DIGITAL TECHNOLOGY TOOLS TO IMPROVE PROFESSIONAL DEVELOPMENT IN BRAZILIAN RADIOACTIVE FACILITIES

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ABSTRACT

This article focuses on digital technology tools to improve workers' skills in Brazilian radioactive facilities. Uniprorad is a web-based system designed to improve the global communication about radiological protection in this very large country, where it is a strong challenge to ensure high quality professional information to as many people as possible. This article presents the authors' experience in the communication of radiological protection and the evolution of this web-based system. Created in 2013, the system Uniprorad is constantly updated to offer a complete web-based repository in Portuguese for research, consultation and information. The content presents discussions related to optimization (since 2013), monitoring (developed in 2015), potential exposure (since 2017) and communication on occupational risk agents in the workplace (started in 2019). Regarding risk agents in the workplace, the content has been developed to teach the identification and evaluation of the various risk agents (physical, chemical biological and ergonomic) and their association to ionizing radiation. In addition, to concepts, definitions and theory, the Project Uniprorad counts on interactive exercises, about radiological protection taking into account.the best practices for radioactive facilities in order to meet both national standards and international recommendations. The aim of this paper is to provide a critical review of the evolutions of this web-based system to outreach this target audience, and to assist other experts on planning and implementing effective strategies to communicate radiological protection. The results of this experience support the idea that in a rapid-changing world it is a must to invest in constant innovations to improve professional development.

1. INTRODUCTION

Brazil is one of the world's most populous countries and the largest country of Latin America. With 8.5 million square kilometers, the country is divided into five regions (North, Northeast, Midwest, Southeast and South) with 3 time zones. In Brazil, facilities involving ionizing radiation are divided into nuclear and radioactive facilities. The nuclear facilities comprise the entire nuclear fuel cycle, power and research reactors, and are government monopoly. The radioactive facilities use and develop other human activities involving ionizing radiation in other peaceful applications, such as industry, medicine, agriculture and environmental protection, among others, under government supervision. All activities involving ionizing radiation must establish a Radiological Protection Plan and a Radiological Emergency Plan in compliance with national and international requirements and recommendations. In Brazil, the national government entity, linked to the International Atomic Energy Agency (IAEA) is the National Nuclear Energy Commission (CNEN), which provides standards for radioactive facilities in the country. In May 2022 the official website of CNEN counted on 2232 licensed radioactive facilities all over the country, among which. 704 facilities for industrial applications. In this category, there are 491 radioactive facilities of Nuclear Measurement Devices operating in 24 different states in the country [1].

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In this large country with continental dimensions, proper communication is a need and a challenge. Radiological protection recommendations can be found in different documents published by different organizations over the past decades: International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA) and National Nuclear Energy Commission in Brazil (CNEN). The IAEA and ICRP together have more than two thousand publications about safety and security. Many of them partially or completely superseded; many of them published in English or Spanish; none of them published in Portuguese.

Indeed, lessons learned prove the relevance of communications best strategies to prevent risks in workplace. One example is the radiological accident in Soreq, Israel, in 1990. The industrial irradiation facility used an intense radioactive source ^{60}Co to irradiate medical products and spices. The day of the accident, the worker in-charge was an experienced technician, with more than 3 years of experience, who had been trained and certified to his function. Nevertheless, according to the official report provided by the IAEA [2], the operator "*was faced with two conflicting signals, one indicating that the source was safe and one that it was not. He chose to believe that the source down signal was correct and that the radiation alarm was false*." The operator, who entered the irradiation room, was exposed with an estimated whole-body dose of 10–20 Gy and the consequences were fatal. The accident, which could have been avoided, resulted from the violation of established operating procedures, followed by a series of mistakes in decision making and unauthorized actions. The IAEA conducted an international review in order "*to document the causes and circumstances of the accident and to draw general lessons for the benefit of those people with responsibilities for the safety of such facilities*" [2]. The commission concluded that the accident was caused by a combination of factors, including the equipment malfunction and unauthorized actions taken by the worker. The official report also highlights that parts of the instructions were not available in the country´s official language:

> "*The training courses had been given in Hebrew (the working language of the operators), but the lecture notes were in English. Similarly, the operating manual and safety instructions (parts of the instruction manual) were only available in the original English. A short list of routine operating and safety instructions, including the procedure for entering the irradiator, had been issued in Hebrew and was posted in the facility*." [2]

This example illustrates the importance of the themes presented in this article: (1) the importance of complete information always available in the workplace and in the official language of the country; and (2) the importance of preparedness to occupational risks and potential exposures, identifying possible scenarios and anticipating possible paths that may contribute to their occurrence. Most often, sequences of events can be probabilistically predicted.

