A VRLE Design Scheme for the Learning of Film Making

Xi Qiao, Zhejun Liu(✉), and Yunshui Jin

College of Arts and Media, Tongji University, Shanghai 201804, China
719548157@qq.com, {wingeddreamer, jinyunshui}@tongji.edu.cn

Abstract. Education of film making has made great progress since the earliest film and television departments were established in American universities in early 1960s. Nowadays, students can learn theories and techniques of film making either online or in a classroom. But the cost of actually shooting a film for practice purposes is still too high and keeps many learners from getting enough training. In recent years, with the development of science and technology, virtual reality (VR) has been applied to various fields, including medicine, entertainment, education, military, and aerospace. The application of VR technology will promisingly become the next big leap in the future development of education. This paper focuses on how to effectively design a virtual reality learning system to help future film makers solve the problem of insufficient practice in resource-constrained situations. A prototype of the system was developed based on prior research conclusions, and 12 participants were recruited to experience the system and answer questionnaires followed by in-depth interviews. The qualitative research results shew that the practice carried out in a virtual reality environment was certainly usable and effective. In conclusion, virtual reality technology may very likely play an important role in the education of film makers.

Keywords: Virtual reality · VRLE · Film making · E-learning

1 Background

1.1 E-learning

The progress of key educational technologies in the past 30 years has transformed the prevailing teaching models from traditional in-classroom lecturing to a contemporary one in which people can learn through electronic devices at any time in any place. E-learning has become an important and ubiquitous learning and teaching mode [1], which is characterized by adopting modern scientific and technological products and centering on learners. A new teaching mode with a large number of resources for learners to share was thus created [2]. At present, e-learning mainly involves the following technologies and applications: online learning platforms based on network technology, serious gaming applications based on computer technology, simulations (e.g. virtual laboratory) based on virtual reality technology, and etc. [3–5].

Virtual reality (VR) is an integration of computer technologies, including computer graphics, simulation technologies, artificial intelligence, sensor technologies, display

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technologies and so forth. It is an interdisciplinary, cutting-edge and challenging research field. In a computer-generated virtual environment with multiple interactable targets, users may enjoy an immersive experience. Today, VR technology has been widely recognized and used in medicine [6], architectural [7], education and other fields. The application of VR technology will hopefully become the next great leap in the future development of education. By creating an environment suitable for self-learning, it changes the learning pattern from the traditional lecturing and listening to a new one in which learners acquire knowledge and skills proactively through the interaction with the environment. For example, in the field of medical education, VR has been used to reproduce complex human body structures to help students to study [8]. Irina Makarova et al. have discussed the application of VR technology to the automotive industry and automotive engineering education [9]. They proposed suggestions for the construction of an education system totally through VR technology. In China, VR simulations have been applied to and highly valued in the education of physics and sports [10]. Teresa Monahan et al. [11] proposed an example showing the application of VR technology in collaborative e-learning in which users were enabled to break the limitation of time and space to learn together "in a virtual classroom" with VR glasses.

In summary, VR simulations allow learners to see the result of their actions immediately, clearly and safely at a very low cost and this characteristic makes it very suitable for solving the problem of lacking practices due to limited resources.

1.2 Film Making

With the continuous development of the film industry, the requirements for a professional film maker are constantly changing, so the education should evolve and change accordingly. The traditional way of film education was like this: students listened to lectures in a classroom, watched some movies as examples, and was given chances to practice several times in one semester [12]. As a future creative worker, practice and training are essential for them to truly understand the theories and to master the skills [13]. Sufficient shooting practice can enable students to skillfully understand the use of film language and Mise-en-scène [14]. Repeated attempts to tell stories in different ways can also inspire learners. However, it is expensive and difficult for a student, or maybe even a school to build scenes and to hire actors just for learning purposes in real life. Furthermore, usually equipment and space in schools are often fully booked for specific plans [15], which also stops students from practicing freely and sufficiently. Therefore, it is worth seeking new solutions with the help of the latest technologies.

2 Aim

"Film language" refers to the language used to communicate thoughts and feelings through shots and events composed of a combination of images and sounds [16], which is basic knowledge for film makers. At the core of it is a variety of theories about the use of composition, layout, montage and etc. [17] To learn the course of film language well, one must work hard both theoretically and practically. It is a miniature of the process of learning film making.

