Designing a Virtual Reality (VR) Storytelling System for Educational Purposes

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Abstract – **This paper addresses the instructional design of a virtual reality (VR)-based educational storytelling system. Indeed, the importance of storytelling in education has long been recognized. Stories are pervasively used as powerful tools in teaching and learning. Although there are efforts to utilize advanced technology, such as virtual reality (VR), in storytelling, most of the research studies focus on immersive-VR that involve expensive and bulky settings, which eventually limit its feasibility to be ubiquitously used. Thus, this project looks into the potential of non-immersive VR, also known as desktop VR, for educational purposes. This alternative low-cost and affordable VR technology requires only conventional computer settings but is able to present an interactive real-time three-dimensional virtual environment (VE) that the learners can navigate in and interact with. A constructivist instructional design theoretical framework [18] is adopted to construct the VR storytelling system. This storytelling system aims to deliver fire safety knowledge to the targeted learners.**

I. Introduction

Stories are pervasively used as a powerful and promising educational means for teaching and learning. Stories draw learners' attention and thus can convey certain messages more easily to them. There are some popular story-based techniques widely used for educational purposes, such as case studies, critical incidents, role playing, and simulations [1]. Through stories, we create and discover meaning in a more engaging manner than just by telling statements of fact. Storytelling is effective as an educational tool because storytelling eases the recall of facts [2], facilitates comprehension, aids in critical thinking [3] and draws attention and concentration [4].

The power of stories in teaching and learning is exhibited from narrative perspectives. Human understanding does not occur as concepts, but as stories organized in narrative form [5]. Storytelling emulates the real life process, where explicit and procedural knowledge are constructed from our daily life. Thus, storytelling is potential in facilitating constructivist learning [6], where learners construct knowledge actively in a learning environment via stories.

Basically, there are two types of storytelling, namely linear and non-linear storytelling (interactive storytelling) [7]. The main distinctive characteristic of these two types of storytelling is the process of the storytelling itself. This project will focus on the non-linear storytelling, where concepts and ideas are the main stem of the storytelling process, without knowing the definite development of the story. Non-linear storytelling is more similar to real life whereby the narrations do not always proceed episodically. Non-linear storytelling allows the audience to have the right to decide how the story goes.

There are researchers who have employed storytelling method in teaching and learning. Kelleher, Pausch and Kiesler [8] show the effectiveness of storytelling in supporting the learning of computer programming. Casey et al. in [9] also show the effectiveness of storytelling via block-building activities in providing an effective context for teaching spatial content. Palmer, Harshbarger and Koch [10] claim storytelling as a constructivist model for developing language and literacy as storytelling is a rich interactive process that facilitates imagination, creative thinking, language abilities, and cooperative learning.

Realizing the potential of storytelling in facilitating teaching and learning, this paper aims to address the instructional design of an educational storytelling system that employs the three-dimensional VR technology. This paper also reviews the current approaches of storytelling, and the potential of non-immersive VR, which is also known as desktop-VR, in facilitating learning via storytelling.

II. Current Approches of Storytelling

A. Non-Virtual Reality (VR)-based Storytelling

The platforms of storytelling are very broad, ranging from oral storytelling, books, music, theatres, movies to technology-enhanced storytelling systems. Apart from conventional storytelling approaches, current storytelling methods are being enhanced with technologies, for instance, electronic multimedia-based storytelling systems [6], which are gaining wide acceptance. There are also various novel approaches of storytelling. In [11], the storytelling process is carried out via multimedia physical storytelling technology, where the participants are placed in a pre-setup room with all the instruments, including the physical objects (which appear in a particular story), sensors, and the physical icons as actuators. However, this type of storytelling requires bulky settings. It also requires the participants to physically explore in the pre-designed limited region and interact by using gross motor (mostly hands). Although it does increase the attractiveness, engagement and the educational benefits of storytelling, it may not be feasible to be used pervasively.

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B. Virtual Reality (VR)-based Storytelling

Virtual reality is used for various purposes, such as entertainment, education, etc. Although there are efforts to use VR technology in storytelling, most of them focus on the use of immersive-VR [12] or mixed-reality system [13]. Besides, the recent research focus is mostly on the construction of attractive and exciting content of the interactive stories [14], intuitive ways of interactivity within the VE as well as sensory feedback and real-time manipulation of the non-linear storytelling [15]. Research also focuses on technical issues such as immersion, interaction, navigation, etc.