2. INSTRUCTIONAL DESIGN OF SCIENTIFIC INFORMATION

Taking advantage of the potential value of Internet in modern Information Society and its institutions, our workgroup has created the web-based-system UNIPRORAD [3], designed to offer reliable updated information in Portuguese, to Brazilian radioactive facilities, operating in several states in this large-extension country. UNIPRORAD is an open access platform with high-quality information about radiological protection, including optimization, monitoring, potential exposures and risk agents in workplace. All content that can be easily

accessed, trough URL https://www.uniprorad.com.br, from any conventional internet point, with good performance even to not high-speed connections. The project was first published in 2013 for the communication of optimization programs, which includes concepts, definitions and theory, optimization programs, help decision making techniques, information related to protection costs, radiation doses and detriment [4 - 7]. During the next years, this platform has evoluted to other fields of radiological protection, taking into account the positive Porphyrian Tree, published by IAEA [8] in 1990. Even though this publication is considered superseded, it brings the most generic and complete tree for an appropriate program of radiation protection, ever published again or updated in other IAEA publications.

Therefore, in August 2015, this web-based-project counted already on ionizing radiation monitoring policy and techniques, integrating and interrelating elements of optimization and monitoring programs. The monitoring content presents the criteria used for control of occupational exposures, authority and responsibility, classification of work areas, practical implications and engineering controls, operational procedures, reference levels, types of monitoring and its functions. The system provides detailed information about workplace monitoring (monitoring for external radiation, monitoring for surface contamination and monitoring for air contamination) and individual monitoring (monitoring of external exposure and monitoring of internal exposure and monitoring for skin and clothing), discussing objectives, routine monitoring, task-related monitoring, special monitoring and interpretation of results for each type of monitoring program [9 – 10].

In 2017 the platform counted already on reliable information about potential exposure, discussing not only the collection and interrelationship of existing information in the several publications (IAEA and ICRP), but also new approaches from some recommendations, due to the fact that there is still lack of knowledge of failure probabilities, which currently constitutes a broad research field in radiological protection. One of the actions to fill this gap is the presentation, development and discussions of fault trees and the analysis of different scenarios [11 – 15].

The advance of the platform has improved in 2019, focusing the communication of risk agents in workplace. Regarding the issue, the web-based program UNIPRORAD offers a further approach among several publications, discussing and explaining their concepts, definitions and recommendations. About risk agents in workplace, the website discusses combined exposures, more specifically, the biological effects of radiation in combination with other agents: physical (ionizing radiation, ultraviolet radiation, electromagnetic radiation, among others), chemical (genotoxic substances and non-genotoxic substances) and biological (such as the action of viruses and bacteria). Numerous examples of combined exposures to radiation can be found in the literature. There are, for instance, a vast material about tobacco and radon, as well as toxic metals or combinations of different types of ionizing radiation. The development of this research and implementation of the proposed theme allow users to find specific relevant information and improve strategies to increase safety culture in workplace [16 – 17].

In 2021, the COVID-19 pandemic caused an unprecedented opportunity to increase professional improvement through online information. Many professionals, immersed in a home office system, took time to refresh professional skills to better perform in their jobs. Radiological protection professionals were no exception. For this reason, the UNIPRAD platform invested in an overview of the basic information on potential exposures, presenting in detail the recommendations of ICRP publication 64. Even though the ICRP 60 (1991)

provides the conceptual basis introducing the first step towards the development of a conceptual framework for the protection of potential exposures, it is in ICRP 64 (1993) that the term "potential exposures" appears for the first time, in ICRP recommendations. This report is the basis for understanding potential exposures, providing the elaboration of the principles and objectives of the ICPR recommendations, basic concepts, terminology and methodologies associated with the application of the recommendations and general guidance on their practical application. The understanding of the evolution of recommendations in a meaningful and interesting way, shall contribute to review behaviors and apply best practices in the workplace.

