THE DESIGN AND EVALUATION OF A VIRTUAL REALITY (VR) – BASED EDUCATIONAL STORYTELLING SYSTEM

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ABSTRACT

THE DESIGN AND THE EVALUATION OF VIRTUAL REALITY (VR)-BASED EDUCATIONAL STORYTELLING SYSTEM

LIEW WAI SAN

This project aims to design and evaluate a storytelling system using desktop virtual-reality (VR). The storytelling system entitled "Survival Skills in Forest" was designed to educate children on survival skills in a forest. It was designed based on the instructional design theoretical framework for VR-based learning environment. Generally, the storytelling system incorporates an integrative goal, problems and support tools to facilitate learning during the storytelling process as well as applying various design principles for effective presentation of information. The usability of the storytelling system was evaluated using cooperation evaluation technique. In general, the results of the cooperative evaluation showed that the storytelling system can be used without much difficulty. Exposing children to the real environment of a forest maybe dangerous, therefore by presenting the environment of forest in the form of virtual environment it is hope that children can effectively explore the virtual forest and interact with it. Indeed, this project provides an innovative way to delivering a story by using desktop VR.

ABSTRAK

REKA BENTUK DAN PENILAIAN SISTEM BERDASARKAN REALITI MAYA UNTUK PENYAMPAIAN CERITA BERUNSURKAN PENDIDIKAN

LIEW WAI SAN

Projek ini bertujuaan untuk merekabentuk dan menilai sistem berdasakan realiti maya untuk penyampaian cerita berunsurkan pendidikan. Sistem penceriataan yang bertajuk "Kemahiran Hidup di dalam Hutan" direkabentuk untuk mendidik kanak-kanak tentang kemahiran hidup di dalam hutan. Sistem ini direkabentuk berdasarkan panduan daripada rangka teori berkenaan dengan rekabentuk persekitaran maya desktop. Pada umumnya, system penceritaan ini menggunakan objektif berkait, masalah dan bahan sokongan dalam reka bentuknya untuk membantu dalam proses pembelajaran. Pelbagai teori rekabentuk juga telah diaplikasikan untuk menjamin keberkesanan penyampaian maklumat. Kesenangan penggunaan sistem ini telah dinilai dengan teknik "cooperative evaluation". Pada umumnya, keputusan penilaian menunjukkan bahawa pengguna dapat menggunakan system ini tanpa masalah yang besar. Pendedahkan kanak-kanak kepada persekitaran hutan yang sebenar adalah merbahaya. Oleh itu, simulasi persekitaran maya hutan diharap dapat memberi peluang kepada kanak-kanak untuk menjelajahi dan berinteraksi dengan persekitaran hutan. System penceritaan ini menunjukkan cara penyampaian cerita yang inovatif berdasarkan sistem persekitaraan maya desktop.

CHAPTER 1
INTRODUCTION

1.0 Introduction of Non-immersive VR

Virtual Reality (VR) system can be categorised into two main categories, non-immersive VR systems and immersive VR system. This project uses on the non-immersive VR system. Non-immersive system as the name suggested, are the least immersion implementation of VR technique. According to Chen and Teh (1998) the virtual environment in non-immersive VR is viewed through a portal or a window by utilising a standard high resolution monitor.

According to Abbott *et al.* (1997), non-immersive system is a simplified system that allows the user to create and to interact with the virtual world. The use of VR equipments typically for immersive VR will burden the user as equipment is attached to their body part such as body suit and data glove. This equipment will limit the user's movement. According to Chen (1997), heavy immersive equipment is not needed in non-immersive system, thus allowing users to perform their task with ease.

The significant advantage of non-immersive or desktop VR system is the cost since it is significantly lower than other forms of VR system. This is because non-immersive VR does not require the use of complex and expensive equipment such as head-mounted display, hand tracker and body suit which are expensive.

