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# Learning and Teaching Cameras Using Virtual Reality Games

# -- A Case Study of the Combination of Virtual Reality and Virtual Lab in Universities

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## Abstract

**Due to the high cost of laboratory construction and maintenance, many higher education institutions generally have problems in laboratory construction, insufficient experimental equipment, and insufficient experimental materials. Advances in instructional technology have provided higher education institutions with solutions to reduce laboratory budgets and high maintenance costs by building virtual reality-based learning environments. The author uses Virtual Engine 4 to design and develop a serious game based on virtual reality technology. The game uses virtual reality technology and virtual reality laboratory simulation to teach students the function and usage of the camera. A case study was undertaken at a higher education institution in Sichuan Province, China, and the game was utilized and assessed as part of the research. A total of 30 freshman students aged 17-19 participated in the study as the experimental group. The usability and user experience of the constructed serious game are examined in this study, and the findings demonstrate that the game has a good user experience score. The majority of students in the experimental group enjoyed the game and anticipated that additional courses would include games with comparable educational benefits.**

## Keywords

**Virtual Reality; Virtual Lab; Higher Education; Virtual Reality Game.**

## 1. Introduction

Information technologies such as computers, mobile phones, mobile Internet, and artificial intelligence affect our daily lives due to the rapid growth of information technology. Visual communication has become an important communication method in the information society(Zhao et al., 2020). Information and communication technology on campus has grown highly popular in higher education. School administrators employ information technology to manage educational tasks such as daily classroom arrangements, laboratory equipment management, laboratory application administration, and library management (Nora & Snyder, 2008). One of the most compelling information technology applications in higher education parks is virtual reality technology. Reports by Van Krevelen and Poelman(2010), Tenberg (2015), and others predict that virtual reality (VR) may become the largest future computing platform in history. The development history of VR technology has been more than 60 years: the concept of VR was put forward in the 1960s, and the first commercial VR tool appeared in the late 1980s. Therefore, in the past 20 years, hundreds of researchers have explored this technology's process, effects, and applications and produced 1,000 scientific papers (Cipresso et al., 2018). Big tech companies, including Apple, Facebook, Google, Microsoft, and Samsung, have already started investing in developing VR-related technologies. Big tech companies

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expect VR to be used for various applications, including learning, especially during the COVID-19 pandemic (Allcoat et al., 2021).

VR is defined as the actual or simulated environment where the perceiver experiences telepresence (Steure, 1993). VR has also been described as an advanced form of visualization. VR technology is used to create various types of VR environments. Each environment has its own goals, architecture, and functions (Tegarden, 1999). According to market researchers, VR technology will soon become one of the most disruptive and influential industries. The VR industry has made progress in many fields such as education, physics, chemistry, astronomy, and medicine. And provide engaging, immersive, and engaging experiences in other use cases such as education, training, entertainment, and shopping (Hu Au & Lee, 2017). Virtual reality technology uses computer technology to produce proper- and left-eye representations of a 3D object or scene, simulating the natural stereoscopic seeing process. The viewer's brain combines the information from these two perspectives to construct a 3D perception. As a result of virtual reality technology, things on the screen appear to have depth and existence beyond the flat picture presented on the net. Using virtual reality technology, the audience may perceive the distance and spatial connection between specific items. Compared to standard visualization tools, object pieces are more realistic and accurate (Okechukwu & Udoka, 2011).

VR in education can be seen as a natural progression from computer-assisted instruction or computer-based training. Based on the fundamental properties of virtual reality, research reveals that it may be a great instructional tool (Pantelidis, 2010). Learning theories can be constructed in a virtual environment based on constructivism. The ability of learners and educators to collaborate in virtual classrooms is the most significant benefit, which transcends geographic boundaries (Youngblut, 1998). Virtual reality may provide a very realistic immersive reality while allowing users to observe items in three-dimensional space rather than two-dimensional space like photographs, making it more suited to science, physics, and other topics. Virtual reality technology is utilized for complex skills training and can decrease experience hazards and expenses. It's a robust environment where users may manipulate time, scale, and physics. Participants get access to brand-new features such as flying in a virtual world, driving any object using virtual characters and seeing the environment from numerous perspectives (Muhanna, 2015). Understanding many viewpoints is a mental and social talent, and virtual reality allows students to develop this skill in ways that are not feasible in the actual world (Bricken, 1991).

Unreal Engine 4 is a game development engine launched by Epic Games. Compared with other engines, Unreal Engine is not only efficient and versatile but also can directly preview development effects, giving developers more substantial development capabilities. Unreal Engine 4 has added VR production functions since 2015, and through multiple versions of optimization, it has become one of the preferred choices for VR content production. This platform can provide support for teachers and learners, aiming to improve the quality of learners' experience. After a specific training, teachers can easily add various VR interactive content to their courses and present them in VR games (Rüdel et al., 2018).

