The use of Augmented Reality for the teaching of dosimetry and metrology of ionizing radiation at IRD

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Abstract. It can be said that ionizing radiation are of great importance to society, considering the range of applications of nuclear technology. In this sense, the Institute for Radiation Protection and Dosimetry (IRD) acts in favor of the health and safety of the population and workers exposed to radiation, promoting the preservation of the environment. Therefore, safety is extremely important in the construction of knowledge in Ionizing Radiation Metrology (IRM), due to the use of radioactive sources in its practice. Then, the adoption of safe methodologies is fundamental in the teaching-learning process. Thus, technological tools such as Augmented Reality (AR) are being increasingly used to present, in real environment, virtual elements such as equipment, spaces, concepts and practices, avoiding contact with radioactive sources. In this case, AR is a technology that dramatically displaces the location and time of learning and training. New information and communication technologies are not only powerful and compact tools for delivering AR experiences through personal computers and mobile devices, but also developed and sophisticated in order to combine the real world with improved information interactively. The objective of this work is to demonstrate the possibility of using AR as a pedagogical tool for the learning of radiation protection in IRD courses, as well as assisting in the training of professionals and students in the nuclear safety area.

Keywords: Augmented Reality; Teaching of Ionizing Radiation Metrology; Institute of Radiation Protection and Dosimetry.

1. Introduction

1.1. Presentation

It can be said that the area of Ionizing Radiation Metrology (IRM) is of great importance for society, considering the range of applications of nuclear technology, such as sterilization of medical and surgical materials, food irradiation, combat agricultural pest control, industrial scouring, preservation of documents and generation of electricity in nuclear power plants, among many others, which makes it essential to use ionizing radiation sources.

Thus, IRM is critical to maintaining adequate levels of safety to support measurements across a range of areas such as health, industry, the environment, agriculture, and power generation. For this, it is essential, first, to empower and empower people before exposing them to a dangerous situation and, if possible, to reduce the time of exposure to radiation. That is, safety is paramount in the practices and principles of IRM.

In this sense, the Institute of Radiation Protection and Dosimetry (IRD) acts in favor of the health and safety of the population and workers exposed to radiation, promoting the preservation of the environment. The IRD is a research, development and teaching institution in the area of radiation protection, dosimetry and IRM.

Connected to the Directorate of Research and Development (DPD) of the Brazilian Nuclear Energy Commission (CNEN), it works in collaboration with universities, government agencies and industries,
generating and disseminating knowledge and technology to promote the safe use of ionizing radiation and nuclear technology, aiming at improving the quality of life in the country [1].

It also has close links with the security and radiation protection sectors of the International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and on metrology with the International Bureau of Weights and Measures (IBWM).

IRD is the laboratory designated by the National Institute of Metrology, Quality and Technology of Brazil (INMETRO) for Ionizing Radiation Metrology and the Secondary Standard Laboratory by the IAEA, and is responsible for the realization, maintenance and dissemination of the quantities related to ionizing radiation in Brazil [2].

In addition, IRD offers courses in dissemination, specialization, master and Ph.D., with the basic purpose of training specialized human resources in its areas of activity. It is understood that safety is extremely important in the construction of knowledge in IRM, due to the use of radioactive sources in its practice.

Therefore, the adoption of safer methodologies is fundamental in the teaching-learning process. Thus, technological tools such as Augmented Reality (AR) are increasingly being used to present virtual elements such as equipment, spaces, concepts and practices in real environment, avoiding contact with radioactive sources.

This work has the objective of demonstrating the possibility of using AR as a pedagogical tool for the teaching of metrology in IRD courses, and can help in the training of professionals and students in the area of Radiation Protection and Dosimetry.

1.2. Theoretical Framework

The evolution of technology has given rise to the use of new computational interfaces that help and influence the users' senses. The improvement of computer graphics, through new software and hardware, and telecommunications, gave rise to the so-called AR, which had its first steps in the 90's, but which only took on greater proportions in the years 2000, with the creation of new devices and systems [3].

AR is a technology that allows computer generated virtual image information to be superimposed in a real-time real or indirect real-time environment. Thereby, AR does not present restriction with multisensory devices, and can be used in any environment (closed or open), and is therefore comprehensive and universal [4].

