

TEKOHÁ: A Virtual Reality Game for Teaching the History of the Jesuit Missions in Rio Grande do Sul

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Abstract. *Introduction:* Virtual Reality (VR) is a computational technology that has grown in many ways, being increasingly used in different contexts. Numerous studies on the use of VR in adult education have shown positive results, however, little is known about the use of VR in children's education.

Objective: this work has the aim to develop a virtual reality game to teach the history of the Jesuit Missions in Rio Grande do Sul to elementary school children. **Steps:** workshop with elementary school teachers, virtual reality game design and VR game development. **Results:** a VR game that can be used in schools to support the teaching and learning process of the history of the Jesuit Missions in RS, allowing children to visit São Miguel das Missões without having to leave school.

Keywords Virtual Reality Game, Brazil Jesuit Missions, Children, Education.

1. Introduction

Recently, especially after the Covid-19 pandemic, there has been a strong demand for technological educational tools in schools. As alternatives to this demand, different technologies and tools have emerged or been improved, which has also occurred with Virtual Reality [Rojas-Sánchez et al. 2023]. Virtual Reality (VR) is defined as a means of communication that requires physical immersion and sensory stimulation, is interactive and can mentally transport the user to another place [Slater e Sanchez-Vives 2016]. According to research in this area, VR has been studied and applied in different learning contexts, offering experiences that would otherwise not be possible in schools, such as visiting a museum abroad, carrying out a space mission, viewing the human organism in operation, among many others.

Cognitive development is a crucial aspect in the education of children, especially between the ages of 9 and 10, when they are in a transitional phase between concrete and abstract thinking. In the educational approach of this work, the focus on cognitive learning is explored, which can benefit the academic and personal development of these

children, providing a solid foundation for future learning. Piaget, known for his theory on the psychological development of children, believed in the role of action in development and the notion that children develop cognitive structure through action and spontaneous activity [Piaget 1973]. According to him, children in this age group are in the phase of concrete operations, where learning is more effective when based on tangible and practical experiences [Piaget 1976]. Vygotsky [Vygotsky e Cole 1978] also emphasizes the importance of social interaction and mediated learning for cognitive development. In practice, methods that favor cognitive learning have shown positive results in several areas [Clements 2014].

This research uses strategies that stimulate understanding and promote deeper and more lasting learning with the use of cognitive teaching methods, such as: Interactive Activities - which involve collaboration and problem-solving, and can improve critical thinking skills and the understanding of complex concepts [Johnson e Johnson 1999]; Educational Games - which stimulate memory, attention and logical reasoning as effective tools to promote cognitive development [Gee 2003]; and Project-Based Learning - involving children in practical projects that require planning, execution and evaluation, and can help in the development of essential cognitive skills [Blumenfeld et al. 2011]. Thus, it is necessary to rethink some pedagogical actions and their learning outcomes with students, especially those related to historical places such as archaeological sites and ruins, where the environment as it was in the past no longer physically exists. Educational practices such as field trips are already configured as constructivist theories in curricular conceptions; however, practical experience with interactivity allows understanding to be built gradually, step by step, through active involvement [DeVries e Kohlberg 1987]. Thus, the application of VR in school projects can be very beneficial, allowing realistic and interactive practical experiences, through the immersion of students in the most varied situations, in which spontaneous action and activity are possible [Fowler 2015].

The use of VR can take the student to “go back in time” and thus experience important historical events, complementing the knowledge obtained in bibliographical studies, as in the case of the Guarani Jesuit Missions, ruins located in São Miguel das Missões in Rio Grande do Sul/Brazil, considered a UNESCO World Heritage Site since 1983. However, no solutions were found that would allow a realistic experience of how the Jesuit Missions were and how they functioned, portraying an interactive experience within the Mission of São Miguel Arcanjo based on their daily lives, which would better involve students with examples of the daily lives of indigenous peoples, in addition to contributing to the teaching-learning process and knowledge retention, especially of content such as this, which is part of the History curriculum component of Elementary School. This would provide students with a deep and sufficient understanding of the concepts so that they could engage in reflective and structured arguments and discussions that reflect a certain level of expertise and “identification” with the subject. [Fowler 2015].

Thus, given the importance of teaching the history of the Jesuit missions to children in the 4th and 5th grades of elementary school, as provided for in the National Common Curricular Base (BNCC) and the Gaucho Curricular Reference (RCG), this work had the aim to develop a immersive virtual reality game to teach the history of the Jesuit Missions in Rio Grande do Sul to elementary school children. This content is essential to value ethnic diversity and the contributions of indigenous, European and

African peoples to the socioeconomic, historical and cultural formation of Rio Grande do Sul.

