education methods. To a certain extent, it can supplement the existing education deficiencies. However, in terms of product content, the relationship between hardware configuration and academic education is low. VR the development of education curriculum lacks the participation of subject education experts and teachers. Compared with the pure virtual reality environment such as Oculus and HTC Vive, the augmented reality environment does not need to wear a heavy helmet and does not need to have a dedicated locator and a specific range of activities that capture the user's space. It only requires a computer with a normal camera, or just need a tablet or mobile phone (own camera), you can do the real environment and the integration of virtual interaction. As a result, this learning technology, which is less demanding on hardware, is easier to find at school and has more audiences. More importantly, the augmented reality environment makes a meaningful connection between the virtual learning content and the real environment. Therefore, AR technology, as a branch of VR technology which is one of the hot spots of current research, can create a scientific inquiry environment for students [14]. The famous publication "The Economist" in early 2017 on the article predicts that AR is more promising than VR [15].

AR + Education is still in the initial stage of presenting the simple and interactive immature. There are still many parts that need to be developed for the research design of the topics of the AR empirical research. It is worth mentioning that the team of the Institute of Modern Education of Beijing Normal University conducted a long-term empirical study on the key technical problems such as 3D modeling and interaction of virtual behaviors in the application of augmented reality education. At present, breakthrough results have been achieved.

Through its empirical research, it can be seen that most students show a positive attitude toward VR / AR teaching tools or the environment, which is in line with the study by Nunez et al. [23]. Therefore, in the future education, we should dig deep into the law of education, use the VR / AR learning environment to build a new teaching model supported by the technology platform and explore how the VR / AR learning environment can support learning and teaching so as to enhance students' Learning effect, return to the nature of education by reshaping the way of learning, and provide support for the cultivation of innovative talents and education.

2.2 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.

1. 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.

1. 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.

1. 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.

2.2.1 Human-Centered Design for VR/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]

Augmented Reality impacts user experience design by reducing interaction costs, cognitive load, and attention transfer. Mobile apps like PokemonGO, SnapChat brought the word "augmented reality" to the spotlight. In July 2016, Niantic, the former PokemonGO (and another popular Augmented Reality game, Ingress), reported that PokemonGO alone earned a revenue stream of up to $ 10 million a day, proving that augmented reality In the mainstream market can be successful. Growing attention to augmented reality has led to the word being heavily used in technology, and some not even in line with augmented reality technologies such as the recorded Michael Jackson concert of holographic projections have also begun to use augmented reality to self-proclaim.

Augmented Reality (AR) refers to the product technology that uses real-world information created in the real world, including both real-world information and procedurally designed elements with interactivity. The product technology relies on the real world to operate. To be referred to as "augmented reality," a technology must meet the following: Respond to virtual environments while also adapting to the real world the user is in. Support real-time gestures and actions with minimal explanation the most intuitive experience imposes no restrictions on user actions during the experience, so it is not an augmented reality that enables concerts of real-time and consistent Michael Jackson holographic projection. Holographic projection does not give real-time feedback on any real-world information, it's just a static device; in fact, the real world built by the dancers enhances the overall projection, and such reverse enhancements are not real augmented reality.

Augmented reality enhances performance by making timely feedback on real-world dynamics. This is different from virtual reality. Virtual reality isolates the user from the real world, presenting the user with a virtual environment that mostly consists of fake elements. (Typical examples of virtual reality include sci-fi games or experiences traversing a huge heart model.) However, both virtual reality and augmented reality are real-time and produce timely feedback on the user's behavior and interaction in the environment.

# Ⅲ. **A Board game for Math**

# 3.1 Introduce and Design principle

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.

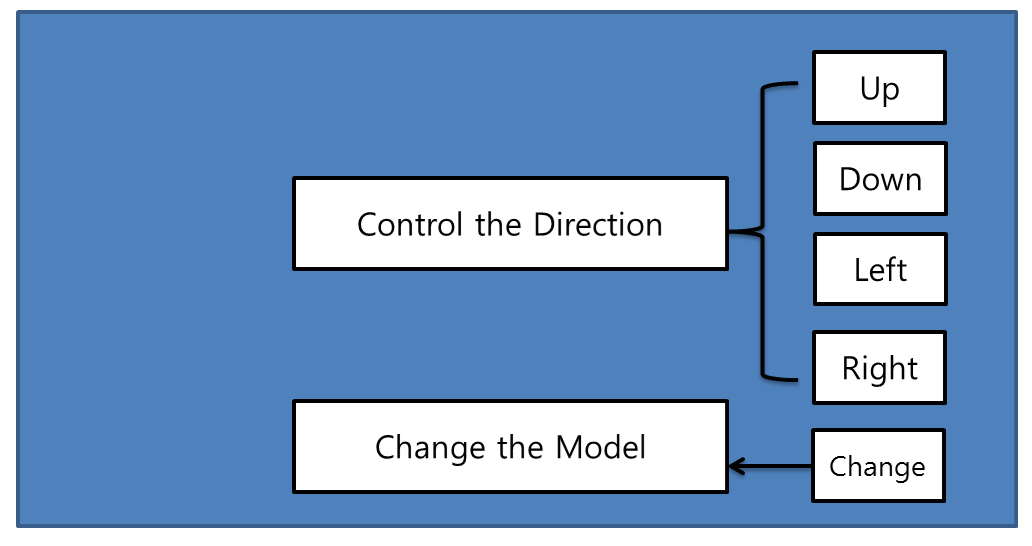
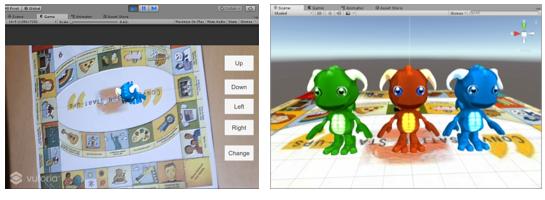


