2017 International Nuclear Atlantic Conference - INAC 2017
Belo Horizonte, MG, Brazil, October 22-27, 2017
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR – ABEN

Agência Brasileira do ISBN
ISBN 978-85-99141-07-6

VIRTUAL REALITY TECHNIQUES IN THE AID TO POPULATION AWARENESS AROUND A NUCLEAR WASTE

Erica Cotelli Aguiar[3], Antônio Carlos A. Mól [1,2], Paulo Victor R. Carvalho[1], André C. E. Santo[1,2], Daniel Mol Machado[4], Ana Paula Legey [2], Daniel Chelles[1]

[1] Instituto de Engenharia Nuclear (IEN / CNEN - RJ)
Rua Hélio de Almeida, 75
21941-906 – Rio de Janeiro, RJ
mol@ien.gov.br

[2] Centro Universitário Carioca (UniCarioca)
Avenida Paulo de Frontin, 568
20261-243 – Rio de Janeiro, RJ
cotelli.andre@gmail.com

[3] Bolsista PCI - IEN/CNEN
Cidade Universitária - R. Hélio de Almeida, 75
Ilha do Fundão, Rio de Janeiro - RJ
Erica.cotelli.2017@gmail.com

[4] Bolsista TCT - IEN/CNEN
Cidade Universitária - R. Hélio de Almeida, 75
Ilha do Fundão, Rio de Janeiro - RJ
machado.mol@gmail.com

ABSTRACT

Nuclear energy has proved to be an extremely important source of energy for today's society. However, these achievements, even present in people's daily lives, often go unnoticed and suffer rejection by the same society that enjoys such contributions. Rejection, mainly due to the lack of information. In this context, this work used Virtual Reality technology to inform and make the population aware of the benefits and disadvantages of nuclear energy. For this purpose, an interactive virtual environment was produced that allowed the exploration of a nuclear waste repository. Subsequently, an educational video was developed to provide end-user information support. Finally, an educational game was also created with the aim of raising public awareness and demystifying the nuclear area by bringing knowledge, in a clear and engaging way, to the population around a nuclear repository. The developed environment allowed the user to walk through the virtual representation of the reject repository, and also enabled the creation of a video capable of transmitting the initial information and improving the spatial comprehension of the model as a whole. In conclusion, the tool developed in the present work has the capacity to assist in the production of nuclear projects before even entering the construction phase. In addition, it is possible to apply this technique to inform the population about the nuclear practices that will be applied, providing a greater involvement of the people and, consequently, a better assimilation of knowledge about nuclear energy.

1. INTRODUCTION

Society is in the full age of communication and scientific information. However, there are several science topics that are not well explored in schools and are not positively disseminated to the population, such as the benefits that Nuclear Energy has for society [6, 1, 9].

Among these benefits can be highlighted: (i) the generation of electricity in nuclear power plants; (ii) the non-destructive inspection and testing of various types of materials in industries, allowing the Identification of structural failures in aircraft parts, among others, which could result in accidents if not, adequately, detected [5]; (iii) evaluation of the efficiency of industrial mixers as well as multiphase flows with wide application in the petrochemical area, where it is necessary to evaluate the flow of materials in more than one physical state in a pipeline; (iv) food industry, using radiation to control microorganisms without risk to consumers [8]; (v) dating of fossils, parchments, documents through the radioactive element Carbon 14 [3]; (vi) nuclear medicine [6] both for the diagnosis and treatment of various diseases, such as cancer. However, even with all these benefits, the population does not associate them as a result of nuclear energy. Unfortunately, due to lack of information, the population only has a negative view of nuclear energy, as a consequence of its military use in the past [10], or of accidents occurring at Chernobyl in 1986 and in Fukushima, in the year 2011.

Particularly for the state of Rio de Janeiro, nuclear energy is even more important simply because a large part of the state's energy demand has been supplied by the Nuclear Power Plants. In this sense, it is very interesting to raise awareness and inform the population about what is nuclear energy, as well as the operating principle of nuclear installations, such as the Repository. Informing the protocols and safety plans for the operation of the facility and to protect the surrounding population in the event of an emergency. It is important to realize that nuclear energy is present daily in the life of every citizen in several different ways. However, in order to establish a communication structure on nuclear energy for the general public, it is necessary to overcome certain barriers such as: technical language not accessible to the lay public and lack of mechanisms to motivate and communicate. On the other hand, in order to promote a more playful, engaging and motivating way of communication and learning, Virtual Reality (VR) technology has been increasingly used.