The aim of this research was to use VR technology to create a system for learners to use easily and economically, so as to provide sufficient and effective practice they need in their education. A qualitative evaluation of the system was conducted to verify its effectiveness.

3 Experiment

3.1 Design of the "VR Film School"

The virtual training system used in this research was developed by the Non-Planar Screen Lab in the College of Arts and Media in Tongji University. It was named "VR Film School" (VRFS in short). Centering around users, VRFS aimed to allow them to explore freely and practice easily just with the help of simple guidance. Hopefully, its users could actively construct the meaning of knowledge by themselves in this process (Fig. 1).

(a) Original film

(b) Recreation in VR

Fig. 1. "Tales of Afanti" - the original film and the recreation in VR

VRFS used a segment from the famous Chinese animation "Tales of Afanti" produced in 1980s as a reference. The scenes and characters were rebuilt with 3D animation techniques. Figure 2 shows the design structure of VRFS. It was divided into three parts: *learning part*, *practice part*, and *evaluation part*.

The *learning part* included: 1. Introduction to 8 common types of shots via example movie clips; 2. Instructions on how to operate the virtual shooting and editing system.

The *practice part* included: 1. Shooting: A user was allowed to freely point and shoot in the virtual environment using the Vive controllers as a virtual camera. He or she also had the ability to lock the camera's position and/or rotation, which was similar to the use of a tripod. The virtual actors only moved when the trigger was pulled down and stopped immediately when it was released to allow changes of the location and orientation of the virtual camera so as to allow montage. 2. Simple editing: A user might also at any time go to the playback mode to review what had been recorded and perform basic non-linear editing by reshooting the unsatisfying parts.

The *evaluation part* included: 1. Watching: After the film had been fully recorded and confirmed by a user, he or she would enter a virtual cinema to appreciate his or her own work. 2. Movie export and sharing: At the end of the experience, the user's own work would be recorded as a video file so that he or she may keep it for later review or share it with instructors and friends. The procedures of using VRFS is shown in Fig. 3.