Immersive VR requires expensive and bulky settings, which eventually limits its feasibility to be ubiquitously used. Hence, the paper looks into the potential of non-immersive VR, also known as desktop VR, for educational storytelling purposes. Non-immersive VR system presents the interactive real-time three-dimensional VE on conventional computer screens, and the user can interact with it by using generic input devices, such as mouse or keyboard. The fact that no additional peripherals are introduced has made such VR setting to be relatively low cost and thus, affordable to be used by most educational settings or even for personal use.

III. The Educational Potential Of Desktop VR Storytelling System

Desktop-VR is recognized as a technology breakthrough that is powerful in facilitating learning process [16]. Desktop-VR also possesses distinctive capabilities which well support storytelling. These capabilities include:

(1) Visualization of three-dimensional representation of a story episode through various scenarios, which emulates real life environments. This reduces the user's cognitive load if compared to two dimensional representations such as storybooks and multimedia or digital based storytelling systems.

(2) Free navigation in the VEs allows flexible flow of story. As mentioned earlier, the narrations of non-linear storytelling do not always progress episodically and it allows the users to decide the storyline. The fact that VE allows free navigation has indeed facilitated this non-linear storytelling.

(3) Active interface in which the virtual objects or virtual characters behave in accordance to the user's action or state of simulation. This capability supports a dynamic storytelling as the objects or characters in a story are always active.

(4) Interactivity within the VEs also facilitates non-linear storytelling in which the user can decide the storyline flexibly.

Realizing these educational potential, this paper focuses on the instructional design considerations to create an effective VR-based educational storytelling system.

IV. Instructional Design of A VR-based Educational Storytelling System

Instructional design is a systematic and reflective process to plan or design methods of instruction based on principles of learning in order to facilitate the construction of intended knowledge by the learner [17]. Instructional design is important to ensure the learning processes achieve its optimization. Thus, a good instructional design makes learning more effective and efficient.

The pedagogical perspectives that form the theoretical basis of VR-based educational storytelling system include the enhancement of constructivism learning via storytelling, and interactive and explorative learning environment supported by VR technology. This VR-based educational storytelling system employs the instructional design theoretical framework (Fig. 1) proposed by Chen, Toh and Wan in [18]. This model proposes instructional methods that are based on various theories and learning principles to ensure the educational goals are best attained in a VR learning environment.

In general, this model incorporates the concept of integrative goals [19] with the model for designing constructivist learning environments [20], which serve as the macro-strategy of the model. Macro-strategy concerns with the selection, sequence and organization of presenting subject. The framework starts from the inner ring (objectives) and progresses to the outmost ring (support tools) gradually. Generally, the objectives (innermost ring) comprise of a list of individual learning objectives, which intended to be achieved. Then, an integrative goal is derived according to the relationships among the objectives.

This is followed by enterprising scenarios/ problems based on three integrated components: the problem context, the problem representation and the problem manipulation space. The scenarios or episodes of the stories are constructed in this stage. The aggregation of different scenarios forms the non-linear storytelling. The storyline experienced by each user will be different based on their navigation and interaction within the VE. This is followed by designing the necessary tools to support constructivist learning in the VE. These support tools include related cases, information resources and cognitive tools.

This model is enhanced with multimedia design principles derived from the cognitive theory of multimedia learning [21], which serves as micro-strategy of the model. Micro-strategy concerns the strategies to present the learning content effectively. This framework employs constructivist paradigm, which is found to be compatible with the non-linear storytelling. Thus, this framework is used to guide the design of the educational storytelling learning environment.

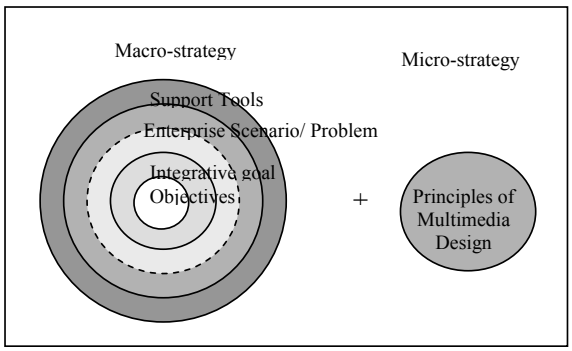

Fig. 1. Instructional design theoretical framework for desktop VR-based learning environment (Adapted: Chen, Toh & Wan, 2004)