Fig.21 the board game Flowchart

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.22 Result of designed Game

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.

# 3.2 Project Implementation(Programing)

# **Ⅳ**. **VR Art Show**

4.1 Introduce and Design principle

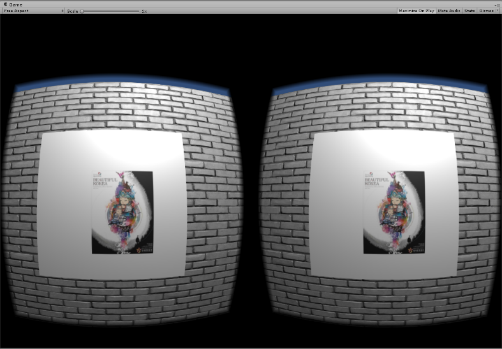


Fig.23 the game scene

Virtual Reality (VR) that is applied to various parts expands not only game and movie but also health care, business S/W, education, 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 we show that utilize multimedia visual design works as VR contents.

This application is a mobile phone application using Google Cardboard, the user can experience the virtual art exhibition from the first perspective. Since the interaction allowed by Google Cardboard and mobile phone is relatively simple, we use the method of line-of-sight control to move. When starting, the user follows the user's direction to follow the character's movements. When he reaches a certain distance in front of the painting, he stops and watches the painting. When the change is made, he moves on.

4.2 Project Implementation(Programing)

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;}}}

# **Ⅴ**. **3D Coloring game for Early Childhood Education**

AR technology is a combination of virtual image and reality. Interaction should be the main focus of AR. Actually AR technology still stays on the screen of mobile devices due to the absence of smart glasses, resulting in a lot of AR technologies As a gimmick, with a receptive visual experience as its mainstay, painted AR products are one of the few successful products in the current AR market that have the following features: high entertainment interactivity; stand alone or as part of a system , Relatively less investment in traditional games; need to collaborate between different areas, mapping UV matching requirements are higher.



Fig.24 Corloring XiXi papers

5.1 Introduce and Design principle

At present, augmented reality technology has begun tentative application in the fields of military affairs, medicine, commerce, education, navigation training and achieved some success. The combination of education and AR technology promotes the deep integration of technology and teaching while creating spatial three-dimensional materials for learners so that they can promote the internalization of knowledge both as teaching contents and as teaching tools, and bring about the innovation and development in the field of education [5]. At present, AR technology in the field of education mainly in the following areas: AR-based classroom teaching; AR-based skills training; AR-based mobile learning.

5.2 Project Implementation(Programing)

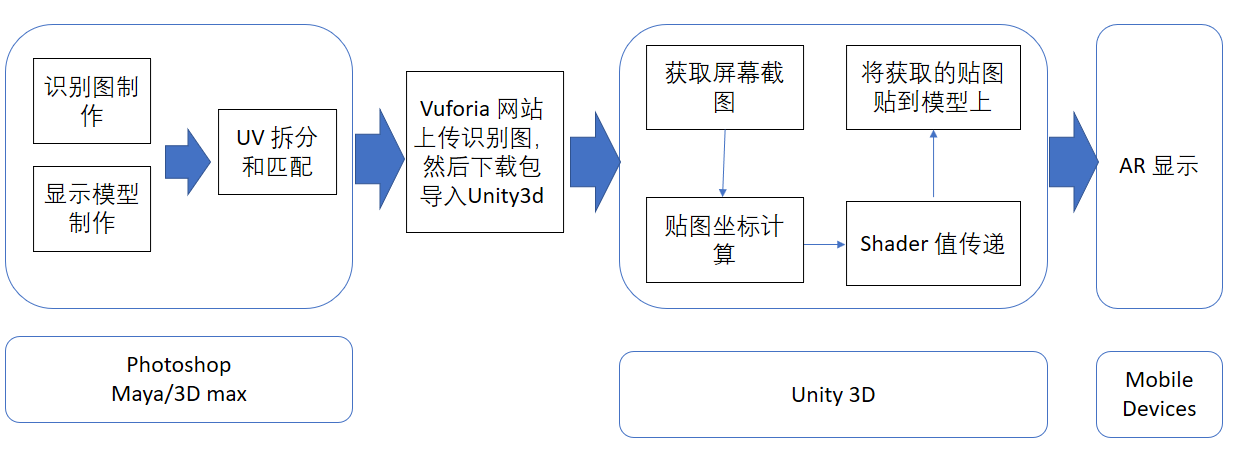


Fig.25 Application development steps

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

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);

# **Ⅴ**. **AR & VR Chemistry Lab**

**Limits in conventional Chemistry education**

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 Introduce and Design principle (Leap Motion and Oculus HMD)

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 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.