The author developed a VR game introducing cameras using Unreal Engine 4 as part of a case study from a learner's perspective. In this VR, students can learn about the camera's various functions and usage methods through interaction and can shoot video in different virtual environments. The presented case study was used at the Sichuan Media Institute in Sichuan Province, China, where a class was formulated as an experimental group using VR for teaching. When interacting with the VR game "*Free Camera*," we evaluated the learner experience and game usability. The following is the outline of the paper. The following part explains the research's theoretical foundation and highlights research initiatives in higher education institutions that employ novel technologies such as virtual reality and augmented reality. The following section includes a description of the VR game "*Free Camera*," an outline of the case

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study, and an analysis of the findings. In the concluding portion, the article mediates the observed results and plans.

## 2. Related Work

In the research on the application of virtual reality technology in education, Youngblut (1998) conducted a comprehensive survey of the work in this field and listed about 50 VR-based learning applications. The Human-Computer Interface Technology Laboratory of the University of Washington has always been one of the hotbeds of early education for VR. Its projects include the Virtual Reality Rover and the VR summer camp program for students (Bricken, M & Byrne, 1993). Students use 3D modeling software on desktop computers to design and construct virtual items as part of a project. Lee, Wong, and Fung (2010) guided students to dissect virtual frogs. Coller and Scott (2009) created a video game for mechanical engineering students to replicate a car on the track. Students develop software programs and understand concepts like thermodynamics during this design process. Medical students are taught via immersive virtual reality, and virtual reality technology is used to deliver surgical training simulations to students.

According to studies, virtual reality technology is thought to provide low-cost training chances for medical students effectively. The abilities obtained in the simulation are equivalent to those acquired in the drying laboratory simulation when employing virtual reality technology. This technology has the potential to assist students and play a significant role in medical education today. Furthermore, surgical training simulation can be performed as a warm-up tool before surgery to assist surgeons (Salzman et al., 1999; Mathur, 2015; Ruthenbeck & Reynolds, 2015; Bric et al., 2016; Sattar et al., 2020; Zhao et al., 2020).

In special education, virtual reality technology is also applied; powers believe that virtual reality technology has potential solid applications in the plans and services provided for the disabled. Some of the uses are modeling, flexible instructional design, realistic training settings, robotics, alternate sensory experiences, stimulus control, and orientation and mobility training. According to research, people with disabilities benefit from the employment of virtual reality technology in an HCI context. Virtual reality technology is mainly used to identify symbols in the case of deaf persons, and the results are positive. On the other hand, virtual reality technology is insufficient for more complex recognition and bidirectional translation. Other aids, such as artificial intelligence, must be found (Sobota & Korečko, 2013).

Another prominent innovative technology adopted in higher education is Augmented reality (AR). It is another tool that allows students to understand complex topics better. AR can integrate and directly manipulate natural objects, such as textbooks, in traditional classrooms. Interaction is no longer limited to using a mouse and keyboard, as it is with web-based learning. As a result, students must learn new interaction strategies, which may cause usability difficulties in terms of comprehensibility, learnability, operability, and extra usability concerns in terms of perception, workload, quick feedback, interaction, and user and task compatibility. AR is a hands-on learning experience that blends 3D, multimodal interaction, animation, and direct manipulation to increase student engagement. The increased interest in AR's educational usefulness is due to new chances to create more productive and engaging learning environments. In various ways, AR-based apps can aid in the development of new learning paradigms. AR facilitates the transfer of theoretical information from analytical activities to practical experience gained through creative actions (Pribeanu et al., 2017).

AR has the potential to improve understanding of discipline-specific concepts, such as the spatial structure of molecules in chemistry. Nechypurenko et al. (2018) appreciate that students can learn more and better from hands-on experience than traditional lectures. Students can better understand basic chemical concepts by interacting with virtual compounds and various chemical structures. Based on pedagogical evaluations of two AR-based learning

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scenarios, Lee (2012) concluded that intuitive 3D visualization and manipulation of natural objects are the main qualities of AR as learning outcomes that lead to faster and more accurate understanding and Mastery of information and better focus during the learning process.

Experiments play a critical role in the educational process. The shortage of equipment and resources in laboratories and the expensive expense of maintaining laboratories due to the restricted funding available to schools is a typical challenge experienced by many colleges and universities. Recent technological advancements such as virtual reality (VR), augmented reality (AR), smart glasses, and smartphones, on the other hand, provide schools with an excellent opportunity to take advantage of low-cost 3D virtual learning environments that support simulation and observation of various experiments. These virtual learning environments allow students to explore without the limits of location or time, and they are available all year, even at home.