The use of AR in the world has been taking on increasing proportions. These applications, which were previously focused on the entertainment area, can now be seen walking in health, industry and even in education. There are many different ways for people to be educated and trained about the specific information and skills they need [5].

These methods include classroom lectures with textbooks, computers, handheld devices, and other electronic devices. In a rapidly changing society where there is a wealth of information and knowledge available, the adoption and application of information at the right time and place is necessary for greater efficiency in school and company settings. In this case, AR is a technology that dramatically displaces location and time of learning and training [5].

Accordingly, new technologies and information communications are not only powerful and compact tools for delivering AR experiences through personal computers and mobile devices, but also developed and sophisticated to be able to combine the real world with interactively increased information [6].

2. Methodology

This paper aims to show how the AR tool can assist in the teaching of Dosimetry and IRM to the classes offered on the subject by the IRD.

The applied methodology has as a research the follow-up of the classes of the discipline "General Revision: Fundamentals" of the Specialization Course in Radiological Protection and Security of Radioactive Sources and the Course of Foundations in Radiation Protection, both with duration of 40 hours.

In this paper both courses are called by Foundations, since they have practically the same structure.

3. Results and Discussion

The Fundamentals course was followed in order to analyze the possibilities for the implementation of AR and the generation of interactive academic material.

The specific subjects and important points suggested by the teachers and pointed out by the students
were verified.

The course began with the theme "Structure of Matter and Ionizing Radiation", where the content on "Search for Stability of an Atom" was written, in which the Beta + and Beta decay of a radioactive element is described.

An animation\(^1\) of the decay of Uranium 238 was then created to serve as an example (Figure 1).

![Figure 1: Animation on the Search for the Stability of an Atom. Video elaborated, with the corresponding QR-code, to demonstrate the radioactive decay of Uranium 238. Source: The author.](image1)

In the discipline "Metrology of Radiation and Radiological Greatness", it was commented on the theme "Accuracy and Precision", which is usually illustrated with a target shot (Figure 2).

![Figure 2: Animation on Accuracy and Precision. Source: The author.](image2)

In the discipline "Natural and Artificial Radiation Sources", doubts were identified in the explanation of more complex subjects, such as the operation and structure of some equipment. QR-code was then generated showing these devices\(^2\) (Figure 3).

In the part of Radiation Detectors, were mentioned: Neutron Meter, CRC Activator and an Electronic Scintillator Detector, among others (Figure 4 and 5).

\(^1\)In order to view the videos you need to download any QR-code reader application for mobile device. In this case, the free Smart Scan application was used.

\(^2\)In order to visualize the equipments it is necessary to download the free application Augment for mobile device and to read the respective QR-code.
Figure 3: Equipment Modeling. QR-code generated for the demonstration of the PTW-TLDO Furnace, the Germanium Radiator and the Germanium Meter. Source: The author.
Figure 4: Radiation Detectors. QR-code generated for the demonstration of the Neutron Meter, CRC and Dosimeter. Source: The author.

Figure 5: Visualization of equipment using the augmented application. Source: The author.

4. Conclusion
The IRD's research, teaching, training, technical support and service activities have enabled it to develop new technologies and deploy solutions, benefiting the use of ionizing radiation. Thus, tools that assist in training, prioritizing the safety of users, become increasingly relevant. In this case, the use of AR is presented as one of these tools, as shown in articles in the teaching-learning fields. However, many issues still persist in terms of efficiency, especially when compared to traditional methods, due to the investments needed in research and design.

Nevertheless, there is much optimism for the use of AR in the future. This is because, through simulations in a virtual environment, it is possible to test the capacity and monitor the improvement of
users’ abilities, improving the results and, above all, their safety.

Therefore, the three-dimensional modeling of equipment and practices in AR, with the creation of devices (QR-code), would allow the teacher greater freedom to demonstrate details, since it is not always possible to go to the laboratory, so that the professional/student can see the material in real working situation, without having contact with the radiation.

In addition to the concepts, equipment and practices developed by AR shown in this work, others are being elaborated, for example, for Area Monitoring - Individual and Environmental, for EPI's Clothing and Procedures, regarding the operation of the X-Ray and how a particle accelerator works, from electric, magnetic or electromagnetic waves.

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