In this context, this proposal, with a multi and interdisciplinary character, aims to use Virtual Reality techniques to inform and make people aware in a playful and enjoyable way about nuclear energy and its benefits, as well as aspects related to the safety of installations and the population of the nuclear units. In addition, using this technology as a form of science diffusion, proposing a more exciting and motivating strategy to teach and promote science learning, which by other means can be monotonous and not illuminating. In this sense, a stereoscopic 3D video was developed using VR tools to succinctly disseminate Nuclear Energy applications to the juvenile audience. Finally, an educational game was also created with the aim of raising public awareness and demystifying the nuclear area by bringing knowledge, in a clear and engaging way, to the population around a nuclear repository.

2. THEORETICAL FOUNDATION

2.1. Virtual Reality

Virtual reality is an interface to access applications executed in the computer, having as characteristics the visualization and movement in three-dimensional environments in real time [11], allowing an immersion and interaction with elements of this environment by the stimulation of the other senses as the hearing, for example. The modeling of virtual environments allows the user to explore scenarios, manipulate objects and other elements of the virtual world, and move within three-dimensional space. The interaction of the user with the virtual environment is one of the most important characteristics made possible by this technique and is related to the user's ability to control an avatar in the first or third person, to act according to the possibilities offered by the virtual world [2].

Virtual environments are the representation of real or fictitious environments generated by the computer. The development of these scenarios can be achieved by several technologies that vary according to the nature of the application and can be controlled by the users personified virtually by the avatars. With proper advance planning, virtual environments can run applications from the most varied sectors, such as: simulation, digital games, videos and can be used for education and training.

2.2 Autodesk 3ds Max

Autodesk 3ds Max, Fig. 1, is an application used for creating virtual environments that emerged in 1990. The software is a 3D modeling, animation, texturing, lighting and rendering program commonly used in the games and media content segments [4].

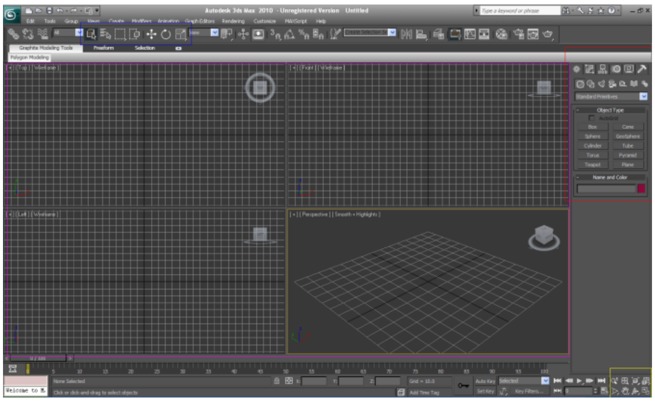


Figure 1: 3ds Max Interface.

2.3 Unity 3D

Unity 3D is a game core, which has several functionalities necessary to develop virtual scenarios, Fig. 2. It is characterized by being multiplatform, for this reason the developer has no concern with the peculiarities of each operating system. Unity also supports a number of programming languages, providing developers with greater flexibility [7].

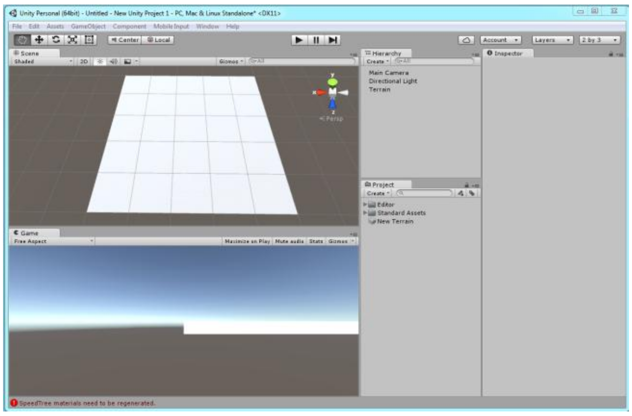


Figure 2: Unity 3d interface.

