

# 利用虛擬實境科技於生物教學：高中生之滿意度與學習成果

## Using Virtual Reality Technology in Biology Education: Satisfaction and Learning Outcomes of High School Students



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### Introduction

Virtual reality (VR) which allows the user to explore or manipulate computer-generated virtual three-dimensional (3D) environments, has been employed in many applications, including but not limited to movies, video games, simulations of constructions, education, and learning, etc. (Kyaw et al. 2019). Among those applications, VR as a form of digital education is particularly intriguing due to the created virtual 3D visualized worlds that can render complex information into more intuitive or simple forms for learning. It is especially practical for certain topics to apply VR as a supporting teaching and training material (Bernardo 2017).

This study aimed to assess the effectiveness of VR application in educational processes in terms of enhancing the comprehension of high school students on the topics of human organ systems in advanced biology courses in Taiwan.

### Materials

The cardiac circulatory system, respiratory system, digestive system, and 3D clinical films by Da Vinci Robotic Surgical System were created into the VR model. The entire 3D education system was developed with the following tools: **3D modeling software-Cinema 4D (C4D)**, **Google VR SDK for Unity**, and **Text to Speech (TTS) voice**.

The C# (C Sharp) language was used to develop an app through which students and teachers could acquire this 3D education system in ios and android operation systems. With cardboard 3D glasses, students could watch 3D films of cardiac, gastric, hepatobiliary, and pancreatic surgeries performed by Da Vinci Robotic Arms on their own cellular phone, and thus could closely observe the anatomy with enhanced visual space perception of various organs (Figures 1 and 2).

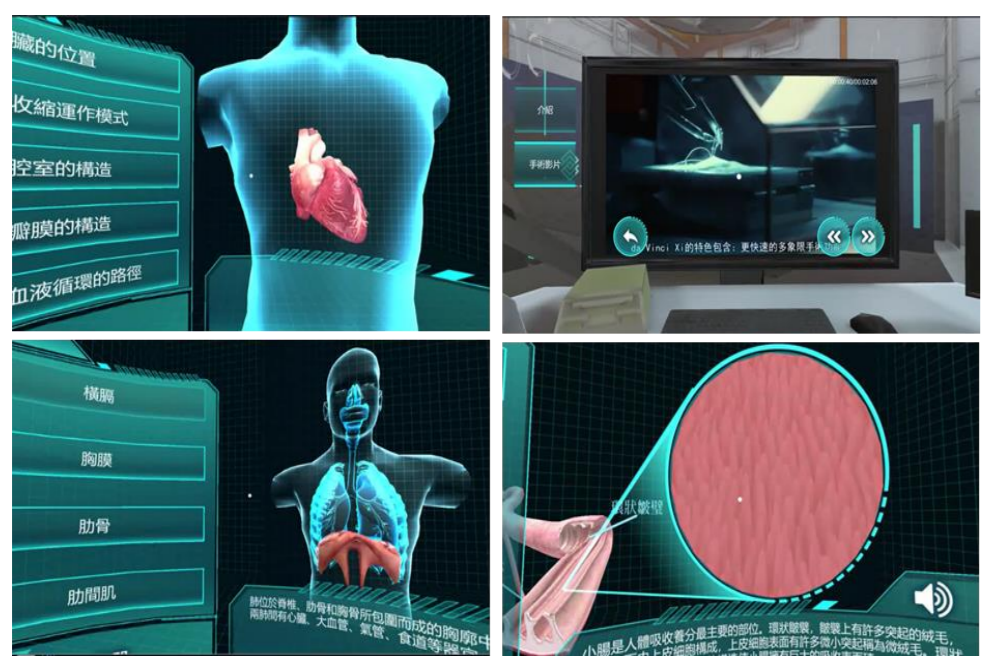


Fig. 1: The e-learning system with VR technology and TTS voice



Fig. 2: A 3D environment which students can use 3D glasses to watch 3D films

### Methods

#### Study Design

In order to verify the effects of implementing VR technology in biology education for high school students, 3 classrooms were selected as test sites, and 138 high school students and 4 high school teachers participated in this study. To determine the impact of VR education from both teachers' and students' perspectives, three Questionnaires (Table 1, 2 and 3) were used to assessment the effectiveness of instructional material and learning satisfaction.

#### The effectiveness of instructional materials

To assess the effectiveness of instructional materials, two stages were taken. Prior to the implementation of the VR program, the program was evaluated by 20 experts using a **Material Evaluation Questionnaire** (Table 1). The assessments were to evaluate whether the instructional material is suitable for targeted students and how it contributes to the learning task and objectives.

After the VR program concluded, a **Teaching Effectiveness Evaluation Questionnaire** (Table 2) was filled out by 20 high school teachers specializing in nature science who participated in this program. The assessments are to evaluate the effectiveness of the instructional material from the primary teaching site.

#### Learning satisfaction

The assessment of learning satisfaction was made by surveying the 138 targeted high school students after the teaching program was concluded. Students' attitudes and opinions on the instructional material were gathered using a **Learning Satisfaction Evaluation Questionnaire** (Table 3).

