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MULTIMEDIA RESOURCES IN NUCLEAR SCIENCE COMMUNICATION IN BRAZIL SECONDARY SCHOOLS

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ABSTRACT

Scientific communication is crucial for the advancement and acceptance of nuclear technologies, given their complex and controversial historic. Effective scientific communication is crucial for the development and acceptance of nuclear technologies, as it addresses public misconceptions and enhances understanding of the benefits and risks associated with nuclear science. In the educational context, scientific outreach plays a pivotal role in fostering a well-informed populace, particularly through the integration of multimedia resources which facilitate engaging and interactive learning experiences. This study focuses on the creation and implementation of an online educational course, "Nuclear Explorers," designed to promote scientific communication about nuclear technology among high school students. The course utilized a range of multimedia resources, including videos, images, GIFs, and flowcharts, to provide comprehensive coverage of nuclear science topics such as nuclear energy, fuel cycles, and technological advancements. The course was deployed to 1,250 students from 53 classes across 8 schools in the metropolitan area of Belo Horizonte, Brazil. Results indicated a substantial increase in students' knowledge and a positive shift in attitudes towards nuclear energy. Notably, 97.76% of students reported enhanced understanding of nuclear concepts, with a significant rise in support for nuclear energy as a future clean energy source. The feedback on multimedia resources highlighted their effectiveness, with 87.76% of students acknowledging their role in improving comprehension and making the learning experience more engaging. Overall, the study underscores the efficacy of multimedia in scientific outreach and educational settings, demonstrating that such resources are instrumental in advancing public knowledge and acceptance of nuclear technology. The findings demonstrate that multimedia-based educational interventions can significantly contribute to better public understanding and acceptance of nuclear technologies, underscoring the effectiveness of this approach in scientific outreach and education.

1. INTRODUCTION

The relevance of radiation applications and the potential of nuclear energy, though undeniable, are frequently subjects of controversy. The origin of these debates lies in the tumultuous history associated with nuclear technology. From its introduction to the world in the form of the bombs that struck Hiroshima and Nagasaki during World War II, to tragedies and disasters such as those in Chernobyl and Fukushima, these events have fostered anti-nuclear sentiments. Despite the predominance of peaceful applications of nuclear energy in contemporary times and the significant advancements in safety studies of nuclear facilities, the consequences of these events still resonate today, posing a challenge for the nuclear industry in terms of public trust and acceptance. [1,2,3]

The public's perception is not accurate enough to discern the veracity of the information received, resulting in misconceptions that directly affect their stance on nuclear technologies. An indisputable fact is that each nuclear accident, despite its negative consequences, has challenged nuclear safety, promoting its development and improvement. Historically, no nuclear accident has occurred for the same reasons as a previous one. However, despite technological advancements, the perception of benefits is overshadowed by the perception of risks due to the lack of knowledge among the population. [1,4,5]

Regarding the Brazilian population, the lack of knowledge, combined with misinformation and preconceived ideas, results in a populace with little inclination toward investments in the nuclear sector and techniques involving radiation. The absence of effective dissemination of information about the functioning and benefits of nuclear technology and radiation exposes citizens to misleading information, which in turn amplifies disapproval of nuclear technology and the use of radiation. This scenario is exacerbated by inaccurate news and the fear caused by uncertainties. Hence, there is a highlighted need for the development of programs and courses aimed at educating the Brazilian population and increasing their level of knowledge regarding the nuclear field and radiation applications. [6,7]

Scientific communication plays a multifaceted role in society, most notably serving to promote cultural development and broad, up-to-date access to knowledge. Through scientific outreach, it is possible to democratize access to knowledge and stimulate public interest in science, fostering awareness of scientific topics. However, the role of outreach is not merely informative; it has a significant educational assignment, enabling the continuous dissemination of scientific content with the aim of establishing scientific and technological literacy. [8,9]