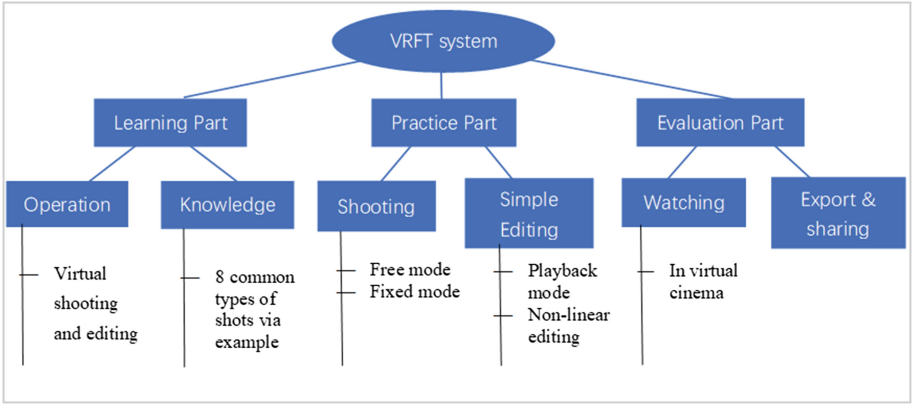


Fig. 2. Structure of VR Film School

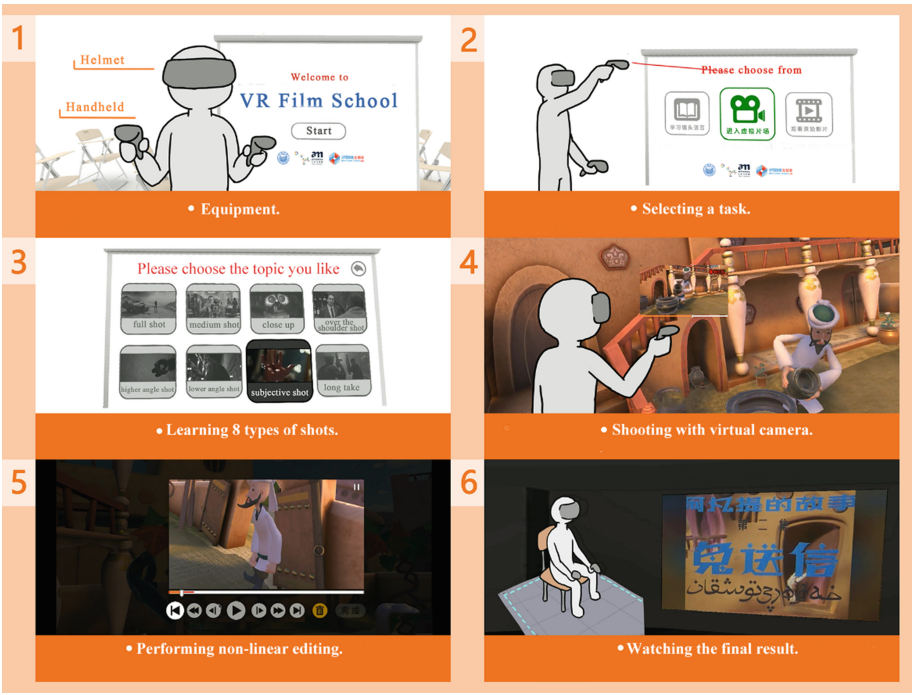


Fig. 3. Storyboard of VR Film School

3.2 Subjects

12 students from Tongji University were recruited to participate in the experiment. 8 of the participants studied in majors relevant to film making, namely "Editing and Directing of Films and TV Programs" (EDFT in short), "Animation" and "Advertising", while the other 4 participants studied in other fields. Half of the students from relevant majors were beginners (freshmen or sophomores), and the other half were more sophisticated learners with more than 2 years of experience. The participants' basic information is shown in Table 1.

Table 1. Basic Information about the Subjects = 12)

	N	%
Gender		
Female	5	42
Male	7	58
Major		
Animation	5	42
EDFT	2	17
Advertising	1	8
Other	4	33

(*continued*)

Table 1. (*continued*)

	N	%
Grade		
Freshman & Sophomore	5	42
Junior & Senior	5	42
Graduated Students	2	16
Had VR experience before		
Yes	7	58
Never before	5	42
Had film shooting experience with a real camera before		
Yes	9	75
Never before	3	25

3.3 Research Ethics

All participants were informed of the purpose of the study and agreed to have the interview recorded before the experiment began. They were also informed of the possible uncomfortableness and/or motion-sickness of the VR experience and their right to quit the experiment at any time at their free will. The experience of VRFS took about 20 min, and the subsequent in-depth interviews lasted for 20–30 min. The duration of the experiment for one participant was controlled within one hour.

3.4 Procedures

The experiment was held in the College of Arts and Media at Tongji University. After experiencing VRFS, the participants were asked to complete a short system usability questionnaire (described in Sect. 4.1) followed by an in-depth interview about his/her opinion of the system. The interviews were semi-structured and the main topics for discussion were as follow:

- What problems did you encounter when you shot a film in reality?
- How do you feel after experiencing VRFS?
- Are you willing to practice using VRFS frequently?
- In your opinion, what is the best way to practice film making?

3.5 Data Analysis

The questionnaire in this study rooted in Brooke's "System-Usability-Scale" questionnaire (SUS for short) compiled in 1986. It worked well for small sample sizes ($n < 14$). Aaron Bangor et al. [18] proposed an adjusted SUS questionnaire and verified the validity and reliability of it. It was further finetuned to suit the VRFS system in this study, reflecting the overall satisfaction of the respondents. Data obtained from the SUS questionnaires was then compiled and analyzed in a way proposed by Bangor et al. [19].

Records of the in-depth interviews were transcribed by software and then manually revised. The interview data was then coded and analyzed in Nvivo 11, a program for qualitative research. First, by open coding, 347 nodes were extracted and formed from the questions and answers. Participants and questions were also marked as independent nodes for the purpose of multi-angle analysis later. At this stage, reflections and inspirations were written in the memo and linked to corresponding nodes.

After the initial coding was finished, a second pass of coding, namely focus coding was performed: by classifying and merging nodes according to topic relevance, nodes were arranged into a tree structure, which made it easier to see the relationship of nodes and to rearrange, combine and delete nodes when appropriate.

Finally, theoretical coding was carried out to define the attributes of the interviewees by majors, grades and prior filming experience. The matrix query function was used to explore how users with different attributes evaluate the usability, emotional tendency and subjective effectiveness of VRFS differently.