Table 1. Material Evaluation Questionnaire

Aspects	Questions	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A. Content	1. Accuracy	1	2	3	4	5
	2. Suitable for targeted students (depth, width, and presentation)	1	2	3	4	5
	3. With reasonable and clear learning task	1	2	3	4	5
	4. The learning task included is appropriate in quantity	1	2	3	4	5
	5. The learning task is with reasonable arrangement	1	2	3	4	5
	6. The content and learning task can contribute to the learning objectives	1	2	3	4	5
B. Instructional design	1. The learning objectives are specific and complete	1	2	3	4	5
	2. The learning objectives are able to be achieved by VR	1	2	3	4	5
	3. The learning task is suitable for targeted students	1	2	3	4	5
	4. The learning task is provided properly to help targeted students understand the learning objectives	1	2	3	4	5
	5. When practicing learning task, appropriate learning feedback can be received	1	2	3	4	5
	6. The evaluation mechanism is able to help target students understand learning status and effects	1	2	3	4	5
	7. The consistency of learning objectives, material, task and evaluation mechanism	1	2	3	4	5
	8. The targeted students' learning interest can be aroused and kept	1	2	3	4	5
	9. The targeted students are able to control the proceeding of learning task	1	2	3	4	5
	10. The learning tracing function provided is able to present the learning status of targeted students	1	2	3	4	5
C. Interface and medium	1. The function of interface is easily used and operated by users	1	2	3	4	5
	2. The design of the interface is able to present the content of materials properly	1	2	3	4	5
	3. The medium is able to present the virtual-simulated effects	1	2	3	4	5
	4. The medium can contribute to the understanding of the materials	1	2	3	4	5
	5. (self-learning edition) The Q&A channel is provided	1	2	3	4	5
D. Program Check list	1. Over 2 operation systems are supported	1	2	3	4	5
	2. Completed program upgrading at least once during the developing of the learning materials	1	2	3	4	5
	3. The learning materials are free for junior high school and elementary school students. No third party plug-in software fee is needed	1	2	3	4	5
	4. The learning materials are highly interactive and with cognition	1	2	3	4	5
	5. The function of learning record is provided	1	2	3	4	5

Table 2. Teaching Effectiveness Evaluation Questionnaire

Questions	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. The material is valuable in the aspect of teaching	1	2	3	4	5
2. The material helped me to guide targeted students to achieve the learning objectives more efficiently	1	2	3	4	5
3. The material made the whole teaching more interesting	1	2	3	4	5
4. The material improved the teaching effects	1	2	3	4	5
5. The material provided related cases /scenarios for teaching	1	2	3	4	5
6. The material helped targeted students familiar with the content with the proper arrangement of learning task	1	2	3	4	5
7. The material helped me to arouse the learning curiosity of targeted students	1	2	3	4	5
8. The material helped me to keep the learning motivation of targeted students	1	2	3	4	5
9. The material helped me to guide targeted students to review the last unit	1	2	3	4	5
10. I am willing to use the materials in the future	1	2	3	4	5
Open-ended Question	Please kindly write down your opinions or comments after using the teaching materials developed by this program :				

Table 3. Learning Satisfaction Evaluation Questionnaire

Questions	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I like to use this material to learn cardiac circulatory system	1	2	3	4	5
2. I like to use this material to learn respiratory system	1	2	3	4	5
3. I like to use this material to learn digestive system	1	2	3	4	5
4. I like to use this material to learn 3D clinical films of Da Vinci Robotic Surgical System	1	2	3	4	5
5. I like to use this material to learn biology	1	2	3	4	5
6. It made learning more interesting when the teacher used this teaching material	1	2	3	4	5
7. It made learning more efficient when the teacher used this teaching material	1	2	3	4	5
8. It made me more understand the learning topic of this unit when the teacher used this teaching material	1	2	3	4	5
9. The material is able to keep my learning motivation	1	2	3	4	5
10. The material helped me to achieve the learning objectives more quickly	1	2	3	4	5
11. The material provided me with appropriate learning task to be more familiar with the content	1	2	3	4	5
12. The material provided an interactive learning method with specific learning scenarios	1	2	3	4	5
13. I am willing to recommend this material to others in the future	1	2	3	4	5
Open-ended Question	Please kindly write down your opinions or comments after using the teaching material developed by this program :				

### Results

Table 4 shows the statistical analysis of the Material Evaluation Questionnaire. Experts remarked through interviews that the VR instructional material could increase student engagement and thus improved their learning.

Table 5 shows the statistical analysis of the Teaching Effectiveness Evaluation Questionnaire. As for responses to open-ended questions, three out of four teachers mentioned that students were more easily engaged and expressed more learning interest when the VR materials were used in classroom.

Table 6 shows the statistical analysis of the Learning Satisfaction Evaluation Questionnaire. The results indicated that students were very willing to use such learning method. However, a few students responded that using the VR glasses to observe the human organs made them dizzy and therefore reduced their willingness to use VR instructional materials.