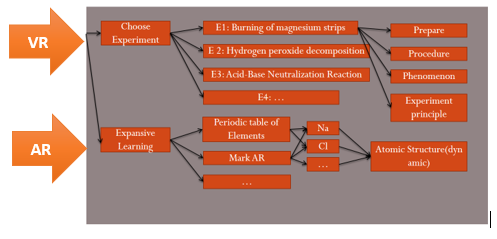


Fig.26 The User Interface

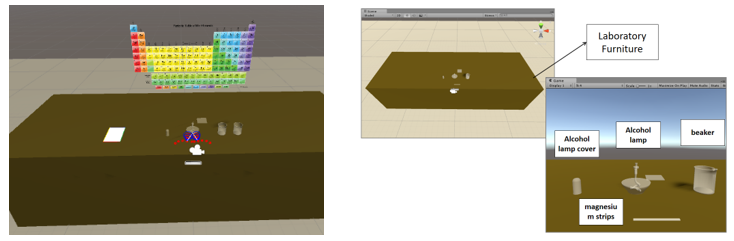


Fig.27 Game composition

**Burning of magnesium strips**

* Read the guidelines or videos on the desk (mark AR)
* Grab the match on the desk and Lighting alcohol lamp
* Put on the goggles
* Use a pair of tweezers to clip one of the two magnesium strips on the table and burn one on the alcohol lamp
* See 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

**Interaction design**

We use LeapMotion as the interaction tool ,users’ hand is recognized as fig below.

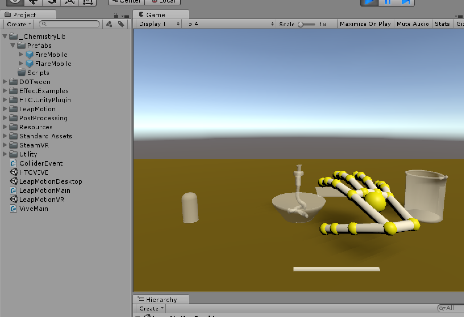


Fig.28 Hand control with Leap Motion

6.2 Project Implementation(Programing)

[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.

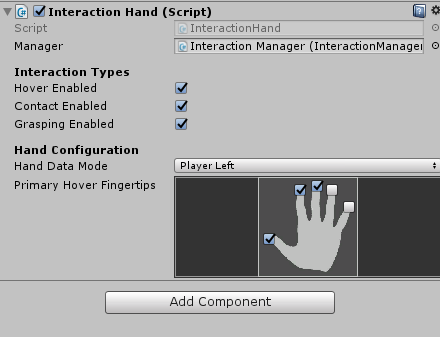
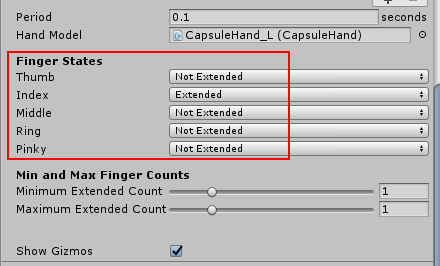
 

Fig. 29 [Definition of hand gesture](javascript:;)s: Lighting the alcohol lamp by pointing with the index finger

# **Ⅴ Evaluation Result**

4.1 Evaluate and Conclusion实验设计和数据分析

四个应用程序分别针对不同年龄的对象进行测试，Board Game 和 AR 3d coloring game 针对的对象是 学龄前儿童，而 VR art Show 和 VR Chemistry Lab 针对的是成人。因此我们的测试任务分为四个组进行。

4.1.1 Evaluation system

测试

1, Price-performance ratio (hardware, cost, portability…)

2, UX (diagram, interview)

3, Educational effect (questionnaire survey)

4.1.2 Evaluations for the 4 cases

4.2 Evaluation Result

4.2.1 Subjective Evaluation

4.2.2 Objective Evaluation

4.2.3 Usability Evaluation

4.2 Summary

# **Ⅴ Conclusions and Discussion**

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.

5.1 Review of Objectives

根据研究的实验结果解决之前提出的问题：

5.2 Contributions and Conclusions

5.3 Discussions

5.3.1 Limitations

“我的问题始终是：虚拟现实与教育片到底有什么不同？”教育科技博客作者及撰稿人奥黛丽·沃特斯（Audrey Watters）说道，“我确实担心，人们会越来越多地在模拟或虚拟现实技术的伪装下使用教育片代替学生的外出实地考察以及其他线下的丰富活动。”[2]

5.4 Recommendations for future work

Future directions in Augment and Virtual reality ---expanding applications ---Apply AR/VR mode in Other subjects (Match, physics, art, biology, geography…)

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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