

Virtual Simulation for History Education

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ABSTRACT

Virtual simulation is an ideal approach for providing situated learning environments in history education, in which virtual reality (VR) and video games are the most widely used approaches in teaching history because of their convenience and popularity. Already-made historical VR materials are usually used for experiencing history, and historical VR materials made by the students could help learn history by "doing history". We have been teaching the history and culture of Tang dynasty by the virtually reconstructed Dunhuang Mogao caves as well as the ancient Chang'an city with Minecraft, 3D modeling systems and 360-degree panoramic videos and images. Based on our practices, we propose a workable method for applying virtual simulation in history teaching. According to our experiences using virtual simulation for teaching history, the engagement and the performance of the students increase after virtual simulation based learning is used.

Keywords: Virtual simulation, Minecraft, 360-degree, WebVR

Index Terms: Computer Graphics—I.3.7—Three-Dimensional Graphics and Realism—Virtual Reality

1 INTRODUCTION

Virtual simulation technologies such as virtual reality (VR), augmented reality (AR), mixed reality (MR), and video games provide the opportunity for teaching/learning history by experiments. The virtual simulation based historical experiments could be classified into two types: virtual tours to the historical sites and history simulation. The students could virtually visit some historical sites without actually being there, which is especially important for the disappeared ones and those not easy to visit. More and more museums, companies, institutions have been recreating virtual historical sites, most of which could be accessed freely online, and could be used as teaching resources. Besides the already-made virtual historical materials, the teachers and students could virtually reconstruct some disappeared historical sites with more scientific values than others because of their expert knowledge learned from historical sources, the procedure of which could largely improve the interest and the engagement of the students in learning history. In a virtually reconstructed world, some historical events or ceremonies could be re-enacted by the students or simulated agents that are driven by artificial intelligence (AI), e.g. multi-agent simulation. These two types of historical experiments could help the students learn history immersively as in a laboratory. The former is more mature and is much easier to apply in history education, because virtual resources (e.g. virtual heritages, museums, etc.) and devices are widely available, however, the latter is much more difficult but could be much more significant because the students could get embodied recognition about the past when they are involved in the virtually created historical events, and simulating the past could help understand the present better [4]. In this paper, we mainly focus on the possible approaches for the virtual simulation based history learning, including the historical VR materials and video games.

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The virtual simulation technologies are more and more important in the field of history education around the world [21], however, the virtual simulation based instruction and learning methodology still needs to be deeply studied [14] [5], because the virtually immersive pasts bring both opportunities and challenges for the pedagogy of teaching history [3]. The virtual environments created with virtual simulation technologies make the learning of history follow an experimental way as the science and engineering subjects, which is consistent with the theory of "learning history by doing history". Doing history means identifying a problem or topic, finding information, deciding what sources are credible for what pieces of information, coming to conclusions about the topic, developing a storyline, and marshaling the information on behalf of that storyline, while giving attention to information that may seem to contradict the argument. [12]. In a traditional teaching environment, the results of doing history are usually in the form of written papers, photographs, videos, websites, etc. The VR materials help the students experience and produce history, which could be map to the reading and writing respectively in traditional history education, and they help the students learn history more interestedly and effectively by better "doing history". There are many papers focusing on the virtual simulation in education, however, most of them provide the students with some already-made virtual worlds or environments, based on which the students could get immersive experiences. Nevertheless, virtual simulation based history education requires extra skills for the students, because the students benefit more in history learning and research if they could reconstruct a virtual world virtually by their own according to their studies in various historical sources and historical analyses. Both the already-made VR materials and self-made VR materials help "do history" immersively, however, the former improves the students' interest of learning history, while the latter improves the quality of learning history.

The rest of the paper is organized as follows: Sect. 2 makes a survey of the related work; Sect. 3 discusses virtual simulation based embodied learning and history education; Sect. 4 introduces a possible method for virtual simulation based history education; Sect. 5 introduces our practices of using virtual simulation in history education as well as the skills that the history major students need to master.