2. Virtual Reality in Education

VR has emerged as a powerful tool in education, offering new possibilities for teaching and learning. VR's ability to create immersive and interactive environments allows students to experiment and explore concepts in hands-on and engaging ways, which can lead to deeper and more lasting understanding.

One of the key advantages of VR in education is its ability to provide immersive learning experiences. According to Ott and Freina [Ott e Freina 2015], VR can simulate complex and dynamic environments that would be difficult or impossible to replicate in a traditional classroom. For example, science students can explore the inside of a cell or travel through the solar system, while history students can visit recreations of important historical events. In addition, VR can increase student engagement. Merchant et al. [Merchant et al. 2014] conducted a meta-analysis that demonstrated that VR-based teaching can significantly improve learning outcomes compared to traditional methods. The immersion and interactivity provided by VR can make learning more engaging and motivating, encouraging students to engage more deeply with the material.

VR also offers unique opportunities for developing practical skills. In fields such as medicine and engineering, VR simulators allow students to practice procedures and techniques in a safe and controlled environment. Seymour et al. [Seymour et al. 2002] found that VR training can significantly improve student performance in real-world situations by providing repetitive practice without the risks associated with real-world errors. Another important benefit of VR in education is the ability to personalize and adapt content. VR can be used to create personalized learning experiences that meet the individual needs of students. According to Rizzo and Klim [Rizzo e Kim 2005], VR can be adjusted to different skill levels and learning styles, allowing each student to progress at their own pace.

However, the implementation of VR in education is not without its challenges. Issues such as the cost of equipment, the need for adequate technological infrastructure, and teacher training to use VR effectively are all obstacles that need to be overcome. Additionally, it is important to ensure that VR experiences are pedagogically sound and aligned with educational goals. VR has the potential to transform education by providing immersive learning experiences, increasing student engagement, and providing opportunities for hands-on skills development.

3. Related Work

Below, we briefly present some studies related to the teaching of History, found in the literature. In the work of Debailleux et. al [Debailleux et al. 2018], a virtual model was used with 19 children aged 9 to 12 and evaluated the efficiency of the use of the virtual environment in the learning outcomes about the cultural heritage of the city of Mons, in Belgium. The work entitled “Design of an Intelligent Storytelling Platform based on Virtual Reality with Human-Computer Interaction” [Pradeep Raj et al. 2018] offers a tool with the objective of designing a flexible and easily configurable story creation screen in virtual reality. Luigine et. al [Luigini et al. 2020] presents an immersive serious

game for teaching the cultural heritage of the traditional bread of the Puster Valley and the popular rural peasant tradition of this place. In this study, an experiment was conducted with 15 second-grade primary school students (ages 7-8) and 21 fourth-grade primary school students (ages 9-10) from the “Rosmin” primary school, located in Brixen, Italy. Gkoumas [Gkoumas e Izzouzi 2023], on the other hand, conducted a usability study of a digital tool that offers educators a fully integrated, classroom-ready virtual reality platform with content aligned with the primary and secondary school curriculum, covering a variety of subjects. In history content, users can explore in first person and interact with new places, such as the Roman archaeological site Augusta Emerita in Spain.

Among the gaps identified, the use of VR stands out to mentally transport children to important historical moments in the past, providing a travel experience to the past, offering experiences that would not otherwise be possible. This strategy has great potential for learning, since, as Piaget (1976) states, children's learning is more effective when based on tangible and practical experiences.

4. TEKOHÁ

The name TEKOHÁ was chosen for the virtual environment of this study due to its deep meaning in Guarani culture. In Guarani, “tekoha” represents much more than a simple physical place; it is the space where the customs, laws, habits and values of the Guarani people are manifested [dos Santos 2016]. This term encapsulates the essence of the Guarani being, reflecting their cultural identity and their intrinsic relationship with the natural environment.

By adopting the name TEKOHÁ, this virtual environment aims to be a space of respect and appreciation of Guarani culture, promoting the continuity of their customs and traditions in a new technological context.

This section presents the steps taken to create the TEKOHÁ, a virtual environment specifically designed to support the teaching and learning process of the history of the Jesuit Missions in RS. Thus, the initial survey with a group of teachers who work with teaching this content, the pedagogical project developed for the use of VR in this context, the design and development of the virtual environment and, finally, its operation are presented.

4.1. Workshop with Elementary School Teachers

In order to involve teachers who have been working on the history of the Jesuit Missions since the beginning of the project, a workshop was organized in which teachers were able to try out VR technology and give their opinions on what the virtual environment to be developed should be like. Suggestions were given orally during the face-to-face meeting, which was attended by 12 teachers.