1.1 Background of the Study

This section discuses on the benefits of storybooks to children and the types of storybook that are currently available. Besides the printed storybooks, there are various types of electronics storybooks available and these will be further discussed.

1.1.1 Benefits of Storybook to Children

Storybooks provide children with access to a world of sights, sounds, and words that may be quite different from what they experience in their homes, their communities, and their schools (Helen & Laura, 2005). For example, it is through a storybook that a child may first experience the magic of animal kingdom (Helen & Laura, 2005). Therefore, children can apply and relate this knowledge during their early education (Helen & Laura, 2005).

Another unique aspect of storybooks is that they offer an opportunity to decontextualise language (Helen & Laura, 2005). This means that the events and concepts in storybooks are not restricted to the here and now. Rather, the events may reflect actions, events, and ideas that exist beyond the present, maybe in the past, in the future, or in another world altogether. This can prepare children for the decontextualised demands that will pervade elementary schooling (Helen & Laura, 2005).

The use of storybooks is that it captures interests and imaginations of the world (Chen, Ferdig & Wood, 2003). According to Linder (1999), imagination provides the framework for young learners to become involved in experiences that challenge children developmentally. Dias and Harris (1988, 1990), found that a fantasy context improved children's syllogistic reasoning. Furthermore, Richert (2003) demonstrated that fantasy affected children's ability to reason about certain types of analogies. Children with stable imaginary companions (a measure of fantasy orientation) succeeded on various theory of mind measures earlier than

their age-matched counterparts (Taylor and Carlson, 1997). It is possible that fantasy provides a more general boost to children's reasoning abilities beyond just their understanding of pretense (Sobel, 2006).

According to Pianta (2000), storybook-reading experiences also provide children with opportunities to build relationships with the adults in their lives. It is within the context of children's relationships with adults that children's developing competencies about language and literacy may emerge (Pianta, 2000).

1.1.2 Types of Storybook

Nowadays, there are various types of storybooks available for children. Besides the printed storybook, there are electronic storybooks. The discussions on types of electronic storybook were summarised from Chen, Ferdig & Wood (2003) study. The electronic storybook includes: interactive toys and games, educational CD-ROMs, Web-based storybooks, and story-sharing tool. The first category, interactive toy and game provide games and toys that tell stories to children.

A second type is educational CD-ROMs. The content includes animations, music, sound, slide shows, movies, audio-video clips, hypertext, graphics, and hypermedia. However, instead of using hyperlinks to the internet's resources, the educational CD exists in a closed environment, which involves the learner in the simulated situation entirely on the CD.

The third type of storybook is the web-based storybooks. There are three different subgroups under web-based storybook. There are one-dimensional electronic storybook, multi-dimensional storybook and hypermedia electronic storybook. The stories are integrated in online system. The first sub-category of web-based storybooks is the one-dimensional electronic storybook. It incorporates a printed storybook into simple hypertext on the internet. The structure of this storybook is the same as a traditional printed storybook except the reader uses the

mouse and keyboard to turn the pages. It contains still graphics, text illustrations that accompany each graphic to form the sequence of the story, a linear story plot, linear links, and simple user control. However, for multidimensional electronic storybook there are symbolic graphics, simple animations, and musical accompaniments. Lastly, hypermedia electronic storybook includes a narrator, characters, plot structure, and other essential storytelling items.

1.2 Problem

Although there are electronic storybooks that provide interactions, sounds and animated graphic, the structure of the stories is still the same as the printed storybooks, which is basically predefined by the author. It means that, the current design of storybooks follow the objectivist learning paradigm where learners learn domain content to solve a problem, rather than solving a problem to apply learning.

The traditional storybook is also found to support limited learning styles. Chen, Toh & Wan (2004) stated that virtual environment can support all four of Kolb's learning characteristics. According to Kolb (1984) the four different learning characteristics are concrete experience, reflective observation, abstract conceptualization and active experimentation. Therefore, learners who learn best through concrete experience and active experimentation will loose out in learning from the printed storybooks and electronic storybooks that are currently available. This is because the printed storybooks and electronic storybooks only allow learners to learn domain content to solve a problem, rather than allowing learners to solve a problem by active experimentation and concrete experience to apply learning.