V. VR-based Educational Storytelling System on Home Fire Safety

The framework discussed in the previous section is further illustrated with reference to an on-going project on VR-based educational storytelling system on fire safety. According to the National Fire Prevention Association [22], about 396,000 home structure fires were reported in 2006, resulting in 2,580 deaths and 12,500 injuries in the United States. Direct damage had caused an estimated total of $6.8 billion in the same year. A surprising statistic shows that home fires have caused 80% of civilian deaths and 76% injuries. This is a huge proportion from overall death cause. Thus, it is crucial to provide adequate education to the nation about fire safety as prevention is always better than reaction. This section provides an elaboration on how the instructional design theoretical framework is used to guide the design of the storytelling system for this particular learning context, focusing on fire safety at different compartments of a house such as the living room, kitchen, bedroom, and study room.

To begin, the individual learning objectives (starting from the innermost ring of the instructional design framework) which are intended to be achieved are listed as follows:

(1) To identify objects that can easily cause fire, such as heat produce objects, flammable objects, explosive objects, etc;
(2) To identify situations that may cause fire;
(3) To name the various types of fire extinguisher ;
(4) To learn the procedure for using a fire extinguisher;
(5) To recognize different types of fire and the best way to react in time;
(6) To identify self-protection and the ways to escape during fire;

With the objectives stated above, an integrative goal (the second ring) which relates all the individual objectives is identified: The learners should know how to prevent home fire and react to it if occur. Then, scenarios or problems which enable the learners to acquire the knowledge are constructed (the third ring). The flexible story content or the non-linear storyline will serve as the problem context. The problem representation is in speech form (uttered by the virtual character), text form, graphic form and narrative form. The virtual house itself will serve as the problem manipulation space, which includes four main locations: living room, kitchen, bedroom and study room. Support tools (the outmost ring) aid the knowledge construction process; include the activation of the objects or characters behavior which acts as the related cases, the link to extra information such as facts about fire acts as the information resources, and the provided hints which guided the users through the story acts as the cognitive tools. Another instance of cognitive tools is a map of the virtual house provided which enable the learner to be aware of their current location in the virtual house and ease their navigation to the other locations.

In this storytelling system, coaching is used as an instructional activity to give feedback to the learner's performance or actions as the story develops. There are various types of coaching such as providing motivational prompts (e.g. give credit to the learners for performing a good task), monitoring and regulating the learners' performance (e.g. asking the learner to check out the ambiguous "zhi...zhi..." sound when they approach the multi-socket) and provoking reflection (e.g. asking the learners whether they place the candle properly). Procedural scaffolding is another instructional activity which is used to scaffold the learners' learning process in the VE. The "Help" button will link to the page that provides information on navigation in the VE.

Apart from the macro-strategy discussed previously, micro-strategy also plays its significant role in enhancing the learning which is guided by principles of multimedia. In this storytelling system, relevant images, sounds and labels are incorporated to enhance the interpretation and learning process, for instance, a fire image in attached to the button "Facts of Fire". Fig. 2 shows a screenshot of the educational storytelling system.

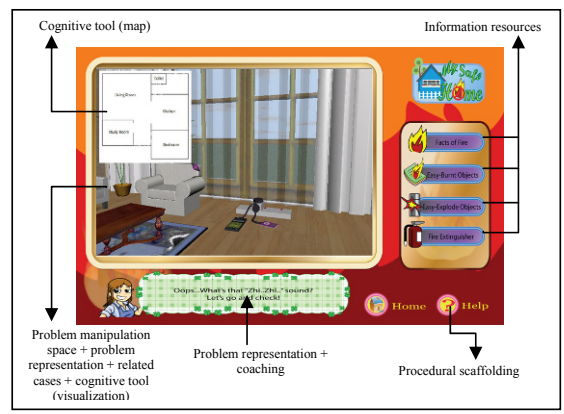

Fig. 2. Screenshots of the educational storytelling system

In the VE, learners are guided through stories where they are able to navigate to a particular location and the VE will be activated and some scenarios are created which require them to perform some tasks and at the same time convey the message of fire safety to them. However, the learners still have the right

to navigate to anywhere else in the virtual house. Hence, unlike conventional storytelling method, this VR-based storytelling system allows the learners to have a flexible flow of story while constructively create knowledge on home fire safety.

VI. Conclusion

This paper presents the potential of using storytelling approach in a desktop-VR based learning environment. It also suggests the feasible use of a theoretical framework that can be utilized by instructional designer or educator to guide the instructional design of such learning environment in the effort to produce effective and engaging educational storytelling process.

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