The participating teachers were on average 45 years old, one man and 11 women. Regarding their education, two were graduates, seven specialists, two masters and one doctor. Nine had degrees in pedagogy, one in Literature, one in Physical Education and one in Mathematics, having graduated between 1982 and 2013. Their experience working with the 4th grade ranged from 2 to 25 years (average of 8.9). Regarding experience with VR, the survey revealed a diverse panorama, with half of the participants (6 teachers)

never having used VR glasses. A smaller group of 3 teachers reported having used the technology on more than five occasions. Another 2 teachers indicated a frequency of use between two and five times, while only one teacher stated that he had used the VR headsets only once.

Teachers described a variety of pedagogical strategies that they employ in teaching the history of the Jesuit missions. Among the practices mentioned, gamification with the use of maps and QR codes, exploration of puzzles, use of Google Earth and specialized websites stand out. More traditional methods, such as reading and interpreting texts, educational games, "story time", creating mind maps, building models (including the use of polygraphs and PowerPoint presentations - PPTs), and educational visits to the archaeological site of São Miguel Arcanjo, were also widely cited. Other approaches include research, expository classes, group work, video analysis, the use of polygraphs and supplementary books such as "Gauchinho nas Missões", and the construction of replicas of the missions in the school environment. Some teachers also reported taking study trips to the Missions region (São Miguel and Santo Ângelo), exploring images and videos, and building large-scale models to immerse students in the mission space.

From the Workshop, it was possible to observe and record their needs regarding the teaching of the Jesuit missions of São Miguel, and thus identify their difficulties with the students when faced with the abstract process and difficult exposition and assimilation of the content in question.

As a result, the following guidelines were suggested by the teachers:

1. Enable the experience of the time when the missions were operating, based on the virtual reconstruction of that historical period;
2. Include a live recreation during the immersion in the missions;
3. Enable interaction/experience with the indigenous people/Jesuits, allowing contact with the culture of the place;
4. Include activities, such as a music class with instruments built at the time;
5. Show the gender difference at that time (example: girls wove and took care of the pottery, boys participated in the studies and songs);
6. Demonstrate clothing, customs, etc.

4.2. Virtual Reality Game Design

The evolution of VR technologies has been rapid, driven by advances in hardware and software that allow the creation of increasingly realistic and accessible experiences. According to [Jerald 2015], the design of VR interfaces must consider not only usability, but also the ability to emotionally engage users. This implies a deep understanding of the needs and expectations of users, as well as technological and ergonomic limitations. In order to develop the visual elements, historical information was considered when designing the immersive virtual environment of the Missions of São Miguel Arcanjo. Taking into account the comprehensive technological possibilities, the historical period chosen to reconstruct the Jesuit mission was at its peak, during the late 17th and early 18th centuries.

In the modeling, it was decided to maintain the scale of the architectural structures, taking as a basis the historical records cataloged by the National Institute of Historical and

Artistic Heritage (IPHAN). The materials of the objects, walls, openings and textures of the buildings also followed the same logic, ensuring that all of these considerations were consistent with the structure of the São Miguel de Arcanjo Mission. Given that colors and lighting influence the user experience in the VR environment, during the creation of the project they played a role in ensuring that the visualization of the models was not impaired.

A female child character, named Apoema, was created to guide the virtual reality immersion (Fig. 1). Her name, of Tupi-Guarani indigenous origin, means “the one who sees further” or “the one who goes further”, reflecting her vision and determination. She lives in the Cotiguacú with her mother, who is a widow, as her father died in the service of the Jesuit mission; this place was intended to house women and children in this situation. Apoena is a twelve-year-old pre-teen, full of curiosity and courage, she invites children on a fascinating journey where they can explore the historical sites of the Jesuit missions. During the VR immersion, Apoena shows the important sites and offers interactive toys to make the experience even more engaging and fun. With her adventurous spirit and in-depth knowledge, Apoena transforms the visit into a true journey into the past.



Figura 1. Apoema, the main character

The experience was designed for the user to remain seated, in order to promote greater comfort and accessibility for children and people with reduced mobility. Teleportation allowed for exploration without major displacements in the virtual environment, in order to avoid possible nausea and dizziness for users. The use of a single control and a single path for all users ensured ease of use for children. Voice instructions given by the characters provide additional support, making the experience more inclusive and intuitive.

Sound design complemented the experience in the virtual environment. It played a vital role in the experience, since the target audience was children, and the approach of teaching through the characters' speeches made it easier to capture the attention of students. The sound design allowed the creation of a learning space using the culture of

baroque music with the indigenous children's choir at the end of the experience. Through this development, we sought to provide a comprehensive understanding of the design strategies that can maximize the effectiveness and immersion of the experiences of this virtual reality application.

4.3. Virtual Reality Game Development

The recreation of historical environments on virtual platforms has proven to be an innovative and effective tool for education and the preservation of cultural memory [Cavalcanti 2020]. In the context of the Jesuit mission of São Miguel Arcanjo, this technology offers a unique opportunity to explore and understand the historical and cultural complexity of this heritage.