## 3. VR Game Free Camera Application Description

VR game *Free Camera* is an interactive 3D immersive computer-based video camera teaching game developed with Unreal Engine 4 and used with the Oculus quest2 VR headset. The teaching content is integrated into the VR game. Through the play, students can understand the functions of the buttons on the camera and the parts of the options of the built-in menu of the camera and can directly use the camera to complete the shooting work in the VR game. *Free Camera* provides a game interface that is the same as the camera interface, including parameters such as aperture, shutter speed, white balance, and sensitivity that need to be adjusted during shooting, as shown in Figure 1(a). At the same time, *Free Camera* provides different game scenes, and learners can complete the shooting work in other locations, as shown in Figure 1(b).


a) Free Camera Game Interface


b) Free Camera Game Scene

**Figure 1.** VR GAME *Free Camera* Application

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To facilitate learners to learn more knowledge in the game, the game provides instructions in audio and text formats to guide learners to understand the game content and game methods further. The camera status and functions presented in *Free Camera* are consistent with the actual camera, and the camera is entirely reproduced. The steps followed in the design and development of VR games are similar to previous studies (Menin et al., 2018), including target specification, application model, scene construction, VR device matching, blueprints, development of educational content (audio track and text), learner satisfaction assessment development, teaching quality control and game dissemination. This VR game is developed based on teachers' suggestions and comments on educational content; it follows the curriculum and achieves expected learning outcomes.

## 4. Case Study Description

### 4.1. Evaluation Methodology

The VR game *Free* Camera was adopted and evaluated as a case study conducted at a higher education institution in Sichuan Province, China. Approval by the Academic Committee of the Sichuan University of Media and Communications was obtained before conducting the study, which met all ethical requirements. All forms provided to students and teachers during the case study are shown in Table 1.

**Table 1.** Documentation for the VR game Project *Free Camera* Application

| Document/From | Experimental Group |
|---|---|
| Ethics Approval (from the academic committee) | Include |
| Assent Form (signed by students) | Include |
| Simple experimental statement | Include |
| Data collection plan | Include |

As demonstrated in Table 2, the case study provided in this research involves an experimental group of learners and comprises multiple phases. This research aims to explain the findings of the learner satisfaction questionnaire experimental group because it has previously been demonstrated that the VR game supplied the experimental group with a statistically significantly higher knowledge gain than the control group.

**Table 2.** The VR game Project Free Camera application case study step

| Step | Experimental Group |
|---|---|
| Step 1: Pre-test of knowledge | Include |
| Step 2: VR game Project *Free Camera* application | Include |
| Step 3: Questionnaire | Include |
| Step 4: Post-test of knowledge | Include |

### 4.2. Participants

The case study presented in this paper was conducted at the Sichuan University of Media and Communications in Sichuan Province, China. A first-year class participated as an experimental group (N=30), aged 17-19.

### 4.3. Data Collection During

In the experimental group course, students took classes in the VR lab. The lab was equipped with a computer and an oculus quest2 VR headset, and the VR game *Free Camera* was installed on the computer. All of them completed the matching with the oculus quest2 VR headset.

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Students can run the VR game *Free Camera* through the Oculus quest2 VR headset. The teachers in the experimental group guided the course and assisted students in providing guidance.

The Learner Satisfaction Questionnaire was provided to the practical classes, which included the following questions:

1. The VR game helps me better understand the function and usage of the camera.
2. The VR games I did in the virtual lab helped me understand what the camera does and how to use it more easily.
3. I use VR games in the virtual lab to make the lessons more practical.
4. I enjoy this lesson and the immersive experience that virtual reality games provide.
5. I would like more courses to include VR game teaching content.
6. VR games distract me from studying.
7. Suggestions and remarks.

The Learner Satisfaction Questionnaire answers to Q1 through Q6 are on a 5-point Likert scale ranging from strongly agree to strongly disagree, where 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.

## 5. Results

### 5.1. User Experience When

Questions 1 to 6 (Q1 to Q6) described in the data collection section were surveyed when evaluating user experience. Table 3 presents the obtained answers on the 5-level Likert scale—strongly disagree, disagree, neutral, agree, and strongly agree, indicating a good user experience. Notably, 80% of students found that the VR game *Free Camera* helped better understand the camera's function and usage (Q1). More than 76% of students felt that the VR game helped them understand the topic at hand more easily (Q2), and more than 73% liked incorporating VR games into teaching. More than half of the students in the experimental group believed that the VR game made the course more practical (Q3), about 66% of the students loved the immersive experience that virtual reality games provided(Q4), and more than 73% of the students hoped to use the VR game to join more courses (Q5). More than 16% of students felt that the VR game *Free Camera* distracted them from studying (Q6).