To foster public acceptance of nuclear energy and radiation applications, the global nuclear industry, in collaboration with academics, has employed various methodologies. Basic education plays a crucial role in the dissemination and acceptance of nuclear technologies for peaceful uses, being considered the most effective technique for this purpose. The impact of education on public acceptance underscores the need to review the school curriculum and develop effective methods of scientific outreach within the educational environment. [10]

Educational content developed for educational purposes is constantly advancing and improving. Digital content is increasingly present in the teaching and training of students and professionals in various segments of nuclear technology. The use of multimedia enables the production and utilization of different art languages, communication media, and expressions, which are conceived, organized, and made available for reproduction through various technological means. The presentation of multimedia content is not limited to the linear dimension of conventional text, redefining the interaction between the reader and the content. The audiovisual resources used in multimedia create interconnections between images and text, contributing to textual cohesion. An audiovisual production aligned with the textual content has a complementary and redundant relationship that enhances the understanding of the addressed topic. [11,12]

Developed in 2009 by the American educational psychologist Richard E. Mayer, the Cognitive Theory of Multimedia Learning (CTML) posits the central thesis that “people learn better from words and pictures than from words alone.” Educational multimedia is a didactic and redundant resource, where the same information can be presented in different ways, considering the level of information presented in such a manner that the learner is spared sensory overload. The use of multimedia focuses on creating learning environments that are receptive to the target audience, establishing synergy between the learning content and the development of critical thinking. Learning environments must be meticulously developed to promote effective learning. Therefore, knowledge of learning theories is of paramount importance to ensure the efficacy of these environments. [13,14]

The creation of a multimedia resource with educational objectives requires meticulous planning, starting with the definition of the target audience, the message to be conveyed, and the concept to be adopted. The production of images, including illustrations, photographs, or graphic elements, as well as GIFs, which may range from animations to frames of actual photographs or videos, must be aligned with the integrated textual content to facilitate the understanding of the conveyed message. These resources should be designed to maintain the clarity and simplicity of the educational message, ensuring their adaptation to formats optimized for the specific virtual environment. [8,14]

With the aim of promoting scientific communication in the field of nuclear science among high school students, an online learning environment was developed in the form of a course, utilizing multimedia resources. The course was implemented for high school students from various schools, following the methodology outlined below.

2. METHODOLOGY

The initial stage of the methodology involved extensive bibliographic research on the main topics in the nuclear field, with the objective of defining the composition of the course. This process included a rigorous review of the available literature, enabling the identification and selection of the most relevant and fundamental topics for high school students' understanding of nuclear technology, while considering the Brazilian socioeconomic context.

The next stage involved the development of multimedia resources associated with the content and the creation of the website where the course would be hosted. All multimedia components were meticulously planned based on learning theories, particularly the Cognitive Theory of Multimedia Learning (CTML), which adheres to the principles of Cognitive Load Theory (CLT), respecting the 4C/ID design model. This approach ensures that visual and audiovisual resources are designed to optimize students' knowledge acquisition. Various types of multimedia were developed, including images, graphics, GIFs, and videos, each selected and created to enhance the educational content in an interactive and informative manner. Additionally, opinion surveys were designed to evaluate students' knowledge and acceptance of nuclear science. These surveys were administered before the start and after the completion of the course, allowing for the assessment of the course's effectiveness in scientific communication and the improvement of public acceptance.

The defined modules were: Introduction to Concepts, Nuclear Energy, Fuel Cycle, Applications in Industry and Medicine, Challenges of Nuclear Technology, and Advances and Future. The course consisted of a total of 45 lessons in various formats, incorporating different multimedia resources such as video lectures, text with images, GIFs, graphics, and flowcharts. The home page is showed in Fig. 1.