There were past researches on the field of storytelling and story sharing among children which used the immersive VR. For example "The Thing" *(*Anstey et al., 2000 as cited in Roussou (2004)) which is a CAVE-based VR engages users in interactivity through constant "conversation" with a virtual character rich in

changing emotional states. Besides that, “The Lighthouse Keepers Lunch” (Bayon, Boltman, Stanton & Wilson, 2003) which is a form of mixed reality story telling and “The Narrative Immersive Constructionist / Collaborative Environments (NICE)” (Bayon, Boltman, Stanton & Wilson, 2003) are examples of the storytelling and story sharing by using immersive VR.

1.3 Purpose of the Study

1.3.1 Aim

The aim of this project is to design and evaluate a virtual reality (VR)-based educational storytelling system for primary school children.

1.3.2 Specific Objectives

The specific objectives of this project are to:

- identify the appropriate content of the storytelling system.
- identify a suitable model that guides the instructional design the storytelling system.
- Design the storytelling system based on the identification on the identified model.
- evaluate the usability of the system to improve the user friendliness of the system.

1.4 Significance of the Study

The development of VR-based storytelling system is a showcase of non-immersive VR in delivering a story that allows manipulation, experience and control for the users. Control and direct interaction with the object in virtual environment can provides a form of experiential learning. Such control and interaction, together with free exploration provided a greater sense of empowerment. As pointed out by Bricken(1990) and Youngblut (1998), one surprising result from virtual reality research is that subject have a strong positive reaction. As pointed out by Chen, Toh & Wan (2004) greater sense of empowerment can act as a motivating factor for users to engage in the learning process.

Using non-immersive VR in delivering a story is feasible since it is cost effective and the system can be ubiquitously used. It does not involve the use of head mounted displays, gloves and high-end computer system that is costly. Indeed, according to Youngblut (1998), non-immersive technology is more mature and ubiquitously used in many different application areas rather than the immersive technology.

CHAPTER 2
LITERATURE REVIEW

2.0 Overview

This chapter presents an overview of the literatures related to this project. It provides the definition of VR and educational benefit as well as the application of VR in education which focuses on storytelling and story sharing.

2.1 What is VR?

It is difficult to give a specific definition of Virtual Reality (VR). VR has been addressed by a large number of authors in many literature and many of them introducing slightly different meanings to the term. Some years ago a common definition of VR should be looked upon as a situation where a person was immersed into a computer generated environment that bore strong similarities with reality (Keppell et. al., 1997). While some authors might define VR of the technological tools that are being used and some even define it from a psychology perspective (Cronin, 1997).

Lately, there are authors that define VR in an almost similar way. In general the definition of VR should include the terms, three-dimensional, computer-generated and interactive. For example, according to Backman, Fallman and Holmlund (1999), VR is stated as a computer-generated simulation of a three dimensional environment, in which the user can interact with both the view and contents of the virtual environment.

There are basically three different kinds of VR, categorized by the quality of the immersion (Cronin, 1997). The first is desktop VR, which is by far the most common and least expensive form of VR. In this project, this kind of VR is of concern since it is more feasible and affordable. Second, a semi-immersive VR system that attempts to give the users a feeling of being at least slightly immersed by a virtual environment and the third form of VR is usually referred to as being fully immersed which is called immersive-virtual reality system (Cronin, 1997).

