

# 網路虛擬實境微世界學習環境之研究

## A Web-Based Interactive Microworld Environment Based on Virtual Reality Simulation for Constructive Learning

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### 摘要

本研究目的為於全球資訊網上建立一個虛擬實境模擬教材，並評估其功能與學習效果。目前網路學習環境中聊天室、視訊會議等功能皆已十分完備，唯獨教材內容與活動的設計仍十分缺乏，尤其是屬於操作技能(*psychomotor*)方面的教材，若只用文字與圖片來呈現人仍是不夠的，甚至於動畫與視訊有時亦無法滿足學習者的需要，若能利用模擬的方式呈現教材讓學習者沈浸於(*immersive*)似真的情境當中，將有助於提高學習者學習興趣及增加學習遷移的可能性。因此本研究嘗試利用網路虛擬實境技術並結合微世界(*Microworld*)與建構學習理論來設計一個網路虛擬實境互動式模擬教材，學習內容則是以教育學程教學媒體課程中幻燈機的操作與維護為案例。開發完的教材則可置於現有的教學媒體網路教學系統中，做為教育學程學生修習教學媒體使用。學習評估的結果顯示，網路虛擬實境模擬教材確能提升學習動機，對於學生的學習成就也確實有正面的效果，幻燈機與幻燈片的實地操作測驗較以往熟練，證明對於學習遷移的效果是有幫助。大部份的學生也都願意再使用類似的模擬教材，但也都認為桌上型虛擬實境仍然與真實情境有差距，而且網路 VR 操作介面若使用不習慣仍會覺得不方便。

### ABSTRACT

This purpose of this study was 1) to build and evaluate a web-based interactive microworld environment based on Virtual Reality simulation for constructive learning, 2) to explore the potentials and limitations of web-based Virtual Reality in operating slide projector. A VR-based interactive and simulated microworld environment on web for immersively learning slide projector operation has been designed, developed, and evaluated. The framework and functionality of the environment described in this study are also presented. The evaluation results report that this learning material has positive effects on students' learning outcomes. Finally some indication of further researches to be done will be given based on using the material developed in this study.

### Introduction

It has been reported that many students fail to easily understand the manipulation activity that occurs at a psychomotor level during the production and presentation of slides, and the operation of slide projector. Students usually do not have enough time to physically practice the operation of slide projector after the class due to insufficient equipment of slide projectors provided by the school. Students are therefore not well motivated to learn this subject and have difficulty grasping these complex procedures. Without sufficient simulation and visualized demonstration, students argued that transfer of skills and retention of knowledge for producing slides and operating slide projector would not effectively work.

VR-based learning environment on the Web could provide alternative to make presentation of learning materials more visualized and enables their demonstration dynamically. Students would be more motivated to actively learn, and able to highly visualize the complex process of producing slides and operating slide projector. Additionally, students could then manipulate the VR-based system dynamically and learn by their own hands-on experiences how slides are produced and a slide projector is operated that is impossible to observe in real situation.

The application of distributed VR to online simulation for the hands-on experiences of operating slide projector on World Wide Web (WWW) are worthwhile creating for reasons of equipment, safety, expense, time, and distance. VR-based learning environment on the Web to learn slides projector operation (WebVR) would be very helpful for students to acquire and construct the needed knowledge in the social and active sense.

## **Application of VR to Psychomotor Learning**

Virtual Reality are drawing more and more attention in skill training and psychomotor learning due to its capabilities of real-time interactivity, three dimensional animation, situated simulation, dynamic mediated environment, immersive sense of presence and so forth. In such a artificial 3D simulated learning environment based on VR technologies, students can highly interact with the virtual world, move around within it at will, highly control over their self-paced navigation through it, freely manipulate virtual objects insides, and immediately have a immersive sense of really being there. Additional, it allows students to visualize abstract concepts, and to observe events at atomic scales that cost, distance, time, and safety factors make unavailable (Youngblut, 1997).

Repair to the Hubble Space Telescope were simulated in VR environment to enable the technicians to familiarize themselves with the dangerous manipulations they would experience before the actual repairs were done (Traub, 1994). Safe space and situation to practice skills of repair was provided in the virtual environment that was risky to do so in real situation. Skills learned in the virtual environment could transfer successfully to the telescope repair ability of real world. VR via the Internet and World Wide Web (WWW) may offer the possibilities of enabling students being able to collaboratively create their online virtual worlds or contribute to those created by others (Moore, 1995). The types of activities supported by VR capability facilitate current educational application that students are better able to acquire, master, retain, transfer, and generalized new knowledge whenever they are actively engaged constructing their knowledge in a learning-by-doing situation (Youngblut, 1997).

## **Design and Development of Learning Environment Environmental Framework and Functionality**

Students can easily move around within and freely navigate through the virtual microworlds and do all kinds of actions, such as freely manipulating virtual objects in any degrees of freedom. Additionally, students immersively existing in the 3D environment of WebVR may experience several degrees of freedom, including full



freedom in navigation, the access to information through multiple interactions, and the capability to figure their own learning process.

