Enhancing the Learning of History through VR: The Thirteen Factories Icube Experience

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Abstract. This paper explores the use of Virtual Reality (VR) for *HH2013 Chinese Mandarins versus European Merchants, 1512-1911,* which was offered to undergraduates at Nanyang Technology University in Singapore. The 22-minute VR version of the Thirteen Factories brought viewers through seven significant scenes reflecting the social, economic and judicial life in the Port of Canton. The visuals, recreated from 49 painting and lithographs of the time, were supported by narration in English, and presented in the EON Icube™ mobile. The research questions were as follows:

1. What was the Icube Thirteen Factories experience like for the participants?
2. How would it fit in an undergraduate curriculum?

Weekly seminars comprised short introductory lectures, discussion of the prescribed readings, visualisation exercises and presentations. Students were invited to view the VR version of the Thirteen Factories after they completed their seminars and assignments. Data collected from four participants included their immediate response to the Icube experience and an online survey. Those who presented the "Shopping in Canton" research were interviewed whether it further shaped their knowledge. Their professor who reviewed their assignments and project work was also interviewed. The findings suggest that the Icube experience was an engaging one, having added much to their understanding of life in the Thirteen Factories. It could be used to augment face-to-face teaching of History at the undergraduate level.

Keywords: Virtual Reality, History, Learner expectations

1 Introduction

Staley (2015) describes Virtual Reality (VR) as "any number of computer-generated, three-dimensional spaces with objects and people that seem very real and with whom viewers may interact as if they were real" (p.92). VR uses "special hardware and software to generate a simulation of a computer-generated environment or three-dimensional (3D) object", enabling "the manipulation of information in potentially the same way that objects would be manipulated in the real world" (Carter, 2013, p. 67). These "new technologies of multi-media representation have generated a host of virtual locations, situations, transactions, relationships, and other culturally significant

phenomena that are poorly accounted for by traditional perspectives on material culture and visual studies" (Wagner, 2011, p.96).

According to Bricken (1991), VR has great potential for education:

> ... VR offers teachers and students unique experiences that are consistent with successful instructional strategies: hands-on learning, group projects and discussions, field trips, simulations, and concept visualization ... (p. 178)

With the immersive function, VR can "allow the user to experience that which is not normally available in traditional educational settings or that which may not even exist" (Carter, 2013, p. 70).

VR has great potential for presenting History (Alison, 2008):

> ...Virtual simulations can be used to present multiple strands of historical narrative simultaneously. Rather than referring to several history books to access multiple points of view, researchers can access distinctive perspectives from one simulation... (p.346)

In fact, VR has been used to teach History at the university level, for instance, the Virtual Harlem Project (Sosnoski, Harkin, & Carter, 2006).

The Cave Automatic Virtual Environment (CAVE) is "a walk-in virtual reality theatre typically configured as a ten-foot cube with three or more of its interfaces rear-projected with stereoscopic, head-tracked, computer graphics" (Craig, Sherman, and Will, 2009, p.6). This sophisticated and expensive environment (Maher, Simoff and Cicognani, 2000) was developed in 1992 to overcome limitations of previous VR solutions, which were poor image resolution, the inability to share experience directly with other users and isolation from the real world. The head tracker allowed the user to "see the entire environment from the correct viewpoint, thus creating a compelling illusion of reality" (Gutiérrez, Vexo, and Thalmann, 2008, pp. 133- 134). Users wear "active glasses" to view a convincing 3D scene (Burdea and Coiffet, 2003, p. 80). A controller can specify the interactions possibilities (Gutiérrez, Vexo, and Thalmann, 2008). A network of CAVE environments could allow for collaborative work (Maher, Simoff and Cicognani, 2000). The CAVE has been used to provide viewers to experience life along the streetscape during the Harlem renaissance of 1925 to 1935 (Carter, 2006), and the Mogao Grottos at Dunhuang (Stromberg, 2012).