3. METHODOLOGY

In the 1990s, electronic games began to use pre-rendered videos, that is, non-interactive sequences to tell a part of the story at specific moments in the plot. The quality difference between the interactive and non-interactive versions was surprising and in this way it took two different models, which resulted in a longer production time. Currently, due to the evolution of hardware and game engines, this difference has been drastically reduced and it became possible to use the same model in both types of virtual environments. The production of the video was done with the modeling tool 3ds Max and the post-production in the editing software Adobe Premiere and all its production was divided in three phases: Rendering, Narrative and Post-production video. In addition, for the development of the game was modeled the virtual environment and implemented an avatar for locomotion.

3.1 Building Modeling and Scenery Items

Most of the buildings had already been modeled in 3ds Max and were used in the virtual environment of video and educational game. The buildings downloaded and used directly in Unity 3D were remodeled according to reference images extracted from the application itself. The difference in quality between the two versions is due to the advanced lighting features available in modeling tools such as 3ds Max. In Fig, 3 and 4 some comparisons can be observed between the two versions.

(a) **(b)**

Figure 3 (a, b): Comparison of the virtual scenario of the gate. Figure (a) developed in Unity 3D and figure (b) in the 3ds Max software.

(a) **(b)**

Figure 4 (a, b): Comparison of the virtual scenario of a building. Figure (a) developed in Unity 3D and figure (b) in the 3ds Max software.

3.2 Educational Game

For the creation of the educational game it was necessary to develop a virtual environment, using the models of buildings created previously. And add an avatar so that the user could move through the installation and understand its operation.

The Unity 3D game core was used to perform the terrain modeling of the repository studied in this work. Using the measurements and proportions from topographic images of the nuclear installation, the terrain of Unity 3D was dimensioned. Thus, the width and length of the developing terrain were adequate to the real ones found at the nuclear site. After the development of the terrain, the existing objects and buildings in the real environment were added. These objects were produced in Autodesk 3Ds Max and imported into the Unity 3D terrain, Fig. 5.

Figure 5: Virtual environment with respective buildings in Unity 3D.

Finally, to enable interaction with the developed scenario, avatars, virtual characters, controlled by the user of the application were inserted. In Fig. 6 shows these characters moving through the installation.

Figure 6: Virtual characters of the educational game.

3.3 Animated Video

In the video was necessary to change some components from the base game, like the scenery items. These items such as sidewalks, light poles, gates, fences, vegetation and paving have been remodeled in 3ds Max (Fig. 7).

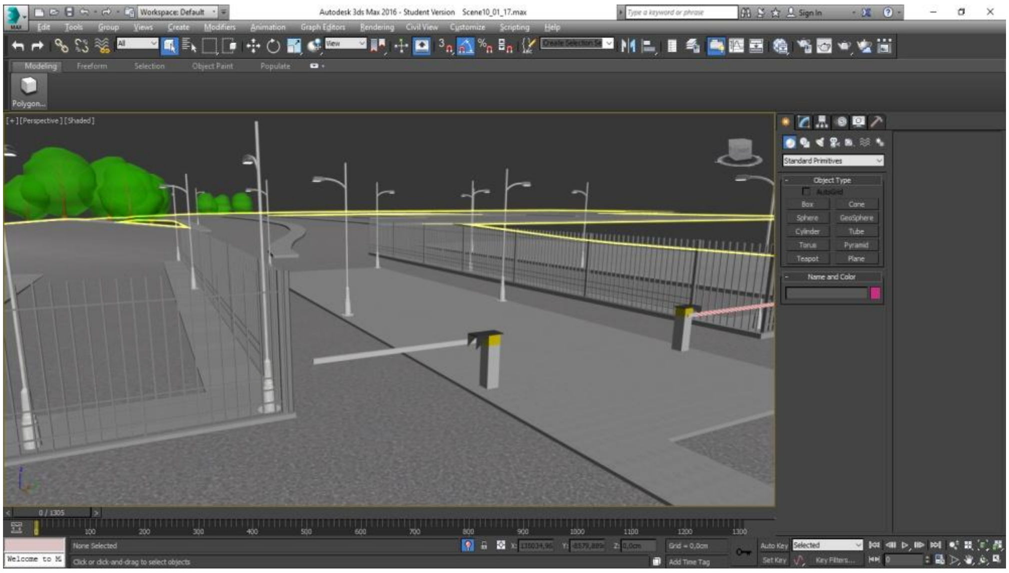


Figure 7: Remodeled Scenery Items for Animation.