3. RESULTS AND DISCUSSION

In a huge country as Brazil, Internet offers great possibilities to spread information to as many people as possible, minimizing costs and optimizing results. Moreover, Internet allows interactive tools to create great learning experiences for everyone who wants to understand a complex content. Therefore, taking advantage of Internet possibilities, there were developed virtual interactive components comprising the six quantitative decision-making techniques, according to the ICRP recommendations [5], allowing the user to enhance his learning experience, simulating situations that fits his workplace needs. These interactive components were original and have been exclusively created for this purpose. In addition, problem-based training interactive exercises about external radiation and air contamination are given, helping users to develop necessary skills for achieving higher performance in workplace [9 - 10]. The development of fault trees and the analysis of different scenarios, also in an interactive way, present deeper discussions about the fault trees presented in ICPR Publication 76, suggesting different paths to quantify probabilistically the occurrence of potential exposures. The discussions consider the recommendations of IAEA Safety Series 102 (the most generic and complete tree for an appropriate program), as well as the IAEA TECDOC 430, which establishes the procedures for the systematic appraisal of operational radiation protection programs [8, 12, 18]. All interactive tools were developed to foster critical thinking and knowledge construction, which are essential competencies for workers in the contemporary Information Society.

To improve health and safety in workplace, it is necessary to foster a positive safety culture and increase employee commitment and responsibilities. A variety of workers in industries and medicine are exposed to ionizing radiation in the workplace. The most recent content developed for the platform UNIPRORAD, and implemented in 2019, brings essential information about combined exposures that can lead to an increase of occupational risks. The content brings accurate information about the physical agent "ionizing radiation" in workplace associated to other physical, chemical and biological factors. As an example, users are given explanations about risk characterization for genotoxic carcinogens chemicals, that may be present in workplace, even at very low levels, which combined with ionizing radiation exposure may increase one's risk. The communication of this theme is part of the principal concern of radiological protection: provide workers paths to identify areas and situations where special protective measures should be implemented to reduce the exposure to radiation.

Other than fostering a safety culture, it is necessary to provide workers suitable and sufficient knowledge. Specially during the pandemic context, the efforts to provide the historical context of potential exposures in a proper, meaningful and interesting way proved successful, according to in-depth data and reports presented by Google Analytics.

Web analytics tools, such as Google Analytics, offer important metrics about audience behavior through timely reports, providing crucial information about the website performance. Figure 1 brings the profile overview of visitor's overview from a trimester report in 2019.