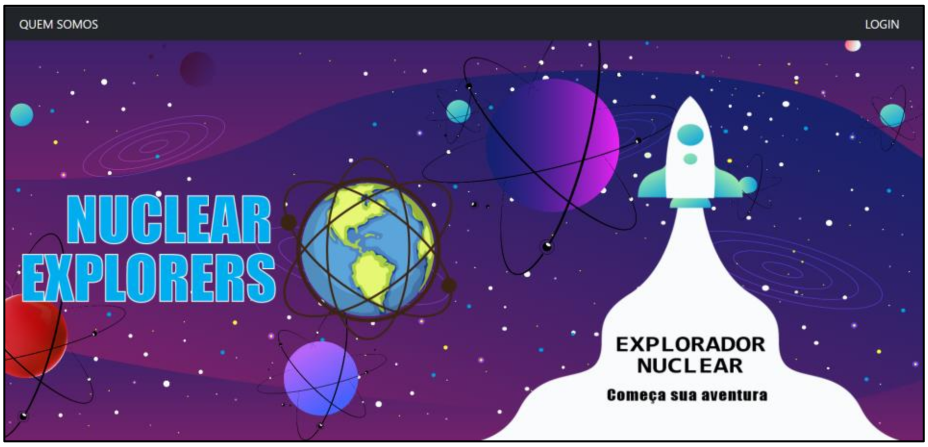

Fig. 1. Layout of the Nuclear Explorers course home page.

After the development of the virtual learning environment was completed, contact was established with schools, and partnerships were formed with high school physics and chemistry teachers. The course was evaluated by the academic staff of each school, and upon approval, it was implemented with the students.

Finally, in the fourth stage, an analysis of the results obtained from the students' completion was conducted, evaluating the data from the survey to assess the extent to which students' public opinions improved after being exposed to educational content about nuclear technology.

3. RESULTS AND DISCUSSIONS

A total of 1,250 high school students and 9th-grade students, from 53 different classes, participated in the course. The Nuclear Explorers scientific outreach project involved 8 schools located in 7 different cities in the metropolitan area of Belo Horizonte, MG. The students' age range was as expected for high school students, with an average age of 16.57 years, varying from 14 to 22 years. This average age confirms that the course successfully targeted its intended audience, including students who are in a critical phase of their educational development and career decision-making. The average time to complete the course was 2 hours and 18 minutes. The Fig. 2 illustrates an example of a computer lab at one of the schools used for the course implementation.

Fig. 2. Example of a computer room used to carry out the course.

After completing all the lessons, students responded to a questionnaire designed to assess their perceptions of their own knowledge and nuclear technologies. Among the questions, students were asked how much their understanding of nuclear science had increased after engaging with multimedia educational materials dedicated to scientific outreach. The results are presented in Fig. 3.

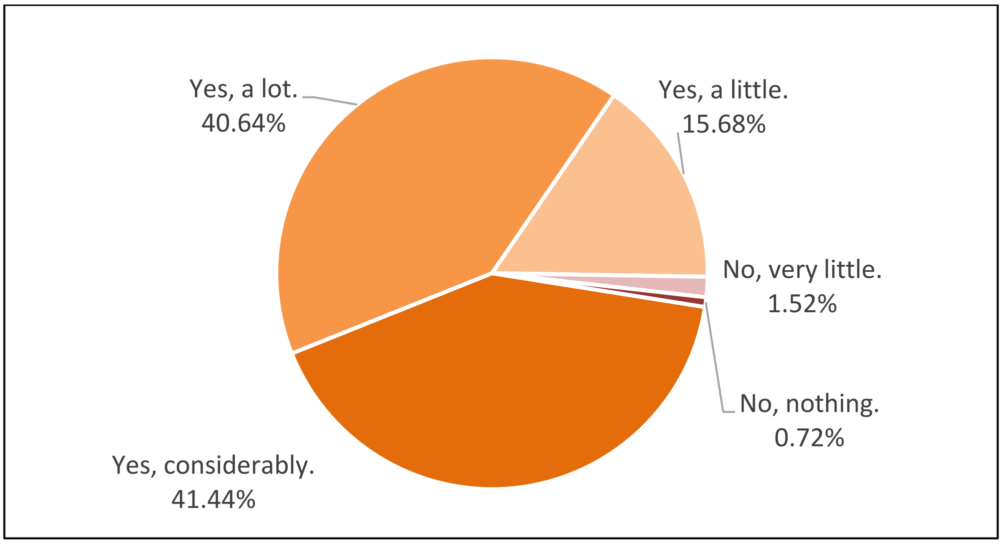

Fig. 3. Results obtained from the question "Do you believe that your journey with Nuclear Explorer increased your knowledge about nuclear concepts?"