To assign fidelity between the interactive and non-interactive versions, the terrain initially developed in Unity 3D was exported to 3ds Max. In this way, the application and the video present the same terrain modeling. During the export process the color information was lost and the texture had to be redone. The texturing process began with the planning of the model

and later painting in image editing software to achieve an approximate result of the application.
The lighting systems applied to the video and the application differ between them and are responsible for the visual differences between the two versions. This setting is important because it directly impacts the total time used to prepare the video. Two factors that should be taken into account in choosing the type of lighting are the quantity and quality of the machines available for the rendering process. For the video in question was used a system available in 3ds max called Mental Ray (MR). This feature allows the creation of a global lighting system, that is, the creation of a light emitter capable of illuminating the scene as a whole, applying shadows with a larger number of shades, calculating the photon refraction simulation and working with textures allow for greater adjustments.

3.3.1 Rendering

In rendering is the moment of production in which all the choices and adjustments made in 3ds max are added for the final image to be calculated and produced. The program offers the possibility of the final product being a video or sequentially named images. It was made the option to render the separated images where each of them is the representation in the order of the frames that compose the animation. This choice provides a superior result as the available video output devices do not provide a high quality product. The most requested computer components for this process are the processor and memory. And the time required for the creation of each frame ranged from seven to seventeen minutes.

3.3.2 Narrative

The narrative was divided into three parts. The first presents some requirements to be analyzed so that a certain area can configure as a candidate for the installation of the enterprise. In the second, the buildings are named and its roles within the flow of activities exercised in the given repository. In the last one, an integration between the application and the video was created, informing about the main activity that occurs in the Radioactive Waste Management Building and that can be observed in real time. For the narrative, expressed by sound, a script was drawn up containing the lines that were recorded and inserted in the video in the post production process.

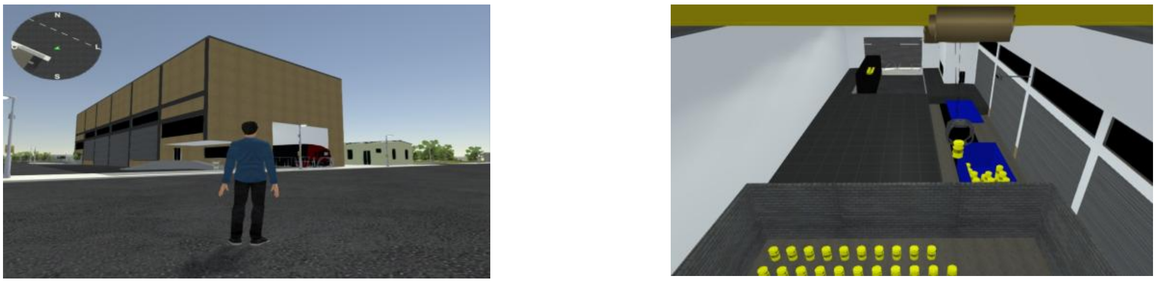
3.3.3 Post-production

The post-production process is used in large scale in audiovisual production. At this moment cuts, adjustments, corrections are practiced and also applied visual and sound effects as the speech for example. For the entire editing process we used the "Adobe Premiere" software, chosen due to previous knowledge of the tool. One of the features present in most modern editing programs is the function of grouping named images in sequence so that when organized, in the timeline, the editing program forms a video. The audio was edited so that the video and the speech were presented in synchrony, that is, the speeches correspond to what is being shown.

4. RESULTS

4.1 Application

The method applied in the construction of the virtual environment allowed the creation of all the desired items and that generated as results a virtual environment that represents the repository of radioactive waste that gives the user freedom to walk through the virtual representation, as can be seen in Fig. 8 (a). In Fig. 8 (b) illustrates the result achieved with the animation that occurs within the Radioactive Waste Management Building.