2.1.1 Non immersive

According to Chen and Teh (1998) non-immersive VR or called desktop VR could be described as a window on a world (WOW) since the virtual environment is viewed through a portal or window by utilizing standard high resolution monitor. A desktop VR environment is a three dimensional perspective display. A perspective display projects 3-dimensional information onto a 2-dimensional surface, that is, the computer screen (Fallman, Backman & Holmlund, 1999). The most common form of input with desktop VR is the clicking approach with a mouse (Fallman, Backman & Holmlund, 1999). In this project, mouse is used as the major input devices. Mouse is used to control the navigation through the environment.

According to Backman, Fallman, and Holmlund (1999) the main forms of feedback experienced by the users in this form of VR are audio and visual feedback with more emphasis put on the latter. Sound is presented via external loud speakers which is affordable. High-speed renderings are very important to

achieve in desktop VR, so as to obtain a real-time response with every input Backman, Fallman, and Holmlund (1999).

The major advantage of a desktop VR system is the cost, being less expensive than other forms of VR systems. The low cost of desktop VR systems makes them extremely attractive for many applications with a relatively low budget. Therefore, this type of VR is used in this project.

2.1.2 Semi- Immersive

According to Backman , Fallman and Holmlund (1999) a semi-immersive VR system attempts to give the users a feeling of being at least slightly immersed by a virtual environment. This is often achieved by different types of so called workbenches and reach-in displays.

2.1.3 Immersive VR

According to Backman, Fallman, and Holmlund (1999), the last form of VR is usually referred to as being fully immersed. It typically consists of head-mounted visual display units that allow users to be completely isolated from the physical world outside. Sometimes, a CAVE (Cave Automatic Virtual Environment) is used. A CAVE is a room in which the walls surrounding the user produce the images, and thus deliver a sense of immersion. The drawbacks of this type of VR are that the hardware and software designed to support full immersion is very expensive and application development in this area is generally more difficult and time-consuming.

2.2 Educational benefits of VR

The educational benefits of VR are summarized from (Chen, Toh & Wan, 2004). First, VR allow the learner to visualize three-dimensional representation of a problem. The use of VR could provide learners the environments within which they can actively construct knowledge. This environment can either be real or artificial but simulate aspects of the real world, which may not accessible through direct experience.

Second, it could provide an authentic representation to its user. Representation of an authentic problem is achieved through the simulation of the real environment. Authentic is interpreted as how learners should engage in activities, which present the same type of cognitive challenges as those in the real world (Haonebein et al; Savery, 1993 & Duffy,1996 as cited in Chen, Toh & Wan (2004)).

According to Chen, Toh & Wan (2004) a virtual environment would act as an excellent visualization tool where it enable the learners to visualize the three dimensional representation of a simulated environment. As the virtual environment is inherited three-dimension, it helps reducing the learner cognitive work load in constructing mental images and performing visualizing activities. This is especially helpful for individual with low spatial abilities.

The forth benefit of VR in education, which is not available in any other traditional media, is its ability to provide infinite or unlimited number of viewpoints of the three dimensional environment to the learner. Having multiple perspective of the world can encourage a diverse way of thinking (Salzman et. al.,1993 as cited in Fallman, Backman and Holmlund (1999)) argues that being able to use different perspectives, or frames of reference, may be useful for highlighting different patterns and relationships in abstract information. In most academic areas, such as mathematics, science, engineering and statistics, the ability to envision and manipulate abstract information is very important.

Complexity in virtual learning environment can be controlled. Cognitive scientists have also pointed out the ability of virtual environment to make the abstract more concrete and visible by providing symbols not available in a non-symbolic real world. In other words, virtual environment is a cognitive tool to make the imperceptible things perceptible. For example, 2-D map can be provided in virtual learning environment while user navigating through complex virtual environment. Besides that, label can be included in virtual learning environment, which is not available in the real world to help learners to perceive thing better.

VR is also able to support active learning. Virtual environment could be used to present a scenario as a problem manipulation space that allows free exploration of environment and manipulation. Feedback is also provided for the learner. A learner in virtual environment could gain experiences instead of just word or pictures that largely relied on the human cognitive ability.