**Table 3.** Group of experimenters Questions 1–6 on the Learner Satisfaction Questionnaire

| | Strongly Agree | | Agree | | Neutral | | Disagree | | Strongly Disagree | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NO. | % | NO. | % | NO. | % | NO. | % | NO. | % |
| **Q1** | 10 | 33.33 | 14 | 46.67 | 6 | 20.00 | 0 | 0.00 | 0 | 0.00 |
| **Q2** | 8 | 26.67 | 15 | 50.00 | 5 | 16.67 | 2 | 6.66 | 0 | 0.00 |
| **Q3** | 12 | 40.00 | 10 | 33.34 | 7 | 23.33 | 1 | 3.33 | 0 | 0.00 |
| **Q4** | 10 | 33.34 | 10 | 33.33 | 7 | 23.33 | 3 | 10.00 | 0 | 0.00 |
| **Q5** | 9 | 30.00 | 13 | 43.34 | 6 | 20.00 | 1 | 3.33 | 1 | 3.33 |
| **Q6** | 0 | 0 | 5 | 16.67 | 6 | 20.00 | 12 | 40.00 | 7 | 23.33 |

### 5.2. Usability

The usefulness of the VR game was evaluated using responses to question 7 of the learner satisfaction questionnaire (Suggestions and remarks). Because this was an optional question, 18 students in the experimental group elected not to respond. The remaining 12 students (40%) gave helpful input on the project proposal, with comments including: "The VR head library can cause slight dizziness" and "Controlling the duration of use makes for a better experience." Five students reported the slight dizziness caused by the VR headset and said that "if the use time is controlled within 20 minutes, dizziness will not easily occur". Three classmates suggested

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adding a complete high-precision three-dimensional camera model to the VR game, which would help students get a similar experience to using a real camera. Four classmates suggested "adding more different scenes to keep the game fresh."

## 6. Conclusion

The research work presented in this paper is part of the functional acceptance project of the Virtual Reality Laboratory of the Sichuan University of Media and Communications, describing the application of a VR game made in Unreal Engine 4 in teaching, providing a description of the VR game and its participating cameras The main teaching content is the introduction of functions and usage methods. A case study run at a higher education institution investigated the usability of VR gaming in the learning environment and its impact on the experience. Feedback on the VR games used was collected through a satisfaction questionnaire. Together with the previously presented experimental group's statistically significant gain in knowledge while using this VR game, it was compared to the control group. From the student feedback, it was found that more than 66% of the students like to use the VR game *Free Camera* for learning. According to the students participating in the game, the VR game will add battery attenuation to limit the duration of each use by the students by simulating the battery usage of the camera. And an additional new interface is added to display a high-precision 3D model of the camera and annotate the function of each button. The VR game *Free Camera* is a VR game developed by the author. It is used in the teaching of camera courses. It is an objective presentation of the teaching effect of the virtual technology laboratory of Sichuan University of Media and Communications. In the future, we will try to enrich this VR game join the online teaching platform MFCUST (www.icourse163.org) for dissemination.

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## References

[1] Ai-Lim Lee, E., Wong, K. W., & Fung, C. C. (2010). How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. Computers and Education, 55(4), 1424–1442. https: //doi.org/10.1016/j.compedu.2010.06.006.

[2] Allcoat, D., Hatchard, T., Azmat, F., Stansfield, K., Watson, D., & von Mühlenen, A. (2021). Education in the Digital Age: Learning Experience in Virtual and Mixed Realities. Journal of Educational Computing Research, 59(5), 795–816. https://doi.org/10.1177/0735633120985120.

[3] Bric, J. D., Lumbard, D. C., Frelich, M. J., & Gould, J. C. (2016). Current state of virtual reality simulation in robotic surgery training: a review. Surgical Endoscopy, 30(6), 2169–2178. https:// doi. org/ 10. 1007/s00464-015-4517-y.

[4] Bricken, M, & Byrne, C. (1993). Summer Students in A Pilot Study on Educational Virtual Reality: Applications of Virtual Reality Technology. In Toronto: Academic Press Professional.

[5] Bricken, M. (1991). Virtual reality learning environments: potentials and challenges. ACM SIGGRAPH Computer Graphics, 25(3), 178–184. https://doi.org/10.1145/126640.126657.