In 2016, the Nanyang Technological University (NTU) explored ways to use VR to enhance learning at the university. The offer was taken by the professor teaching *HH2013 Chinese Mandarins versus European Merchants, 1512-1911* in the School of Humanities. This 13 week semester subject focused on the love/hate history of the port of Canton over four centuries preceding the 1911 Revolution. Students discussed broader questions fundamental to the subject, such as state-merchant relations, different worldviews, and the political issues of translation. They also examined the cultural, economic, religious and legal aspects of these encounters. They read a rich variety of letters, memoirs, journals, newspaper reports, and translated archives that gave detailed accounts of the encounters. During their weekly three hour face-to-face seminars, they were encouraged to visualise the scenes from these rich descriptions. Students faced difficulties visualizing the details of the Thirteen Factories in the Port of Canton. Hence, it was selected for the VR project to present a "back in time" experience based on insights synthesized by the professor. It was hoped that this multi-sided

immersive environment could add to the learning experience of the undergraduates as the Thirteen Factories no longer exists today.

The Teaching and Learning 2.0 project team explored recreating scenes based on historical paintings and lithographs, matched with narration and music. As this was the first time the Icube™ Mobile was used to present an academic project at NTU, this qualitative study aimed to understand the value of the VR experience. The research questions were as follows:

1. What was the Icube Thirteen Factories experience like for the participants?
2. How would it fit in an undergraduate curriculum?

As universities ponder over the usefulness of VR (Matthews, 2017), and how to cater to neo-millennial learners' learning styles and preferences (Dede, 2005), this study will shed light on how undergraduate students take to VR in Singapore.

2 Literature Review

VR provides great opportunities for learning that are unique and different from the regular classroom experiences:

> … VR learning environment is experiential and intuitive; it is a shared information context that offers unique interactivity that can be configured for individual learning and performance styles … (Bricken, 1991, p. 178)

It allows the user "to experience, interact with, and discover digital knowledge first hand, while the manipulation of the verity of the virtual world allows the user to make visual or kinesthetic relationships to help him/her understand the real world, or concepts related to it" (Carter, 2013, p. 69). A three-dimensional, interactive environment allows users to manipulate, explore and modify the environment, collaborate, and have their performance and actions tracked (Craig, Sherman and Will, 2009). Affordances of learning in 3D virtual environments are spatial knowledge representation, experiential learning, engagement, contextual learning, and collaborative learning (Dalgarno and Lee, 2010). Hence, VR has a place in education because its rich environment that allows learning to take place naturally.

VR provides sensory and mental immersion (Sherman and Craig, 2003). For sensory (or physical) immersion, VR can present "perspective-dependent images to each eye, synchronized audio to the ears and haptic information to the body". When the user moves, "the visual, auditory, haptic, and other qualities that establish physical immersion in the scene change in response" (p. 382). Mental immersion is determined by the level of the viewer's engagement.

Visualisation is an important skill. According to Carter (2013), visual cues are one of the tools used to explore various themes within a text. Learning how to visualise words on a page will enhance the comprehension and enjoyment of a text. By visualising and identifying with characters in the text, readers can understand "the context in which the work was written as well as experience the setting from another person's perspective" (p. 66). Digital tools like VR also help to present humanities in another form of visualization. Different points of views can be presented. According to Sherman and Craig (2003), a first-person point of view presents a world seen through the

user's own eyes; a second person point of view, the world is viewed from near the action, allowing for the sharing of the same space with the main characters; while a third person point of view presents a view that signals that the viewer is not part of the action taking place.

VR has to be designed carefully to ensure that learning takes place with specific activities in mind. For instance, the *Le Boullongne* was deployed on a virtual reality platform providing multimodal (vision, sound, haptic) and immersive interaction. The interactive and collaborative virtual reality applications were at multiple local and remote users. Other immersive devices were also used (Barreau, et. al, 2015). It is also essential to provide supporting resources to help learners process their experience. For instance, ClassVR (2016), which presents students with rich VR experiences tied to the school curriculum, provides teachers with over 500 pre-made activities.

Maher, Simeon and Cicognani (2000) describe virtual realities as environments that prioritise the simulation of a physical place. Hence the "sense of space needs to be recreated to simulate a physical set of sensations - mostly visual and tactile" (p. 193). For historical VR recreations, it is important that the sources of information are authentic. VR developers used information logbooks and other historical documents to recreate the lost historical 18th Century ship, *Le Boullongne* (Barreau, et. al, 2015). The historical layers of Hisham Palace were studied for visualisation because of the condition of the physical remains and lack of historical literature (Ghadban, et al, 2013). Historical geographic information system data were used to recreate the 17th Century city of Kyoto in the early Edo era, while the 3D models were constructed from polygon data, fences from line data, and pedestrians and trees from point data (Isoda, et al, 2009). The actual Dunhuang caves were scanned to produce a fully interactive virtual exhibition (Stromberg, 2012).