Figure 1 Main manu of the WebVR

### Designing Instructional Strategies

The constructivist principles of learning in the design of WebVR are proper approaches to the work of our instructional strategies. The main learning approaches to implementing the constructivist principles in the 3D virtual microworlds are exploration, discovery, problem-solving, and learning by doing. Using web-based VR browser capabilities, students are able to freely explore the virtual objects, discover phenomenon, practice skills, move around and navigate through the 3D virtual microworlds composed of simulated equipment and tools.

The manipulation of an object in a virtual microworld supports the practice of constructivism. According to Salis & Pantelidis (1997), object manipulation in the virtual microworlds is a powerful learning strategy frequently used for constructing a knowledge framework that presents concrete components for associating some superior knowledge. Additionally, transformation and rotation of the objects enable students clearly to observe their various situations that can be rarely observed in traditional situation. The attributes of virtual objects can be explored through direct interaction with them. In this study the WebVR was using these strategy to develop psychomotor skills for high level of human interaction and knowledge association from a motor answer to a stimulus which students received in the virtual microworlds.

A self-space learning navigation system is employed in the WebVR to increase the opportunities for exploration, manipulation of objects, discovery, movements, and senses of real or not real by using visualized controlling elements within virtual microworlds. The self-spaced learning navigation system for users through the virtual microworlds was designed and used as a learning tool in search for information and

objects so as to highly take control over their exploration and manipulation. In a virtual microworld students may use the navigation system to freely determine to select and manipulate the objects that might be of interest and for the observation at convenience.

Visualization, navigation, and manipulation tools was developed in the WebVR to allow students to move around within a virtual microworld and to discover the attributes of an object.

### **Designing Learning Content and Activities**

The content of this WebVR material for the VR simulation part (operating slide projector) was divided into four essential parts based on the results from a content analysis and task analysis, they are individually Set Up, Operate, Disassemble, Maintain, and Troubleshooting.

The VR-based learning microworld contains many virtual objects such as slide, focus button, lens barrel, slide tray, lock ring, elevation leg, remote controller, forward button, reverse button, and selection button that are the components of a slide projector. Each object is made from many models and attributes. Models describe its outside appearance, while attributes present its interactivity and actions. Students are allowed to reinforce their experiences of operating slide projector through manipulating the virtual objects and exploring the virtual microworlds.

When students pick up a virtual object, they may execute the actions predefined inside it by clicking the mouse button such as rotation or deflection. Students can pick up and move the objects, as well as observe them and their behaviors from various directions. The scenes in the virtual microworlds have viewpoint so that students can quickly view the virtual objects from the front, back, left, right, top, and bottom. Object names are shown when students move the cursor on them using mouse, while the names disappear when the cursor is moved away. By this way, students may observe the various components of the slide projector, and learn the names, appearances, and attributes of the virtual objects. In other words, students must actively manipulate, explore, and interact with the virtual objects, otherwise they could not be able to learn their attributes.

In the VR-based learning microworld of operating slide projector, the functionality and simulated actions are as follows (Heinich, Molenda, Russell, & Smaldino, 1996):

1. Slides could be load into tray and locking ring could be tightened as users pick up the slides and place them into the tray, and adjust the locking ring on the tray by clicking mouse button and moving the mouse.
2. The slide would be pop up as users push and hold selection button by clicking mouse button.
3. Slide tray would rotate clockwise or counterclockwise as users press forward or reverse button on slide projector or remote controller to project slides by clicking mouse button.
4. Lock ring could be locked on slide tray as users tighten it by clicking and moving mouse button. If it is not locked, system would present a warning message that "slides would drop out."
5. Lens barrel would move out or in as users adjust focus knob or move lens barrel to focus image, position it on screen, make it smaller or larger by clicking mouse button and moving the mouse.
6. User could remove slide tray and remove slides from the slide tray buy clicking mouse button and moving the mouse.

- 7 Slide projector could be viewed from different directions by clicking mouse button and moving the mouse.
8. Names of virtual objects such as button, lens barrel, slide tray, lock ring, elevation leg, remote controller, forward button, reverse button, and selection button would be shown up when users place cursor on them by moving mouse.
9. Slide's image would upside down or backwards as users remove the slide and reverse it by clicking mouse button and moving the mouse.

### **Development Platforms and Tools**

Due to the factors of cost and convenience, a desktop virtual environment with less immersion was developed in this study rather than using a head-mounted display with higher immersion. In order to make interfacing uses as friendly as possible and keep the cost as low as possible in cases of educational institutions' using our system, we chose a standard mouse rather than a data glove or a 3D mouse. In addition, data glove and 3D mouse are still not popular to the public at large was taken into consideration for not using them. WebVR in the study may therefore support direct dynamic interaction with the virtual microworlds and objects with a standard and regular mouse.