[6] Cipresso, P., Giglioli, I. A. C., Raya, M. A., & Riva, G. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. Frontiers in Psychology, 9(NOV), 1–20. https://doi.org/10.3389/fpsyg.2018.02086.

ISSN: 2688-8653

[7] Hu Au, E., & Lee, J. J. (2017). Virtual reality in education: a tool for learning in the experience age. International Journal of Innovation in Education, 4(4), 215. https:// doi.org/ 10.1504/ ijiie. 2017.1 0012691.

[8] Lee, K. (2012). Augmented Reality in Education and Training. TechTrends, 56(2), 13–21. https: // doi. org/10.1007/s11528-012-0559-3.

[9] Menin, A., Torchelsen, R., & Nedel, L. (2018). An Analysis of VR Technology Used in Immersive Simulations with a Serious Game Perspective. IEEE Computer Graphics and Applications, 38(2), 57–73. https://doi.org/10.1109/MCG.2018.021951633.

[10] Muhanna, M. A. (2015). Virtual reality and the CAVE: Taxonomy, interaction challenges and research directions. Journal of King Saud University - Computer and Information Sciences, 27(3), 344–361. https://doi.org/10.1016/j.jksuci.2014.03.023.

[11] Nechypurenko, P. P., Starova, T. V., Selivanova, T. V., Tomilina, A. O., & Uchitel, A. D. (2018). Use of augmented reality in chemistry education. CEUR Workshop Proceedings, 2257, 15–23. https:// doi. org/10.31812/pedag.v51i0.3650.

[12] Nora, A., & Snyder, B. P. (2008). Technology and higher education: The impact of E-learning approaches on student academic achievement, perceptions and persistence. Journal of College Student Retention: Research, Theory and Practice, 10(1), 3–19. https://doi.org/10.2190/CS.10.1.b.

[13] Okechukwu, M., & Udoka, F. (2011). Understanding Virtual Reality Technology: Advances and Applications. Advances in Computer Science and Engineering, March. https:// doi. org/ 10.5772/ 15529.

[14] Pantelidis, V. S. (2010). Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality. Themes in Science and Technology Education, 2 (1–2), 59–70.

[15] Pribeanu, C., Balog, A., & Iordache, D. D. (2017). Measuring the perceived quality of an AR-based learning application: a multidimensional model. Interactive Learning Environments, 25(4), 482–495. https://doi.org/10.1080/10494820.2016.1143375.

[16] Rüdel, M. O., Ganser, J., Weller, R., & Zachmann, G. (2018). UnrealHaptics: A plugin-system for high fidelity haptic rendering in the unreal engine. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 11162 LNCS (January), 128–147. https://doi.org/10.1007/978-3-030-01790-3_8.

[17] Ruthenbeck, G. S., & Reynolds, K. J. (2015). Virtual reality for medical training: The state-of-the-art. Journal of Simulation, 9(1), 16–26. https://doi.org/10.1057/jos.2014.14.

[18] Salzman, M. C., Dede, C., Loftin, R. B., & Chen, J. (1999). A model for understanding how virtual reality aids complex conceptual learning. Presence: Teleoperators and Virtual Environments, 8(3), 293–316. https://doi.org/10.1162/105474699566242.

[19] Sobota, B., & Korečko, Š. (2013). Virtual Reality Technologies in Handicapped Persons Education. Inase.Org, I. http:// www. inase.org/ library/2014/ santorini/bypaper/ COMPUTERS/ COMPUTER S1-18.pdf.

[20] Steure, J. (1993). Defining virtual reality: Dimensions determining telepresence. Journal of Communication, 42(4), 73–93.

[21] Tegarden, D. P. (1999). Business Information Visualization. Communications of the Association for Information Systems, 1, 1–38. https://doi.org/10.17705/1cais.00104.

[22] Tenberg, R. (2015). Learning in a Mixed Reality System in the Context of Herausgeber Bernd Zinn. Jounal of Technical Education.

[23] Van Krevelen, D. W. F., & Poelman, R. (2010). A Survey of Augmented Reality Technologies, Applications and Limitations. International Journal of Virtual Reality, 9(2), 1–20. https:// doi. org/ 10. 20870/ijvr.2010.9.2.2767.

[24] Youngblut, C. (1998). Educational Uses of Virtual Reality Technology. IDA Document D-2128, January, 131. http://www.hitl.washington.edu/scivw/youngblut-edvr/D2128.pdf.

ISSN: 2688-8653

[25] Zhao, R., Geng, J., & Shen, Y. (2020). Digital media vision innovation based on FPGA and Convolutional Neural Network. Microprocessors and Microsystems, November, 103465. https:// doi. org/10.1016/j.micpro.2020.103465.