The VR learning environment is able to accommodate different individual learning styles. Chen, Toh and Ismail's (2005) study of academic performance and perceived learning effectiveness and satisfaction, showed no significant difference for students with different learning styles in the VR-based learning environment. They also found that the guided exploration VR with navigational aids had significant positive effect compared to those with non-guided exploration VR.

Mikropoulos and Natsis (2011) found that theoretical models used in research of virtual environments were constructivism, social constructivism, situated learning, constructionism, experiential learning, inquiry-based learning, collaborative learning, guided discovery learning, and learning by doing. However, VR lends itself to Constructivist, Constructionist and Situated Learning (Burdea and Coiffet, 2003). Constructivist learning involves explorations of prebuilt worlds and discovery, while Constructionist learning requires the active building models. Situated Learning, happens through role play of a certain character to understand its way of life.

Mikropoulos and Natsis (2011) also identified a range of data collection tools: questionnaires with close, open and multiple-choice questions, interviews, observations, recordings, log files, completion of tasks in the educational virtual environments, and students' submissions of papers, pictures, stories and quests. Studies in human-computer interaction require in-depth qualitative research methods to review complex phenomena. Adams, Lunt and Cairns (2008) recommend data collection

methodologies which include “a range of observational and ethnographic methods, and various forms of qualitative interviewing” and methods of analysis, namely “thematic analysis, grounded, discourse analysis and conversational analysis” (p. 152). Because VR offers a different and unique learning experience, educational research opportunities abound: “transfer of learning, appropriate curriculum implementation, elements of effective virtual world design, multi-sensory work-load distribution in VR and the psychological and social aspect of the technology’s use” (Bricken, 1991, p.183).

3 Methodology

The subject *HH2013 Chinese Mandarins versus European Merchants, 1512-1911* was offered to undergraduates at NTU between August to December 2016. Except for an exchange student from USA, all were Singaporean fourth year students in the School of Humanities and Social Sciences. They were in their mid-20s. The 25 undergraduates worked in groups of five.

The Thirteen Factories played a significant role in the lives of the Chinese and Europeans. A three-hour seminar devoted to the Thirteen Factories involved a short introductory lecture, discussion of the prescribed readings (selected from the rich repository of texts and paintings), and a visualisation exercise which required drawing a map of the Thirteen Factories. In another seminar session, one group presented “Buying a piece of China, Shopping in Canton, from a Western Perspective”. They covered the following:

1. Introduction - Thesis - Definition of shopping - Currency - Sources used
2. Shopping in Canton - Food and Drinks - Clothes and Textiles - Export paintings - Knick-knacks

This group had an additional tutorial with the professor to help scope their research, clarify doubts as well as locate additional information. Students could also write an essay on the Thirteen Factories for their assignment.

3.1 Design of the Thirteen Factories

The VR experience was conceptualised by the HH2013 Professor, who as a scholar and an expert in modern Chinese History, had studied the Thirteen Factories for over a decade. As VR lends itself to Constructivist learning (Craig, Sherman and Will, 2009), the Icube experience was to complement the existing Constructivist approach used during seminars. While viewers would have had some knowledge of the Thirteen Factories, it was hoped that their Icube VR experience could enhance their learning experience and provide information and understanding through another medium.

The VR version of the Thirteen Factories presented the economic, social, and judicial life in the Port of Canton. While the actual period spanned 150 years (5500 days), the seven scenes each depict a day in life in the mid-1800s. The following are descriptions of each scene:

1. On Top of Red Fort: Viewers are on top of the Red Fort, situated opposite the Thirteen Factories, on the other side of the river and have a magnificent bird's eye view of the Canton Port city and the Thirteen Factories from afar. The narrator introduces viewers to the virtual tour that would unfold.
2. River Crossing Point. River Scene and Boat Crossing the River: Viewers travel on a boat on the river, from Red Fort to the Thirteen Factories. Along the river is a busy floating city with different types of boats and boat people living on the river. When the scenes move past the viewers, it generates a sense of speed. The narrator introduces life on the river.
3. Mid-River Stop: This scene, in the middle of the river, allows viewers to interact with three pieces of export porcelain on board the boat. They can pick up these items with the control and have a 360 degree view of them. The narrator gives a brief history of China's porcelain exports the world.
4. The Square and Street: Viewers continue to travel on the board and land at the square of the Thirteen Factories. The narrator then introduces the Thirteen Factories and life there.
5. 1807 Neptune Trial: When viewers enter an English Factory where a trial of a murder case of 1807 is taking place, they are in fact entering a painting that depicts the trial. The narrator introduces the history of the murder case which happened in the Thirteen Factories' Square.
6. Tingqua Studio: Viewers travel through New China Street and enter Tingqua Studio, famous for its export painting. They can interact with a painting by picking it from the wall. The narrator introduces the history of Chinese export painting.
7. 1829 Pirates' Trial at Consoo House: Viewers enter Consoo House, the Guild House of the Chinese Hong merchants. Inside this magnificent building, an 1829 trial (case of pirates murdering 13 Frenchmen) is taking place. Viewers leave Consoo House to enter the Thirteen Factory Street where various Chinese shops flank both sides of the street. The narrator first introduces the history of the murder case and then the street.

The VR version included both visual and textual representations from the required readings. A total of 49 visuals were selected from over 100 watercolours, oil paintings, and black and white lithographs of the era by famous Chinese painters like Lamqua, Tingqua and Spoilum as well as western painters like George Chinnery and Warner Varnham. As it was not possible to do 3D renditions from some 2D artifacts, a "walking into pictures" experience was to define the design.

Information gleaned from the historical texts was converted into narration. The script for each specific scene was written in English by the HH2013 professor. Viewers would feel that they are on a guided tour. The visuals would transport them to the place and event, while the narration would help them focus on the key aspects of life in the Thirteen Factories. Here is an excerpt from the opening lines of scene 1:

> … You have entered Virtual Reality version of the Chinese historical port of Canton. Canton was one of the most exciting places in the world of maritime trade in the years between early eighteenth and mid-nineteenth centuries. Tea, silk, porcelain, lacquer ware and other amazing Chinese products were shipped from Canton

to the rest of the world. In front of you is the city of Canton and its surrounding areas…

As it was impossible to recreate the exact street sounds and dialogues of that era, soft instrumental Chinese music was used in the background instead.

Discussions on the VR design started in September 2016. Production took around two months, requiring three full-time staff working about 120 man days. A reiterative design-development approach was used. The initial continuous guided tour without interactions with objects was created with Eon Studio. After several refinements and tests, the VR version with interactions, pausing and playback capabilities was ready for viewing by February 2017 in the NTU Icube™ Mobile which could accommodate up to four viewers at one time (see Visual 1).

Visual 1. Viewing the Thirteen Factories at NTU Icube

The overall product, a 22-minute VR, provided a first-hand experience of happenings in History, and the opportunity to explore different perspectives in a virtual environment and interact with objects in the Thirteen Factories as well as travel on a ship through waters (Centre of IT Services, 2017). The Icube allowed for free roaming, offered different views (i.e. standing, stooping), and provided a panoramic view rendered in stereoscopic 3D to provide a high-quality VR experience. It overcame the limitations of visual representation as it contained more colourful and imaginative textual representation through narration.

3.2 Data collection and analysis

Because of the delays in the start of the project and technical challenges, the VR was available after the semester was over. Students were invited for viewing on 5 February 2017 and 9 March 2017. Full data from four participants were collected:

- Participant 1, a male History major, had no prior experience with VR Icube. He liked to learn History by reading and tended to visualize History "to add value to his analysis".

- Participant 2, a female History major, had prior experience with VR Icube. She preferred to “learn about history by watching” [sic]. She wrote a web essay entitled “Beyond Ordinary: Men and Women of the Thirteen Factories”.
- Participant 3, a female History major, had no prior experience with VR Icube. She preferred learning History by watching and reading. Her group presented “Shopping in Canton”.
- Participant 4, a female Linguistics and Multilingual Studies major, had no prior experience with VR Icube. She preferred learning History by watching documentaries. Her group presented “Shopping in Canton”. She wrote a web essay on the Lamqua Paintings.