4 Results

4.1 Data from the Questionnaires

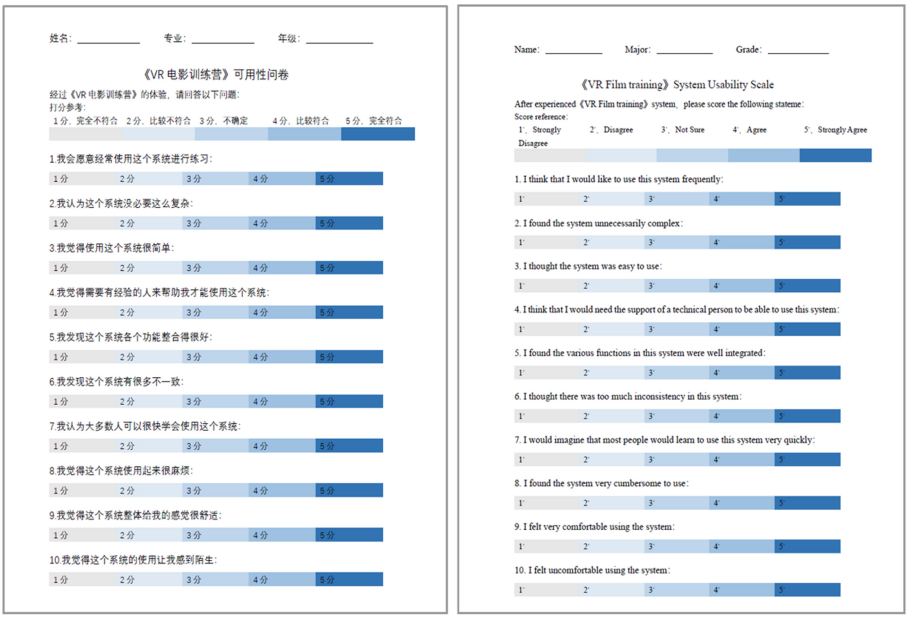
The SUS questionnaire contained only 10 questions so as to allow quick feedback. The odd ones were positive statements and the even ones were negative. The fourth and tenth statements provided information in the learnable dimension, and the other eight, in the usability dimensions [19]. In this study, the last two statements were changed to ask about users' feeling after his/her experience, which also provided information in the usability dimension, but put more emphasis on knowing about a user's subjective feeling. Finally, because all participants were Chinese, a translated version of the SUS questionnaire was used in the study (Fig. 4).

According to the recommendations given by Bangor et al. [20], the scores of the questionnaires were calculated in the following way:

- For odd items: subtract one from the user response
- For even-numbered items: subtract the user responses from 5
- These scales all values from 0 to 4 (with 4 being the most positive response).
- Add up the converted responses for each user and multiply that total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40.

The scores from the 12 questionnaires were between [52.5, 92.5] with an average of 74. Four questionnaires from participants in non-relevant majors scored 67.5, 67.5, 85, 90, with an average of 77.5, reflecting a higher level of user satisfaction. The average score of the other 8 questionnaires was 72.2. The average scores of beginners and experienced learners were 72.5 and 71.2 respectively.

The fourth statement in SUS questionnaire was "I think that I would need the support from a technical person to be able to use this system.", intending to reveal the system's learnability. The resulting average was 2.2 (total score = 4), which was not very high. Unexpectedly, VRFS was more learnable for students from non-relevant



(a) the Chinese version of the SUS questionnaire in use **(b) the English version of the SUS questionnaire in use**

Fig. 4. Questionnaire-SUS

majors, with an average score of 2.5. The scores of the beginners and experienced learners from relevant majors were 1.8 and 2.3.

The total average of the 9th and 10th questions was 5.8 (total score = 8) which meant that the subjective feeling of VRFS was fairly good for all the participants. The average score from participants in relevant and non-relevant majors was 5.5 and 6.3 respectively as shown in Fig. 5.

The original purpose of SUS was to measure usability quickly and dirtily [21], so this was a suitable way to recognize problems before conducting in-depth research. As Jeff Sauro [22] pointed out, the SUS score was not a percentage but rather revealed the overall satisfaction of the participants. Through many empirical tests [23], it was verified that a SUS score above 68 meant good user satisfaction. But because the questionnaire could only offer a single score, the reasons behind it and a user's true feelings must be explored using other methods, namely in-depth interviews to be discussed next.