(a) **(b)**

Figure 8 (a, b): Virtual environment. Figure (a) shows the character walking in the application and figure (b) displays the Radioactive Waste Management Building.

4.1.1 Application Map

The map created to aid in spatial location is positioned on the upper left side of the screen and is always visible, as can be seen in Fig. 9 (a). In Fig. 9 (b), it is possible to observe the details of the map as the arrow highlighted by the red circle that indicates the positioning and the direction of the avatar.

(a) **(b)**

Figure 9 (a, b): Application Map. Figure (a) shows the map on the upper left side of the screen and figure (b) indicates the position and direction of the avatar.

4.2. Video

The buildings modeled for this work sought to reproduce in detail the versions intended by those responsible for the project. Through Fig. 10 (a, b, c), it is possible to make a comparison between facades of buildings provided by images, and the result achieved with 3d modeling, always in this order. This aesthetic adaptation contributed to make the end user experience more pleasing and faithful both in the application and in the video and helps in the elaboration of the architectural design of the buildings

(a)

(b)

(c)

Figure 10 (a, b, c): Model buildings. On the left side images used as reference and on the right side the 3D model. Figure (a) Administration Building and Logistic Support, figure (b) Technical Support Center Building and figure (c) Laboratory Building.

4.3 Workshop Analysis

Analyzed the responses of thirteen research participants who had an average age of fifty and twenty-five of services in the nuclear field with four linked to waste areas, six to creation of virtual simulators and three technicians. The responses were tabulated in three columns as can be seen in Table 1. For the first were considered the positive responses, the second the negative responses and the third the positive or negative responses with some kind of suggestion.

Question	Positive	Negative	Suggestion
1	13	0	0
2	11	0	2
3	11	2	0
4	10	1	2
5	12	0	1
6	12	0	1
7	10	2	1
8	10	3	0

Table 1: Questionnaire Responses

Raising the considerations made in the first question, we obtained answers such as: "Yes. It allows an anticipated vision of the future installation, being a valuable tool in the evaluation ". All participants assessed that Virtual Reality can be considered an aid tool for the planning of nuclear installations.

For the second question, the participants agreed that it is possible to evaluate and perceive the characteristics of the terrain, as well as the vegetation and the river near the chosen site. A number of monosyllabic responses were obtained and those who explained said, "Yes, it allows a closer look at reality." Two people claimed they did not understand the question.

A high level of immersion was achieved with the recognition of the facilities assisting in the setting of the application as analyzed in the third question. In this case, responses such as: "Good. I believe to be realistic enough for the purpose " and "Very good immersion. The facilities are very well represented. I missed a little more identifiers ... plates ... figures that show where we are". One of the respondents claimed to have missed objective indications such as values, distances for a greater degree of immersion.

In the fourth question, most agreed that the map is effective and helps in spatial location. However, some suggested that the map might show more of the map and the name of the buildings. Here is one example of an answer: "All spatial orientation in a virtual environment is important. It might be interesting to add the names of the buildings on this map. "
The animation can be understood perfectly and the respondents were able to transport the information presented in the video to the application. There was a suggestion of including subtitles in the app for this time.

In the fifth question, all the respondents agreed that it was possible to recognize the animation of the main activity carried out in the Radioactive Waste Management Building and in response we had: "The animation allows recognizing the activity with relative ease as previously described in the video presentation". A respondent suggested captioning responses such as: "Yes, but it might help if while the animation is running, a caption appears in the bottom corner of the screen saying: Removal of waste from the truck to the temporary storage and then transport of waste for container permanently and concrete".

The sixth question assesses whether the video was successful in passing the information to the listener and we got as one of the answers: "The video shows well the knowledge about the facilities as well as the information about the buildings." Only one of the respondents did suggestion of audio suitability depending on the type of audience.

For the seventh question evaluating the application, eleven participants responded positively: "Yes, with the clear information from the video, it was easy to recognize the activities of the Radioactive Waste Management Building". However, one participant referred to the video saying, "The video fails by not explaining in more detail the locations that the avatar can visit and which buildings contain interactive content, explaining their goals and how to activate the content". Another suggested that the application and video could be presented in a single tool.