While this small number might affect the validity of the data (Cohen, Manion and Morrison, 1993), they were all were “qualified” to critically assess the value and quality of the VR and articulate how it could be improved. This was because they were trained in visualization during their seminars, and VR would be another form of visualisation. Their reaction to the Thirteen Factories was recorded immediately after viewing it. They were also asked to respond to an online survey on Google docs.

To design the survey and interview questions, areas to be investigated were first identified under the following categories: reaction, expectations, usability, and learning. The survey questions were then written and sent to the stakeholders for comment and modification. The interview questions aimed at augmenting insights for these areas. Those whose researched “Shopping in Canton” were interviewed to probe the usefulness of the VR viz a viz learning from the texts, lectures, projects and VR. Notes were taken of their recorded responses and interview. Data from the online survey on Google forms were saved. The professor was interviewed on the participant's’ understanding the Thirteen Factories through his observations in class, his face-to-face interactions in class and interactions during a separate research project group tutorial. He had noted their ability to draw the streets around Thirteen Factories, and had evaluated their research presentations and assignments. The researcher also observed the Thirteen Factories seminar and related presentation. The data was then triangulated.

4 Findings

The experiences of the participants are reported below, under various themes: reactions, expectations satisfaction and significance, pace and equipment. Its place in the History curriculum is reported after that.

4.1 Reaction

Their immediate reaction was that of sheer delight to see what they had learnt in class translated into a VR version. Participant 3, who enjoys watching documentaries, described the Icube experience as “more fun because it's novel!” She felt that “It was great to see”...and felt “Wow. Its [sic] great.”

The VR experience left the participants wanting more. They felt that there could have been the inclusion of more realistic ambient sounds to add to the atmosphere e.g. sounds from the streets, e.g. commotion as described in the texts. Indeed, one of the questions during their presentation was on the type of communication between the traders and westerners. Also, there could have been the inclusion of more flower boats (Participant 2).

4.2 Learner Expectations

The participants' response varied when asked if they imaged the Thirteen Factories to be what was presented in the VR version. While it was close to the imagination of Participants 1 and 3, Participant 2 did not expect to be able to move around in the space. Expectations of Participant 4 were higher, as he imagined it to be slightly more interactive. In terms of satisfaction and significance, scenes varied in terms of satisfaction and significance. The data was calculated from the Likert scale ratings in the survey. While participants were satisfied with the Icube experience, more so for scenes 1, 2, 3 and 6 (see Figure 1).

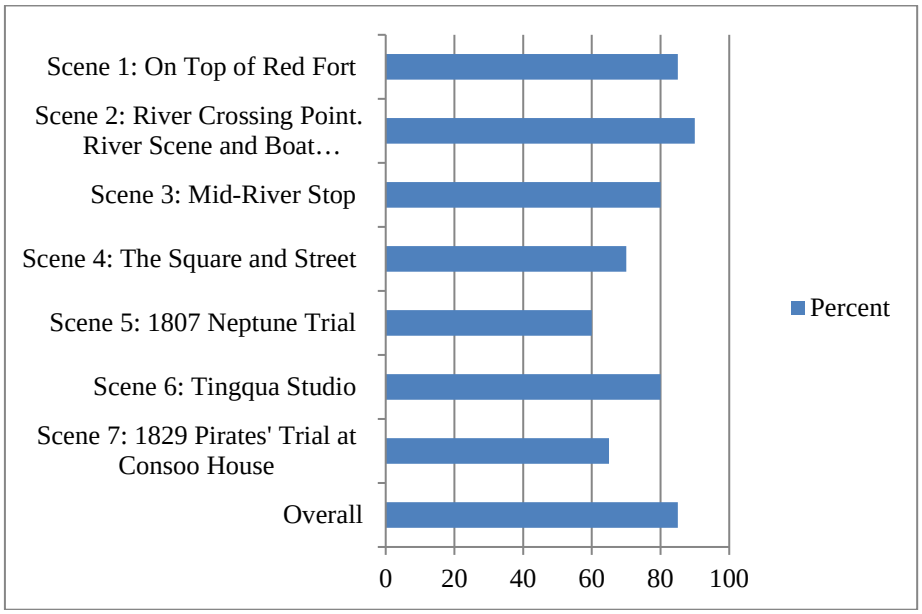

Fig 1. Satisfaction of Experience

Reaction to the scenes differed. Scenes 2 and 6 impressive all participants most, while Scenes 1, 3 and 4 only impressed half of them (see Figure 2).