4.2 Data from the Interviews

After sorting out the interview data from all participants, it was open-coded and formed 347 nodes according to the content analysis in Nvivo. At this stage, nodes only belonged to the specific case from which they were generated. The next stage was classifying and merging nodes according to the topics so as to generate data trees as shown in Fig. 6. Thirdly, a second pass of coding was performed through further

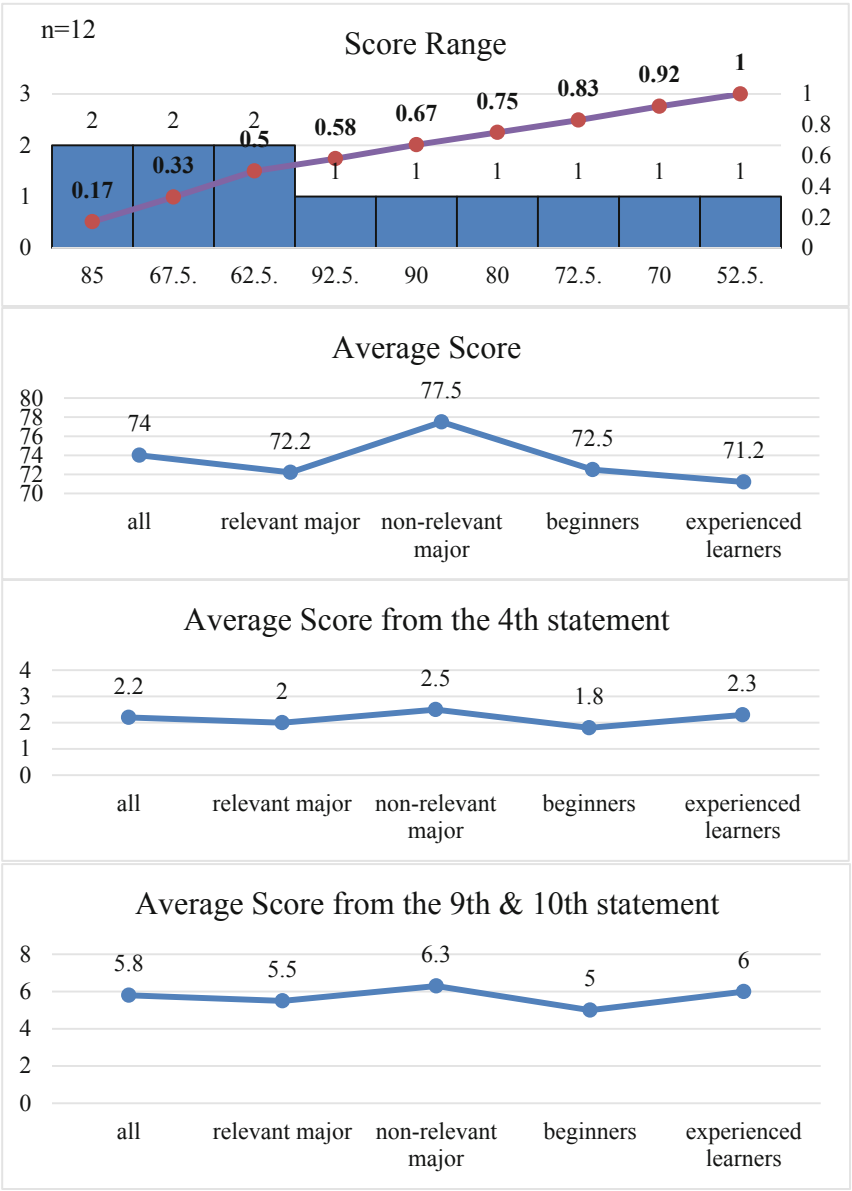


Fig. 5. SUS Score

conceptualization to summarized and to obtain the final conclusion. The conclusions shown in Fig. 7 are drawn from three perspectives: "usability and subjective effectiveness", "emotional tendency", and "target people and suggestions" (described in Sects. 4.3–4.5).