Unlike many other educational tools, a virtual environment is designed without a specified sequence. Its focus shift from the design of prescribed interactions with the learning environment to the design of environment that permits the learner with various types of interaction that the system is capable of. This complies with the learner-centered approach where a learner can keep control over what they are exploring and manipulating. VR allows students not only to visualize models and data in a more appropriate three-dimensional context, but also to interact with the models and take on several different points of view, including changing the models' relative sizes as well as the perspective from which the users experience the models.

Control and direct interaction with object, together with free exploration, provide a greater sense of empowerment. They feel free and empowered and the empowerment is indeed a factor that contributes to motivation. As pointed out by (Bricken, 1990 as cited in Chen, Toh & Wan (2004)), one surprising result from virtual reality research is that subjects have a strong positive emotional reaction.

2.3 Application of VR in Education

For educational purposes, VR has been widely proposed as a significant technological breakthrough that possesses an immense potential to facilitate learning (Youngblut, 1998). Reasons for this are, as mentioned before, VR allows students to experience and interact with events that is impossible to achieve in the real world because of distance, time, scale, safety or money.

Indeed, it is admitted that in the United States, children do not experience enough learning of skills and concepts which are related to society's needs. (Durlach & Mavor, 1993 as cited in Mills & Madalena (1995)). Perhaps VR is a way of addressing this lack since VR systems could be used to simulate a concept which is difficult for children to visualize. Thus, educationally, VR is an important tool to help students in gaining understanding of complex systems and processes, abstract models and other non-intuitive material. Most application of VR in education is in the field of science, history education, art and cultural heritage representations.

The development and research on VR in education is vast expanding while some are still under construction. From scientific subjects to storytelling, its application has only one major motive, which is to increase the effectiveness in learning.

2.3.1 Review on Storytelling and Story Sharing using VR

There were past researches on the field of storytelling and story sharing among children which used the immersive VR. For example “The Thing” *(*Anstey et al., 2000 as cited in Roussou, (2004)) which is a CAVE-based VR engages users in interactivity through constant “conversation” with a virtual character rich in changing emotional states. Besides that, “The Lighthouse Keepers Lunch” (Bayon, Boltman, Stanton & Wilson, 2003) is a form of mixed reality storytelling

system. Another example of the storytelling system and story sharing by using immersive VR is “The Narrative Immersive Constructionist / Collaborative Environments (NICE)” (Bayon, Boltman, Stanton & Wilson, 2003). These researches will be further discussed.

2.3.1.1 The Thing (CAVE-based Virtual Reality)

The Thing *(*Anstey et al., 2000 as cited in Roussou (2004)) which is a CAVE-based virtual reality engages the user in interactivity through constant “conversation” with a virtual character rich in changing emotional states. The work is structured in three acts in order to take advantage of narrative tools like pacing, surprise, and movement through time. For the story to progress, the user must engage in activities and respond to the character's requests by dancing, moving, selecting objects, or performing actions. In this case, storytelling serves as a driving force for a highly interactive experience, and, vice versa, interaction between real and virtual characters, plot, and emotion becomes central to the form of the story. The Thing bases all of its power on interactivity by maintaining a simple visual and aesthetic form. Visuals are used to set the scene rather than define the artistic process, while the constant demand for interaction between the participant and the virtual character helps the participant to almost entirely ignore the surroundings. No matter what choices the user makes whatever the attempts to modify the world or cause a response, the final result is derived from a set of predefined options, predetermined by the creator.

Further examples that demonstrate mastery of what Schell refers to as “indirect control” (Schell’s, 2003 as cited in Roussou (2004)) include the DisneyQuest VR attractions of Aladdin, Hercules, and the more recent adventure of the Pirates of the Caribbean (Schell & Shochet, 2001 as cited in Roussou (2004)). In all these cases, visitors assume the roles of central characters in the story and, for the duration of their experience, believe they control the progress of the story, which is rapidly building to a climax.