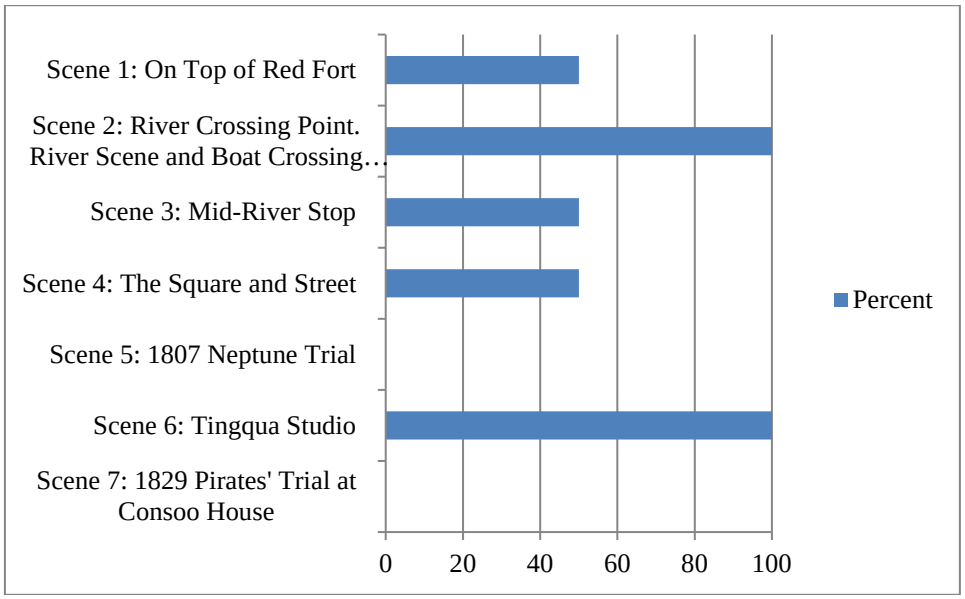

Fig 2. Most impressive Scenes

4.3 Usability

The VR experience varied in terms of ease of use. As to the use of VR Glasses and Controller, the participant who had previously experienced another VR in the Icube did not have any problems with the VR glasses, while the other three found it sometimes difficult viewing with it. Except for one participant, the others did not have problems working the controller.

There were different reactions to the pace of the VR experience and the ability to follow the narration. While half the participants found it all right, it was too slow for the other half. Half of the participants were able to follow the narration all the time while the other half did most of the time.

4.4 Learning

The History professor who taught the subject felt that the VR version helped the participants put things together, bridging the gap between reading and imagination as learning from text and pictures had its limitations. Participants had struggled to draw the map of the Thirteen Factories during their week 7 seminar on 20 Sep 2016. Locations of factories were incorrect, and purposes of the shops were mixed up. Participants confessed having difficulties constructing a mental model of the Thirteen Factories for their “Shopping in Canton” research. Participant 3 was not good at visualising while Participant 4 needed to draw an aerial view. Both needed additional resources for their research project and clarified with the professor details of the locations of the shops. They also presented using text and 2D visuals, and focused more on what they

could do and find, and less on the space. This was gap the VR version attempted to fill. Overall, the participants found the coverage comprehensive:

> … The project covered the majority of the sites and scenes of the Thirteen Factories that we learnt about... (Participant 2)

New experience: It provided new ways of experiencing the streets of Canton like navigating the streets). For instance, the VR version gave Participant 3 "a personal experience in the street". She had taken a personal interest in the TingQua Shop as it was her presentation topic. It provided Participant 4 with "a realistic view" as "it gives us spatial awareness when we were in the cube [sic] and it was like walking in a painting!" In fact, it was preferred over merely reading texts:

… Much better, made things more tangible (Participant 2)

… It gave me a better idea of where and how the streets looked like from a front and eye perspective … (Participant 4)

However, it made less of an impact on Participant 1, who tended to visualise what he read, found that it would be about the same.

New insights: Having newly experienced "what it was like riding onto the flower boat", Participant 1 could almost "feel how pensive the Europeans might have felt".

Spatial awareness: VR made them aware of the "spatial aspects" (Participant 3 & 4), "seeing things as though I was present (Participant 4).