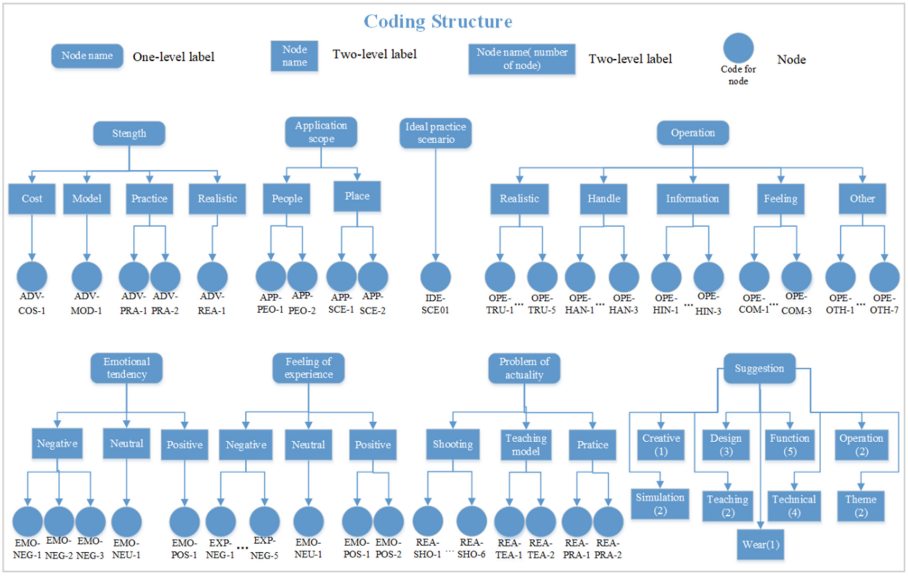


Fig. 6. Nodes Structure in second stage

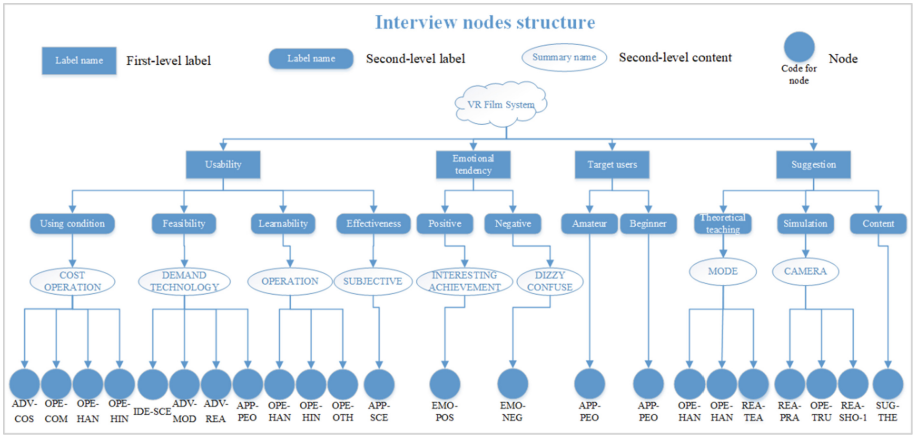


Fig. 7. Interview nodes structure in final

5 Analysis

Qualitative research was conducted to verify the participants' opinions toward VRFS. The conclusions were basically categorized into three groups: "usability and subjective effectiveness", "emotional tendency", "target people and suggestions".

5.1 Usability and Subjective Effectiveness

Usability. The usability here refers to the participants' evaluation of VRFS from various angles, including use conditions, learnability, feasibility of operation, function, and content. Most participants gave high marks to the usability of VRFS and believed that the system could be effectively mastered after simple and quick learning. This was coincident with our original intention when designing this system.

Nan: I think this system is very comfortable to use… I think it's very enjoyable.
Chuan: I think the usability is quite high… I think this technology, VR, is to solve the problem of time and space. So, I think this system is quite good.

Several participants expressed their views on the usability of VRFSs from the perspective of accessibility. They believed that it would be very expensive in real life to arrange a scene, to hire actors, to purchase equipment and etc. It was also restricted by time, weather and other environmental conditions. In contrast, the practice method proposed by VRFS was very convenient and accessible. One only needed a small open space, a computer and an HMD to use it. As for the space for practice, some participants suggested that it should be done in a familiar space or at home. Because when wearing a helmet, one would be isolated from the outside world. For safety reasons, it would be better to use virtual reality systems, including VRFS, in familiar environments.

Wang: Umm…When shooting in reality, the problem is that resources are difficult to obtain, such as all equipment, manpower, and actors. In contrast, this system will be a good choice (for practice).
Qian: Well, I feel that this idea is very good…. Well, I think there is a learning process happening with this kind of system… I think this kind of learning is more vivid. If you practice in real life, it is unlikely that you will find a suitable scene at your disposal and actors willing to cooperate with you, so this form is better.
Pan: I used to film with my mobile phone. I needed to stand on the stool for a look down shot. I climbed up and down often and it's very tiring. But I've never encountered a similar problem in this system… It would be better if I could practice in an environment where no one is around so that I don't need to worry about whether I might seem strange in others' eyes.