In the eighth question, ten people answered that the video has the potential to collaborate with the acceptance of nuclear activity regarding the generation of electric energy by the population and one of the answers was: "Yes because it explains and demystifies the functions and knowledge about the repository of radioactive waste". However, three people rated negatively with a response such as: "No, because the video does not address key issues for the acceptance of nuclear activities in national territory, for example, what is the probability of accidents and which are consequences of accidents".

5. CONCLUSIONS

By the analysis of the results it is possible to notice that with the applied method it was possible to develop a virtual environment that allows the user to walk through the virtual representation of the waste repository, observe an animation of the main activity that takes place inside the Radioactive Waste Management Building and consult a map that assists in the user's spatial location and is updated in real time. The applied method also enabled the creation of a video capable of transmitting the initial information and improving the spatial comprehension of the environment as a whole. This type of tool can extrapolate the boundaries of nuclear professionals and contribute to a better understanding of the nuclear sector by the population.

Due to the application of the methodology and the responses of the experts in the tool presentation workshop, the results obtained were enough to fulfill the objectives proposed in this article and thus serve as a tool in the analysis process in the development of the initial project of future nuclear projects and still carries great potential to promote an improvement in public opinion in this sector.

ACKNOWLEDGMENTS

This research was sponsored by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES and Conselho Nacional de desenvolvimento Científico e Tecnológico - CNPq. Our thanks also to the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro - FAPERJ and Comissão Nacional de Energia Nuclear - CNEN, that, through the Instituto de Engenharia Nuclear - IEN, has provided all necessary resources to the development of this work.

REFERENCES

1. ALMEIDA, R.A. Um estudo simplificado sobre a percepção pública na área nuclear: sugestões para campanhas educativas para os diferentes segmentos da sociedade. M.Sc. Dissertation, Instituto de Engenharia Nuclear, CNEN, Rio de Janeiro, RJ, Brazil. (2010).
2. ARAÚJO, R.B.; Especificação e Análise de um Sistema Distribuído de Realidade Virtual. Tese de Doutorado, EPUSP, Julho, 1996
3. ATKINS, P.; JONES, L. Princípios de química: questionando a vida moderna e o meio ambiente. Porto Alegre: Bookman, 2006.
4. AUTODESK. Guia Oficial 3ds Max. 1. ed. Rio de Janeiro: Elsevier - Campus, 2010.
5. CARDOSO, E.M.; ALVES, P.A.; BRAZ, C.; PESTANA S.. Apostila Educativa: Aplicações da Energia Nuclear. CNEN, Rio de Janeiro. In: http://www.sjt.com.br/tecnico/gestao/arquivosportal/file/ENERGIA%20NUCLEAR%20-%20APLICA%C3%87%C3%95ES%20-%20CNEN.pdf. (2009).
6. CORDEIRO, M.D.; PEDUZZI, L.O.Q. Aspectos da natureza da ciência e do trabalho científico no período inicial de desenvolvimento da radioatividade. Revista Brasileira de Ensino de Física, v. 33, n. 3, 3601, 2011.
7. GOLDSTONE, W.; Unity 3.x Game Development Essentials, Packt Publishing, New York, United States of America (2011).
8. HEWITT, P.G. Física conceitual. 9 ed. Porto Alegre: Bookman, 2002.
9. MELO, M.F.S. and GARAVELLI, S.L., Conhecimento e Aceitação da Energia Atômica pelos alunos do Curso de Física da Universidade Católica de Brasília. B.Sc. Dissertação, Universidade Católica de Brasília, Brasília, Brazil. (2010).
10. MILANEZ, J.V.; ALMEIDA, R.D.; CARMO, F.S.. Energia Nuclear Socialmente aceitável como solução possível para a demanda energética brasileira. Revista Ciências do Ambiente On-Line, V.2, n.1, pp.1-10. (2006).
11. RODRIGUES, G. P.; PORTO, C. M.; Realidade Virtual: Conceitos, Evolução, Dispositivos e Aplicações. Interfaces Científicas, v.01, n.03, p.97-109, junho, 2013