2 RELATED WORK

Historical visualization projects should be accepted as a legitimate endeavor equal in standing to written work for historians [21], and the virtual simulation could play more important role in history education. Virtual simulation technologies provide history education with immersive virtual worlds that could motivate a better form of "learning history by doing history", in which the use and the construction of virtual historical resources, the new pedagogy of teaching history with them as well as the skills the history major students require are surveyed in this section.

Virtual reality makes it possible that the learning can happen "then" and "there" [6] as a result it increases the interest of the students and improves the performance at the same time. The learnability in a 3D virtual heritage is analyzed and proved in [23].

Virtually reconstructed historical worlds provide opportunities for "authentic experiential learning activities that have the potential to re-mediate students' understanding of space and place through enacted interaction, and to make the learning more memorable" because

immersive virtual reality could help enhance the spatial awareness and interest of students in the subject of history with better embodied experiences [15] [16]. It is proved that virtual worlds are better than books and videos in history education [9], where an ancient city Uruk around 3000 B.C. was reconstructed and populated with AI-controlled 3D avatars. The students could not only observe historical buildings, events, they could also interact with the simulated objects and persons. For example, the user could enact as different roles in a historical event as stated in [20], which give the students an overall experience of a history event. Besides history education, virtual worlds can also be used in historical research [11], and help to generate new knowledge [22], because the historical re-enactment in the virtual worlds allows historians to criticize different interpretations of history and produce new knowledge on the past [11].

Role-plays and simulations are growing popular in different levels of education, because of the deeper learning, student engagement, and transferable skills development [7]. Thinking like a historian is an popular and effective framework for teaching and learning history [13], and the virtual simulation technologies could provide the framework with a better teaching method compared with traditional texts-focused ones.

In order to fulfill the requirement of virtual simulation based history education, the history students need to try to transmit their knowledge that learned from many history materials with a historical critical view into visualization, e.g., an embodied learning environment as stated in [10]. It is impossible to achieve if they don't know what kind of technologies could realize their ideas. It relates to many kinds of skills which could be found in digital humanities, such as data analysis, data visualization. During the students' learning processes, they can do some "digital artifacts" including in the form of photographs, audio recordings and typed notes, as stated in [15]. It focused on mobile technology for history learning, while we can provide better experiences for the students with virtual simulation technologies, which is discussed in section 5.1. Historical architectural heritage is an important source for learning history, the paper [2] discussed the user requirements for architectural heritage learning through virtual reality. Historians play an important role in the whole procedure of recreating virtual historical sites, therefore we need to prepare the students for the skills they will need in the future.

3 EXPERIENTIAL/EMBODIED LEARNING AND HISTORY EDUCATION

Embodied learning in history is different to other subjects, because both the experiencing in the virtual reconstructed historical sites and the procedure of constructing historical sites by their own could provide the students with embodied experiences. The forms of embodied learning in history could be virtually visiting historical sites, role-playing in the historical events, historical reconstruction by their own, etc.

There are two types of historical sites that could be used in history education: existing historical sites and disappeared ones, both of which are important for the students learning history. In our university, the history major students are required to go to Dunhuang, an ancient city on the Silk Road famous for hundreds of existing Buddhist grottoes, to do academic investigations. According to their reports, we find this kind of field-trip is much better than reading related texts for the students learning history. Dunhuang is more than 1,500km from Xi'an where our university is located, therefore, it is not easy for the students to visit the historical sites frequently. From this example, we can see it is common that visiting the existing historical sites are not always possible for the students in learning history. We have built a virtual simulation laboratory to partly solve this kind of problem, where the virtually reconstructed Mogao grottoes are provided to the students. They can watch the Mogao grottoes much more clearly than they physically visiting. Besides the ex-

isting historical resources, there are many more disappeared ones that could only be found in the historical documents. For example, Xi'an was the capital city (named Chang'an) for thirteen dynasties in Chinese history and we are in Xi'an, however, we can only refer to the history archives to get the historical information of the ancient city. In our laboratory, the students are working collaboratively on building the Chang'an city of Tang dynasty in Minecraft according to their studies of historical sources (books, archaeology records, etc.).