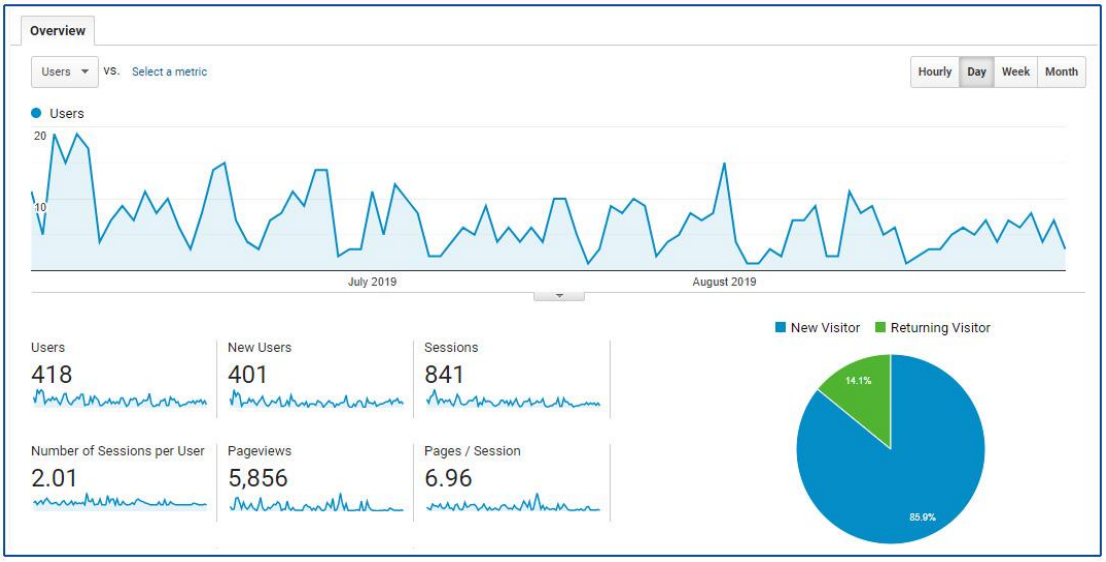

Figure 1: Visitors overview from 01/06/2019 to 31/08/2019

According to the above information, between 1st June 2019 and 31st August 2019, the platform received 418 users, with 5,856 pageviews and an average of 6.96 pages per session. Moreover, the graphic show that 14% of visitors, which means 59 people, returned to search information during these three months, proving UNIPRORAD a helpful tool in 2019.

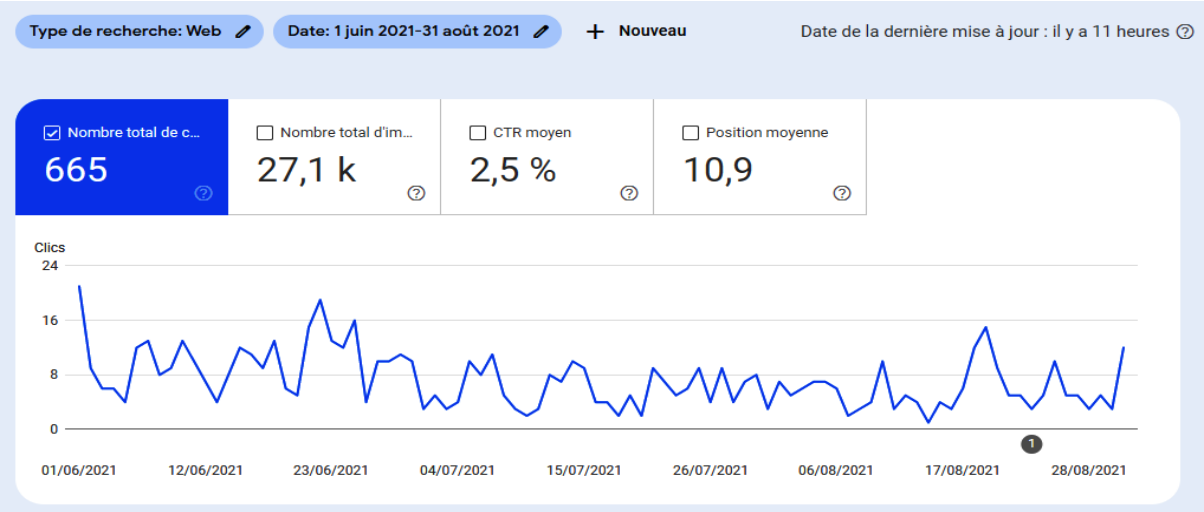

Figure 2: Visitors overview from 01/06/2021 to 31/08/2021

Figure 2 brings the Google Search Console results of audience behavior from the very same trimester in 2021. During the COVID-19 context, with the rise of online learning for skills development, the number of Internet users grew by 60 per cent. Moreover, the number of pageviews grew from 5.856 in 2919 to 27.100 in 2021, proving the engagement of the target-public and effectiveness of communication strategies.

4. FINAL CONSIDERATIONS

UNIPRORAD is a complete repository for research, consultation and information which provides relevant, accurate and understandable information in Portuguese. It is understandable that international organizations provide their publications in the world's most spoken languages. Nevertheless, regarding radiological protection it is very important to ensure access to information in the workers´ own language. Regarding potential exposure, occupational risks at workplace or monitoring ionizing radiation, among other vital issues, there is no space for misconceptions or misunderstandings. We live in a fast-changing world that increasingly requires integrated knowledge, constant update information and effective communication. Internet has revolutionized communications and it is out target to take advantage of ICTs (Information and Communication Technologies) possibilities to provide quantitative and qualitative high-quality reliable information to the several radioactive facilities throughout the country, contributing to develop workers´ professional skills and to improve safety culture in workplace.

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