New knowledge and understanding: For Participant 3, there were "additional things learnt that were not caught in class". While participants 1 and 3 felt that the VR version enhanced their understanding of the Thirteen Factories, Participant 4 did not find it in-depth enough.

4.5 Role in History Curriculum

There was overwhelming positive response to having the Thirteen Factories VR for undergraduate History lessons.

> … "History can be told using a very different and yet effective format. This is promising …" (Participant 1)
>
> … "Visualisation helps make history more tangible…" (Participant 2),

Two participants felt that it should be used on a supplementary or complementary basis, and as "a tool to learn in class, but not as the entire package" (Participant 4).

5. Discussion

Overall the participants were positively engaged (Dalgarno and Lee, 2010) during their 22 minute sensory experience of captivating sight and sound, interaction with virtual objects and navigating at will. However, some scenes stood out more than the others. Because of the Icube setup, viewings were influenced by the main viewer who held the controller.

The sense of space (Maher, Simeon and Cicognani, 2000), was experience in the recreation of the Thirteen Factories from the piecing of various paintings. Because the narration was designed to guide the viewer, the script could not contain as much of the rich descriptions contained in the letters written by the people of the time.

While the brain is powerful enough to visualise the information, it is impossible to share these visualisations in the mind. Hence, the VR version provided a shared experience (Bricken, 1991) not normally available in traditional educational settings (Carter, 2013). It provided a recreation of the Thirteen Factories which was completely destroyed in 1856 at the start of the Second Opium War. Given the opportunity to be virtually "on site", in a shared information context (Bricken, 1991), enabled contextualised learning (Dalgarno and Lee, 2010). While the participants were familiar with the Thirteen Factories, revisiting it through a digital genre provided opportunity to gain new knowledge, insights and realisations, adding to their understanding of the Thirteen Factories and the refinement of their mental models. In this case, VR lent itself to Constructivist learning (Burdea and Coiffet, 2003)

The 3D format of VR in the Icube allowed participants to literally enter into the space and time to experience the history recorded in text and in 2D paintings. This psychic experience of entering it seemed to trigger a great degree of excitement among them. By 'walking' into the space, the participants were mentally inside the history. The meaning of immersion is simultaneously physical and mental (Sherman and Craig, 2003) enhanced the retaining of historical knowledge.

The participants found VR useful as an enhancement to the subject. While the findings are useful and interesting, they represent views and experiences of 16% of the class, thus limiting the generalizability of the findings (Cohen, Manion and Morrison, 1993).

6. Conclusion

The VR version of the Thirteen Factories show that a lost historical site could be constructed using modern technology, allowing for the ease of experiencing what was lost in history. Although participants were fully aware that the VR was not the actual Thirteen Factories, the reconstruction using paintings and texts description of the site is the closest one can get to the historical reality, allowing opportunity to 'visit' the site. This enhanced their learning experience. The findings for the preliminary study suggest that the VR Icube experience was a positive one and it certainly has a place in the undergraduate History curriculum. VR for learning history would generate an enhanced learning experience especially when there are visualization exercises of history and other preparatory process in place.

To complement this study, further work with Eye-tracking technology could be used to capture what was actually viewed, providing insights on how viewers explore VR and learn from it. A case study could be carried out for the integration of the Icube VR into the HH2013 curriculum reaping data from reflection logs, pre- and post-course surveys, and interviews. For practitioners, further research would inform how learner expectations and preferences could influence how the subject could be delivered for 21st century learners.

The VR version presented a new acceptable way of learning HH2013. In addition, it generated interest among other History students and faculty in Singapore and overseas. However, the biggest technical challenge to develop VR from paintings and lithographs, limiting participants' experience to "walking into paintings" as the full of immersion in the historical scene had yet to be realised. While the prohibitive cost to develop lessons using the Icube might limit the undertaking of such projects, the full potential of VR has yet to be reaped and reached. VR Designers must consider the expectations and demands of a tech-savvy new generation who have played video games or are used to high-tech innovation. While they would be attracted to VR, they may require a higher resolution of the screens (more pixels to cover the full field of view) and more stimuli. The overall production such as sound effects and the quality of scenes need to reach a higher level in order to make it a genuinely fully immersive experience. There could be more modes for navigation or exploration. In addition, the use of immersive VR headsets could be explored in the design as they would provide more personalised viewing.

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