Historical events could be simulated in virtual environments, for example, the user could enact as different roles in a historical event as stated in [20], which give the students an overall experience of a history event by playing the role of Lenin, part of the audience, or Trotsky. VR setup allows for a period of embodiment as a character in the scenario then this should be employed in order to maximize the chance of participant presence and engagement with the story, which results in better learning performance.

For history education, reconstruction of historical objects (sites, environments, etc.) by the students is a kind of advanced embodied learning, because the reconstructed artefacts are based on the knowledge extracted from historical sources according to the studies of the students. It conveys dynamic knowledge that is more difficult to learn than the static knowledge, which could only be learned through experiential learning, e.g. an embodied learning environment was constructed collaboratively by the students in [10] [18]. The virtually reconstructed historical sites should be accepted and considered the same as an academic work (paper, books) [6] [21].

3.1 Already-made VR Materials

There are lots of already-made VR materials we can use such as the virtual resources provided by museums, historical heritages, where virtual simulation technologies have been widely used. Some universities construct their own VR materials by their own faculties or together with some companies. Most of these already-made VR materials could be used freely, therefore, the teachers need to do good research to include suitable related VR materials into their courses based on the VR devices they have.

The main task of using ready-made VR materials is for demonstration and immersive experience of history for the students. It is difficult to find new knowledge because all the objects in this kind of virtual environments are managed and run in a planned routine. However, comparing to the virtual simulation in other disciplines such as chemistry or medical areas, the construction of the virtual environments is as important as experiencing in there, because the reconstructed historical sites would have limited scientific value if they can not accurately reflect the related history. The history scholars and students have the most professional knowledge about the past, therefore we consider that it is more important for them involving in the construction of virtual resources than just experiencing in the virtual worlds.

3.2 Self-made VR Materials by Students

Most projects related to VR in history education use ready-made VR materials, which are built by companies or teachers. They make the students more interested in learning history, however, some simulations constructed without the involvement of historians and archaeologists lack scientific values [11]. In the past it was impossible for the historians or archaeologists to create their own virtual historical worlds, because the techniques are much difficult for the history major students to master, such as some advanced 3D modeling tools, game engines, and VR demonstration/distribution. With the development of IT and the education, the history major students, even the secondary students, are able to develop VR materials by their own using VR tools such as Unity, Blender, Sketchup, as well as some game platforms such as Minecraft, SecondLife.

The accuracy of the reconstructed historical objects (environments, worlds) is important to their scientific value, but the accuracy here not only means the historical objects virtually reconstructed are the same with the real ones in the appearance, which usually need some advanced complicated 3D modeling software. As we know, most of the history scholars and students have limited IT knowledge and skills, therefore, it is not easy for them to complete. According to our practices, the most important part for the students using virtual simulation in history learning is the step that they collect historical materials, analyze them and finally generate a plan for virtual historical buildings, sites, or scenes by their own. For example, the Big Goos Pagoda is built in Minecraft according to the historical drawings by our students as shown in Fig. 1. The procedure is similar to the paper they submit to the teachers in traditional history education.

There are many technologies could be used in building VR materials for learning history, including 3D modeling, laser scanning, panoramic video and image capturing, etc. Here we classify the related technologies into two classes: VR content construction and distribution, which could form an ecosystem for virtual simulation based history education.

3.2.1 VR content creation

As to the creation of VR materials by the students, we are using Minecraft for the disappeared historical resources and 360 degree cameras for existing ones.