Table 4. Statistical Analysis of Material Evaluation Questionnaire

Aspects	Questions	Mean (M)	Standard deviation (SD)
A. Content	1. Accuracy	4.87	0.35
	2. Suitable for targeted students (depth, width, and presentation)	4.87	0.35
	3. With reasonable and clear learning tasks	4.50	0.53
	4. The learning task included is appropriate in quantity	4.50	0.53
	5. The learning task is with reasonable arrangement	4.50	0.53
	6. The content and learning task can contribute to the learning objectives	4.37	0.51
B. Instructional design	1. The learning objectives are specific and complete	4.50	0.53
	2. The learning objectives are able to be achieved by VR	4.75	0.46
	3. The learning task is suitable for targeted students	4.62	0.51
	4. The learning task is provided properly to help targeted students understand the learning objectives	4.50	0.53
	5. When practicing learning task, appropriate learning feedback can be received	4.75	0.46
	6. The evaluation mechanism is able to help target students understand learning status and effects	4.62	0.51
	7. The consistency of learning objectives, material, task and evaluation mechanism	4.75	0.46
	8. The targeted students' learning interest can be aroused and kept	4.50	0.53
	9. The targeted students are able to control the proceeding of learning task	4.62	0.51
	10. The learning tracing function provided is able to present the learning status of targeted students	4.25	0.70
C. Interface and medium	1. The function of interface is easily used and operated by users	4.62	0.51
	2. The design of the interface is able to present the content of materials properly	4.50	0.53
	3. The medium is able to present the virtual-simulated effects	4.37	0.51
	4. The medium can contribute to the understanding of the materials	4.37	0.51
	5. (self-learning edition) The Q&A channel is provided	4.37	0.51
D. Program Check list	1. Over 2 operation systems are supported	4.75	0.46
	2. Completed program upgrading at least once during the developing of the learning materials	4.75	0.46
	3. The learning materials are free for junior high school and elementary school students. No third party plug-in software fee is needed	4.75	0.46
	4. The learning materials are highly interactive and with cognition	4.62	0.51
	5. The function of learning record is provided	4.25	0.88

Table 5. Statistical Analysis of Teaching Effectiveness Evaluation Questionnaire

Questions	Before using the Instructional VR material		After using the Instructional VR material	
	Mean (M)	Standard deviation (SD)	Mean (M)	Standard deviation (SD)
1. The material is valuable in the aspect of teaching	4.16	0.37	4.42	0.51
2. The material helped me to guide targeted students to achieve the learning objectives more efficiently	3.95	0.23	4.06	0.40
3. The material made the whole teaching more interesting	4.37	0.50	4.53	0.61
4. The material improved the teaching effects	4.42	0.51	4.47	0.51
5. The material provided related cases /scenarios for teaching	4.26	0.45	4.42	0.51
6. The material helped targeted students familiar with the content with the proper arrangement of learning task	3.74	0.56	4.11	0.46
7. The material helped me to arouse the learning curiosity of targeted students	4.26	0.45	4.42	0.61
8. The material helped me to keep the learning motivation of targeted students	4.00	0.58	4.26	0.65
9. The material helped me to guide targeted students to review the last unit	3.74	0.45	3.89	0.66
10. I am willing to use this material in the future	3.74	0.45	3.58	0.51

Table 6. Statistical Analysis of Learning Satisfaction Evaluation Questionnaire

Questions	Before using the Instructional VR material		After using the Instructional VR material	
	Mean (M)	Standard deviation (SD)	Mean (M)	Standard deviation (SD)
1. I like to use this material to learn cardiac circulatory system	3.91	0.67	4.03	1.01
2. I like to use this material to learn respiratory system	3.98	0.73	4.03	0.99
3. I like to use this material to learn digestive system	3.93	0.73	4.00	0.97
4. I like to use this material to learn 3D clinical films of Da Vinci Robotic Surgical System	3.90	0.79	3.88	0.95
5. I like to use this material to learn biology	3.97	0.74	4.74	5.69
6. It made learning more interesting when the teacher used this teaching material	4.04	0.77	4.17	0.84
7. It made learning more efficient when the teacher used this teaching material	3.87	0.89	4.01	0.90
8. It made me more understand the learning topic of this unit when the teacher used this teaching material	3.87	0.71	3.78	0.87
9. The material is able to keep my learning motivation	3.73	0.76	3.68	0.88
10. The material helped me to achieve the learning objectives more quickly	3.65	0.83	3.80	0.91
11. The material provided me with appropriate learning task to be more familiar with the content	3.88	0.65	3.90	0.92
12. The material provided an interactive learning method with specific learning scenarios	3.96	0.73	3.98	0.94
13. I am willing to recommend this material to others in the future	3.90	0.70	3.94	0.96

### Conclusion

From the teacher's perspective, the VR instructional material was a good educational tool that can increase students' attention and contribute to the improvement of learning outcomes. Meanwhile, from the students' perspective, they are willing to use VR learning materials and were satisfied by this learning method. Therefore, applying VR technology in the classroom shall be encouraged. However, it must be noted that some students may feel dizzy.

### References

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