Participants also discussed the feasibility of using VRFS in practical education. Participants thought that the learning mode proposed by VRFS was innovative and had great potential. Yet this system needed more content to be a complete educational platform. Some participants believed that VRFS had a good potential commercial value. With more scenes and performances added to it, VRFS might bring people, even with little knowledge of film making, a wonderful and novel experience by allowing them to merely appreciate different stories in VR. And hopefully they might also learn something about film language.

Yu: This system will be great if you can enrich the content so that you can have different training scenarios. But I can imagine the development will need a lot of time.
Yuan: …if it is promoted as an entertaining device, I am actually willing to buy this. It is interesting.

The participants possessed different opinions about the learnability of the operations. Some thought VRFS was relatively complicated to use. There were too many buttons to remember and one needed to operate the camera with two controllers at the

same time. It took some time to learn and to get used to. This was the reason for the low usability score from the SUS questionnaires. Some other participants, however, said that they could grasp the operations without difficulty. They could understand that in order to mimic to real camera, the operations would inevitably be complex to some extent. But they also suggested that the operations be described in more details in the tutorial session so as to make later use easier.

Wen: I think this system is a little bit too complicated for amateurs, but if the purpose is to serve students majoring in film making as a practice tool, of course, he can spend enough time to learn how to use this system very well… It is mainly because there are a lot of buttons on the controllers and it is complicated for me to use.
Li: I think that the functions of buttons are a little bit too complicated. If there were only one button, the operations would be much easier to determine. So many buttons, separated on two controllers, are somehow confusing.

Effectiveness (subjective). From the perspective of the effectiveness, almost all participants believed that using VRFS is helpful for learning film making. VRFS simulated the operations of a real camera, so that beginners might have a close-to-reality experience and form a basic understanding of how cameras worked. Some participants even thought that the system had certain advantages that the actual practice could not offer. For example, VRFS allowed a user to try to take the same shot from many different angles which was almost impossible in real life.

Xin: It is a good way of learning for students, umm, because it allows you to experience filming in a much more real way than a software running on a desktop computer.
Zheng: I think it would be helpful to learn how to use different types of shots. When you experience VRFS, you need to design shots on your own by moving the virtual camera around, similar to what you do in reality. Therefore, I think it may be helpful to film language learning..

On the other hand, some other participants thought that the current version of VRSF should further improve the simulation of reality. For example, the horizontal indicator of a camera, very important to film makers, was missing. Besides, it was also a problem mentioned by some participants that all the lights were predefined, not allowing user adjustment. Moreover, the virtual experience disturbed the judgment of some participants, which was an important thing many participants hoped to improve.

Tang: It will be better to allow all different kinds of shots possible in the real world.
Dong: In real life, you can clearly distinguish the real world and its representation in a camera's viewfinder, but the virtual environment gives me a lot of trouble: what you see in the helmet is virtual, and what you see in the viewfinder is also virtual. This nested virtuality bewildered me sometimes.
Qian: This system can be more realistic with the ability to allow light adjustment. In this way, more kinds of practices can be done and the system will be better.

5.2 Emotional Tendency

Most of the participants showed a positive emotional tendency, and almost all participants were willing to use VRFS frequently.

The advocates in non-relevant majors agreed that they had not only a very pleasant learning experience but also an unprecedented VR enjoyment. The whole process was very interesting and they really learned something from it, making it even more

rewarding and attractive. Most of the advocates from relevant majors supported VRFS because of its unique convenience, immersion and interesting interaction. Generally speaking, fun of use is the main reason for attracting them, but to be more helpful to those advanced users, VRFS needs to enhance perceivable realism.

Nan: I think the experience from start to the end is very interesting. Well, first of all, it is new. I have never heard about a similar system before. The fact that you can make a short film of your own is very attractive to me.
Jiang: If I can use VRFS in my course for daily training, I am willing. Because it does show some benefits as a training method.

Only three participants said they were less willing to use VRFS again. Two participants expressed their reluctance to continue because of the discomfort of wearing the VR helmet. The other one doubted that there was a large difference between the virtual and the real experience as far as operation was concerned.