Minecraft¹ is a sandbox game engine, which is widely used in education. Ancient cities or historical sites of large scale are usually needed for simulating history as well as virtual tours. GIS data and digital maps could be imported into Minecraft [19] [8], in which the historical buildings could be reconstructed collaboratively by the teachers and students. 3D virtual worlds could be built using Second Life, OpenSim, etc., compared with which Minecraft has better adaptability, because the secondary students and college students could build anything they want in Minecraft. The Palmyras Temple of Bel, destroyed by the Islamic State of Iraq and Syria in August 2015, has been virtually reconstructed in a crowdsourced manner in Minecraft as shown in Fig. 2.

360-degree videos and images are the most convenient means for the students recording existing cultural resources, e.g. museums, cultural activities/ceremonies, because the 360-degree cameras are popular and cheap, and they could be viewed from any perspective by the users.

3.2.2 VR content distribution

The distribution of VR materials could be through game platforms such as Steam, or VR device platforms such as Oculus store, however, the most popular and effective means is the web. WebVR helps present VR contents on the web, through which the 3D models, as well as the panoramic videos and images, could be immersively viewed with VR headsets on the web. Facebook's 360-React² and Mozilla's A-frame³ are two of the most popular WebVR frameworks, and they are used in our laboratory by the students majoring in history and museology. Besides the recorded panoramic videos and images, some additional interactive information (e.g. background, navigation, history, etc.) could be integrated into the WebVR applications as the cases of Google Arts & Culture⁴, which could serve as the tour guide for the users.

4 A VIRTUAL SIMULATION BASED TEACHING METHOD FOR HISTORY EDUCATION

When the virtual simulation technologies are adopted in teaching history, the methods that direct the teachers how they can make

¹<https://minecraft.net/>

²<https://facebook.github.io/react-360/>

³<https://aframe.io/>

⁴<https://artsandculture.google.com/>

a good use of them to improve the learning besides the improved interest and engagement of students. It is obvious that the virtual simulation methods could not apply to every history class, but only part of them. The VR materials could be inserted into traditional history teaching procedure in different ways according to the type of the teaching methods as well as the content of certain class. The three phases and nine steps VR-based pedagogy proposed in [6] based on the framework in [17] is applied in our practices.

Phase 1: Plan accordingly beforehand and analyze the needs and environment.

Step 1. Analyze the "Problems in practice".

We need to identify what we are going to teach with VR, i.e. the exact history topic that is taught with VR in or out of our classroom.

Step 2. Assess the technological resources of a student and the school.

We need to guarantee that the existing resources, including the VR devices (VR headsets, smartphones, etc.) we can use in our classroom, could afford the VR practice in the classroom. If we want the students use VR materials off class, we need to guarantee the already-made ones are available and the students could use by themselves and they are familiar with the environments for creating their own VR materials.

Step 3. Identify the possibilities of a given technology: directed strategy or a constructivist approach?

For directed strategy, delivering information accurately and efficiently is important, and it should be assessed using a traditional test; with a constructivist approach, we need to identify how a given technology will help students develop skills and discover answers for themselves. The already-made VR material based history learning could be assessed with a traditional test, and the self-made VR materials could be assessed grouply according to the complexity and accuracy of their recreated historical objects.

Phase 2: Design an integration framework.

Step 4. Design a concrete learning objective and assessment

A measurable outcome and means for assessing student clear for both the teachers and students are needed.

Step 5. Design integration strategies and determine relative advantages.

How and why a technology is being integrated. A technology could be for amplifiers (makes a process more efficient, like word processors) or transformation (completely changes an instructional method, not otherwise possible without the technology). VR belongs to the transformative category by allowing students to experience three-dimensionally from another perspective that which would otherwise not be possible in real life.

Step 6. Prepare for the instructional environment and implement the lesson.

It includes how a lesson is run in a classroom, the rules for using the technology, the instructional materials, and "plan B" if the VR content is not feasible. Before using the VR materials, the students should be familiar with the VR devices and be well prepared for what they are going to experience. During the students experiencing with the VR materials, they should get clear instructions from the teachers. If the VR content is not feasible or some students cannot use VR devices, the teachers should have a "plan B" for the class.