Recent advanced technology in WWW platform have provided with tools and browsers for the capability of A desktop Virtual Reality known as the Virtual Reality Modeling Language (VRML). 3D Webmaster, the ultimate software tool for designing interactive 3D WebVR microworlds in the study, allows developers to create rich, interactive, real-time 3D microworlds quickly and efficiently, as well as lets developers add interactive 3D virtual microworlds to flat 2D Web pages. 3D Webmaster not only may support VRML and 3D web producing but also can integrate with HTML and JavaScript commands. In addition to hundreds of ready made components and Virtual Clip Art objects, there is a fully functional 3D Shape and MicroworldModeller as well as Sound and Image Editors included in 3D Webmaster. This also includes the powerful VR control language SCL (Superscape Control Language) for assigning behaviors to virtual microworld objects (see <http://www.superscape.com/>). 3D Webmaster provide users interactions and offer a natural way for extending the practice environment to a virtual 3D practice microworld. This extension provides with more advanced simulation and enable learning transfer from a virtual situation to a real situation.

Prototyping WebVR materials including interface was first developed by using Frontpage, and then completed environments were further established on the WWW by using 3D Webmaster to create the 3D virtual microworlds and objects relevant to slides production and slide projector operation. Superscape Viscap, the fastest 3D browser plugin, enables users to view the product developed by 3D Webmaster and lets users experience interactive 3D virtual microworlds on Web. It is therefore needed to install for viewing the WebVR materials in the study.

### **Evaluation Methodologies and Results**

We evaluated the quality of the WebVR through doing qualitative study for mainly examining the functions, interface, content, and learning experiences by means of questionnaires that embrace specific questions. The results from the survey of students' feedback on the satisfactions for the WebVR reported that the system interface is easily accessible and usable to users. They also indicated that there are many learning materials that can be delivered more effectively by video and audio media that are not provided in the WebVR materials. Students reported that they liked

having hands-on experiences with the virtual microworlds, and they felt comfortable with the simulated capabilities provided by the WebVR material.

In summary, the conclusions drawn from the evaluation study are as follows:

1. The majority of students had a very positive response in the functionality, usability, interface, and content of WebVR.
2. Students commonly enjoyed learning within the virtual microworlds, and their learning process was highly motivated.
3. Students were not tolerant of the low running space that sometime occurred.
4. The use of WebVR could encourage students self-directed learning
5. The use of WebVR could captivate students' attention and foster active involvement in their learning process.
6. The test scores of students had higher learning performances than those of traditional instructions in classroom based upon the comparisons with last few semesters.

As a result of the evaluation study, the WebVR provides a promising platform for exposing students to actively learn in the domain of "Slides Projector Operation", draw a high attraction to students and can be employed for a wide variety of instructional purposes. A claim can be derived from observation study that identified a fact that WebVR does support the learning process, reception of information, and active participation. WebVR acts as an experience facilitator who allows students observe and explore phenomenon via their various senses. In short, our key insight to the evaluation results of the WebVR material is the verification of its successful design, creation and use experiences.

## **Lessons Learned**

It is believed that distributed VR in an instructional context may not become effective if one ignores the pedagogical side of the problem. Therefore we should take into consideration not only the functionality of a learning environment, but also its pedagogical validity and learning effects on learners. Rather than being a teacher who provided with all the answers and informational presentations, the teachers found themselves acting as a facilitator who helped students explore the virtual microworlds and build concepts based upon information gained from those microworlds, and also acting as a monitor who guided their learning progress.

VR technology offers significantly positive support for learning and indicates proficient potentials to justify continuing study and increasing practical evaluations of effects on learning process. As an instructional designer for distributed VR-based instructional environment, we must know how this new learning support tool can be used and integrated into classroom setting, and which instructional strategies and activities must be taken into account when designing VR-based environment for students' active learning.

## **Conclusions and Summary**

A VR-based learning environment on the Web was developed to examine the feasibility of applying VR to media education. However, the material does not want to replace the teacher, but only wants to be a teacher-assistant or student-assistant to help guide the student during the learning process. This means that if students experience difficulties learning, they may attempt to solve the problem in collaboration with their peers under the support of web-based VR technologies.

Evaluation results of WebVR indicates that it is a helpful tool both for students

and teachers in the learning process. This is concerned about the experiences students gained from the free navigation and high interaction afforded to them, and from the exploration of basic skills of operating slide projector. In summary, this study not only refines the content of distributed VR-based learning materials on the Web developed to learning slides production and slide projector operation, but also help us verify a methodology for instructional designing uses.

We do believe that the application of VR on web not only highly encourage the creative design of learning environments, methods, and tools, but also bring us into the new instructional strategies and tactics. It is hopeful that more studies on the web-based VR learning environment will be conducted to benefit all students in teacher preparation program.

### **Suggestions and Future Work**

The WebVR is currently a stand-alone application not associated with the learning support tools such as chat room, conferencing and discussion board on the Web. It would be greater to be integrated into a web-based instructional environment so that the high level of collaborative learning activities can more profoundly be developed and relative issues can more deeply be investigated.

In this study, we experienced difficulties in displaying a large amount textual information, however some textual information is indispensable for learning slide projector operation. Therefore, how to display large amounts of textual information using current VR techniques is still a big problem that needs to solve. An experimental research to examine the real learning performance by comparing the classical classroom situation with the WebVR through statistically controlled group and experimental group is recommended being conducted in the future.

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