Yang: The helmet pressed my face hard. I felt uncomfortable.
Wen: I think it is not very friendly to people with glasses. It pressed my glasses hard.
Jiang: I don't want it, I think it might feel better to shoot with a real camera.

5.3 Potential Target Users

During the interview, many participants mentioned the potential target users of VRFS. After data analyzing and coding, the characteristics of them and the reasons for this conclusion are as follow.

Target Users. Most participants believed that VRFS was more suitable for two types of people: (1) junior students in majors relevant to film making and (2) amateur film makers.

For junior students just started to learn about film language, the participants agreed that they did need adequate training to understand it better. But for beginners, practice opportunities were usually scarce, and the operation of a camera was also unfamiliar. VRFS could help them in this context.

For amateurs or hobbyists of film making or maybe even VR itself, VRFS had good learnability, which meant that using it was not difficult for novices. Besides, at the same time of teaching people about film making, it also brought novel VR experience to them. Finally, the fact that a user could make a short film of his/her own and bring it back as a video file made this experience more fulfilling and appealing.

5.4 Suggestions for Future Improvement

At the end of the interviews, participants were asked to give some suggestions on how to improve VRFS in the future. Their opinions are summarized below.

Suggestion. The suggestions could be categorized into teaching, simulation, and content:

1. Teaching: The current way of introducing 8 basic types of shots was to let a user watch an example segment, which was not very interesting. Participants suggested that it would be better if the introduction were done in 3D interactively as well.

2. Simulation: The current version of the virtual camera only supported the basic functions of recording, stabilization and zooming. In the future, more important functions of a real camera (such as horizontal indicator, depth of field adjustment, etc.) should be added to offer a more realistic experience.
3. Content: VRFS had a great potential of content extension. Currently, it only had "Tales of Afanti" in it. It would become more attractive and useful if a user might choose from more stories of different genres and styles.

6 Conclusion

The influence of technological advances is gradually increasing in daily life and a lot of innovations have happened in the field of education. In recent years, the application of VR technology in education has gained much attention, but most of the applications are about medical simulation, virtual campus, virtual laboratory and so forth. Applications of VR in art education are rare. VRFS was an exceptional trial which turned out to be satisfactory in terms of usability and subjective effectiveness. The SUS questionnaires gave an average score of 74, which reveals that VR technology can provide a new way of practice. In the in-depth interviews, participants also recognized that VRFS has certain advantages for practice-intensive courses thanks to its advantages such as low cost and better accessibility. Most participants also believed it would be helpful for their practical film making in reality.

From the emotional aspect, the majority of the participants' attitudes towards VRFS were positive. It is natural because shooting in a virtual environment was a novel experience for most of them. At the end of the experience, a user could obtain a copy of his/her own film, which made it even more appealing.

The most suitable users of VRFS are likely be beginners and amateurs of film making. This conclusion is justified by the fact that interviews and SUS scores from students in non-relevant major (77.5) were higher than the counterpart (72.2). The reason may be that beginners need to practice more to master the skills of using equipment and to construct a basic understanding of film language, while sophisticated learners needed more control and close-to-reality feedback to give full play to their skills and creativity.

In general, VRFS was a novel and welcomed system. When the cost of practice was too high to afford, VRFS could be a good alternative. The effectiveness of practicing in a virtual environment was acknowledged by most participants.

7 Limitation and Future Research Proposal

In the process of seeking approaches to solve practical problems in film education with VR technologies, this research developed new learning tools and models. Though its effectiveness is verified, there are still limitations to be dealt with in future studies.

Firstly, there are some restrictions in VRFS because the virtual camera is still different from a real one and there are many functions to be added. This encourages

future development of VRFS to expand the range of potential users. As a result, an upgraded system in the future need to be revisited.

Secondly, the experiments were all conducted in the College of Arts and Media in Tongji University. It's a controlled environment quite different from real-life learning scenarios. In real life, there will be no strict time limit for a user, and he/she would receive training in a cozy environment instead of an unfamiliar space. All these factors may affect the experiment result, so future researchers are encouraged to verify its effectiveness in a real educational environment.

Last but not least, the research mainly used qualitative methods, and the conclusions were derived from the subjective answers from the participants. More objective proofs are thus needed to support their validity. It is recommended that future researchers employ more objective methods, such as EEG analysis or eye tracking, to verify and extend the conclusions of this paper.

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