The development of virtual environments represents a dynamic field that combines elements of programming, design and human-computer interaction to create immersive and interactive experiences. As pointed out by [Sherman e Craig 2003], the creation of effective virtual environments depends not only on the underlying technology, but also on understanding the needs and expectations of users.

To carry out the development stage of the virtual environment, the main tools and platforms used were: Unity 3D game engine, Blender three-dimensional modeling software, Substance Painter and Designer for creating some textures, Visual Studio Code and Community for creating scripts and Meta Quest Link for running the game. In addition, Github was used for code versioning, Discord for communication, and Trello and Miro for planning and monitoring development progress and centralizing project ideas. Three Scientific Initiation scholarship holders, undergraduate students in Digital Games, participated in the development team.

The complexity of developing the virtual environment lies in the need to integrate multiple platforms and technologies. According to [Jerald 2015], developing software for VR requires a holistic approach that considers both technical aspects and human factors. This includes creating intuitive interfaces, optimizing graphic performance, and ensuring a fluid and engaging user experience.

4.4. Virtual Reality Game Experience

This section presents the functioning of the developed virtual environment and covers technical and pedagogical aspects, highlighting how three-dimensional modeling, interactivity, and multimedia resources can enrich the educational experience. In addition, the importance of historical accuracy and accessibility of content to ensure an immersive and formative experience is discussed.

The experience begins with the user inside a carriage used at the time. The goal is to allow the user to familiarize themselves with the virtual environment, and the narrative only begins when the user presses the “start game” button. Then, the main character, an indigenous avatar named Apoema, welcomes the user with a greeting in Guarani and invites him/her to visit the place where she lives (Figure 1). To accept the invitation and start the tour, the user needs to nod their head, as illustrated in the virtual environment itself. When the user nods, accepting the invitation, the character reacts by showing happiness and excitement and begins explaining the Cabildo, which was a kind of town

hall for the place [Stello 2005] and offers the first interactive object, a model of the Cabildo.



Figura 2. Apoema presenting the Church and offering a model for user interaction

Later, the character presents Cotiguacu (Figure 3), a large house with a courtyard in the middle and a single entrance that served as a place for the gathering of widows and maidens [Custódio 2002]. The character reports that she lives in this place, as she is an orphan and lives with her mother. Once again, she offers the model of the place for the user to explore. Soon after, Apoena presents the church and again offers the model to the user exploration (Figure 2).



Figura 3. Apoema presenting the Cotiguacu

Next, the user stands in front of the São Miguel Arcanjo Church, where they meet

another important character in the experience, Father Antônio Sepp, who was responsible for the musical development and created important records of the functioning of the Jesuit missions. According to Lara [Lara F. 2014], the study of Father Antônio Sepp's epistolary production is of great importance for better understanding the norms of Jesuit writing. The priest presents the context of missionary art, offering a statue of the missionary cross (Figure 4) and introducing the indigenous missionary choir. After the choir's presentation, the experience ends with the possibility for the user to interact with the voices, recognizing all the voices in the choir.



Figura 4. Father Antônio Sepp, missionary cross and the indigenous choir

5. Conclusion

This study addressed the importance of teaching the history of the Jesuit missions to children in the 4th and 5th grades of elementary school, as provided for in the National Common Curricular Base (BNCC) and the Gaucho Curricular Reference (RCG). This content is essential to value ethnic diversity and the contributions of indigenous, European and African peoples to the socioeconomic, historical and cultural formation of Rio Grande do Sul. However, the visit to the ruins of São Miguel das Missões, although educational, faces challenges such as distance and the perception of children that "only ruin" are seen.

The aim of this study was to design and develop an Immersive Virtual Reality (IVR) environment to complement and enhance the teaching and learning process of the history of the Jesuit Missions in southern Brazil, in the early years of elementary school. IVR offers an interactive and engaging experience, allowing children to use all their senses to explore and learn, something that is not possible with traditional technologies.

In the specific context of the Jesuit Missions, VR can overcome geographical and temporal limitations, allowing children who do not have the opportunity to visit historical sites to come closer to this cultural heritage. However, the effectiveness of VR in education depends on pedagogical design and teacher training to use the technology effectively. Integrating reflective activities and post-experience discussions can enhance

the benefits of immersion, helping students contextualize and interpret what they have experienced.

Despite the benefits, the implementation of VR in education faces challenges, such as the cost of equipment and the need for adequate training for teachers. In addition, it is essential to ensure that the content is appropriate and safe for children. Therefore, it is essential to expand the studies of techniques and methodologies for developing research using VR with children. This includes investigating pedagogical approaches that maximize engagement and knowledge retention, as well as adapting emerging technologies to create more effective immersive experiences, to be investigated in experiments with students to be carried out in the context of this work.

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