Phase 3: Post instruction analysis and revisions.

Step 7. Reflect and revise the course.

When the VR based situated experiential history learning is applied in our class, we need to think about the reflection of the students critically. They could be collected from the students after their use of VR content, based on which the teachers should revise the design of the course.

Step 8. Implement the revisions.

After reflection, a revision could be designed and implemented and could be used in the next iteration.



Figure 1: Big Goose Pagoda in Minecraft (right) According to Historical Drawings (left)



Figure 2: The Virtually Reconstructed Palmyral Temple
<https://arck-project.org/project/temple-of-bel-in-palmyra/>

Step 9. Share the lesson revisions and outcomes with peers and across the internet.

When applying these nine steps of the three phases, the VR-based pedagogy for history education forms a close and iterative improving loop. The details of VR-based pedagogy for history education need further and deeper study in practical courses.

5 OUR PRACTICES

Our university has built a teaching center for virtual simulation based history education since 2017, which focuses on the history and culture of the ancient SilkRoad during Tang and Sui dynasties.

Two important sites were chosen as the targets: Chang'an (the

capital city of Sui and Tang dynasties) as shown in Fig. 3 and Dunhuang (an important ancient city for communication of economy and culture between West and East in the history) as shown in Fig. 5. All the ancient buildings of Chang'an are reconstructed in Minecraft by hundreds of our students as shown in Fig. 3, because Minecraft could be used to "craft the past" [1]. The Mogao grottoes in Fig. 5 are captured by our students with 360-degree cameras and demonstrated with WebVR. The 360-degree images could be immersively viewed through the HTC Vive headset as shown in Fig. 4.

5.1 Required Skills of the Students

In order to apply the virtual simulation in teaching history, the history major students need to do extra work to make it possible. Some related software and frameworks can help the students obtain the required skills for better utilizing the virtual simulation based history education.

Though programming and very limited number of software are hardly used in learning history in the past, in our laboratory, some courses are provided to help the history major students do some virtual recreation by their own, e.g. Python programming, 360-degree camera usage, 3D modeling basics, etc.

Fig. 5 shows a panoramic picture of a Dunhuang Mogao cave that was taken and processed by our students. Besides the static historical sites, some traditional historical ceremonies as well as the important events could be recorded with 360 degree cameras.

3D reconstruction is important for history education, especially in culture, heritage, etc. It is usually related to some place with some famous architectures and cities. Blender and Sketchup are used by some students, especially for the students majoring museology. They not only use the 3D modeling software for reconstructing historical sites, but also they use them in designing their curations, which would prepare them for their future work better.



Figure 3: Ancient Buildings in Chang'an City



Figure 4: Virtual Visiting to Dunhuang Mogao Caves

Programming in History Education Python is widely used in many research fields, and it could be taught in history education. When our students build the ancient Chang'an city, both Python-based automatic construction and the manual construction are used, which greatly improve the efficiency. The city wall, streets as well as the houses are constructed with Python code, and the details of them are built manually by the students. Blender uses Python as its script language too, and our students also practise building historical sites with it.

AI-based history simulation [4] would play an important role in history education and research, therefore, the students majoring in history should have certain programming skills to help them construct their own AI-based history simulation system. The multi-agent simulation for simulating history in a bottom-up pattern is studied in our laboratory and it is still in the very primary stage.

6 CONCLUSION

In this paper, we discussed the use of virtual simulation technologies in history education, based on the related learning theories and the practices in our university. We analyzed the virtual simulation based pedagogy of history education, and the skills the students need to implement this pedagogy. The history simulation that based on multi-agent simulation is studied in our laboratory, and will be discussed in another paper.



Figure 5: A 360-degree Picture of Dunhuang Mogao Cave

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