The results obtained are highly positive, indicating that out of the 1,250 students who completed the course, 97.76% reported some level of increased knowledge about nuclear concepts. The majority of students, 518 (41.44%), perceived a considerable increase in their knowledge following the completion of the course. Additionally, 508 students (40.64%) indicated that their knowledge had increased significantly, while 196 students (15.8%) reported a slight increase. Only 19 students (1.52%) claimed that the course had a very minimal impact on their knowledge, and a negligible number of students, 9 (0.72%), stated that there was no gain in knowledge.

Students were also asked about their belief in the potential role of nuclear energy in future clean energy production. A comparative analysis of their responses before and after the course is illustrated in Fig. 4.

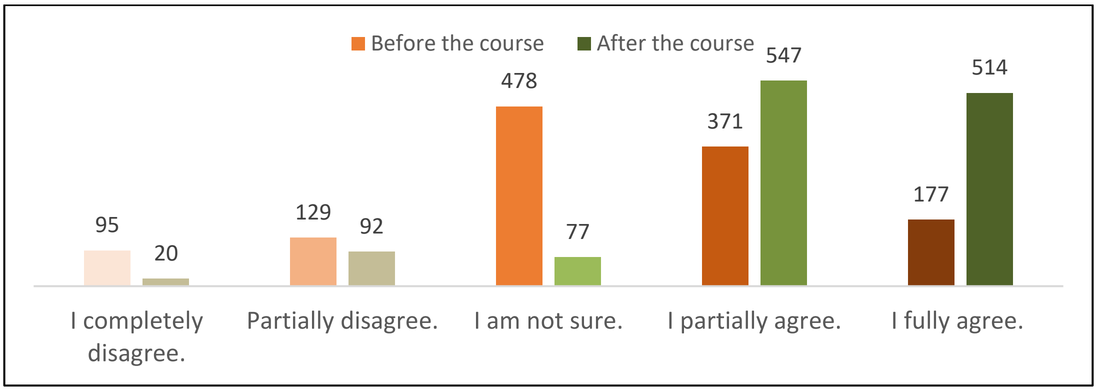

Fig. 4. Results related to the question: "To what extent do you agree with the statement: Nuclear energy will be the energy of the future."

Students who fully disagreed with the statement that nuclear energy could play a significant role in energy production totaled 95 (7.6%) before the course, a number which decreased to only 20 students (1.6%) after engaging with the course content. Similarly, the number of students who partially disagreed also decreased, from 129 students (10.32%) to 92 (7.36%).

The uncertainty regarding the role of nuclear energy in the future, reflected in the "Not Sure" response, also saw a substantial reduction, dropping from 478 students (38.24%) initially to just 77 students (6.16%) by the end of the course. This reduction indicates that the course was effective in clarifying doubts and providing information that helped students form more definitive opinions.

On the other hand, support for nuclear energy as a potential energy source, whether partial or full, nearly doubled, increasing from a total of 43.84% to a significant 84.88%. A closer analysis reveals that the number of students who partially agreed rose from 371 (29.68%) to 547 (43.76%), while the number of students who fully agreed increased from 177 (14.16%) to 514 (41.12%).

These changes in student perceptions again highlight the positive impact of scientific communication on public acceptance and support for nuclear technologies. The results underscore the tendency for greater acceptance and recognition of the potential of nuclear energy for future energy production following the completion of the Nuclear Explorers course, emphasizing its contribution to a more informed and supportive public opinion.

Finally, students were asked about the multimedia resources used in the course. They were required to respond regarding the extent to which educational resources, such as videos, images, GIFs, flowcharts, etc., influenced their learning. The results are presented in Fig. 5.

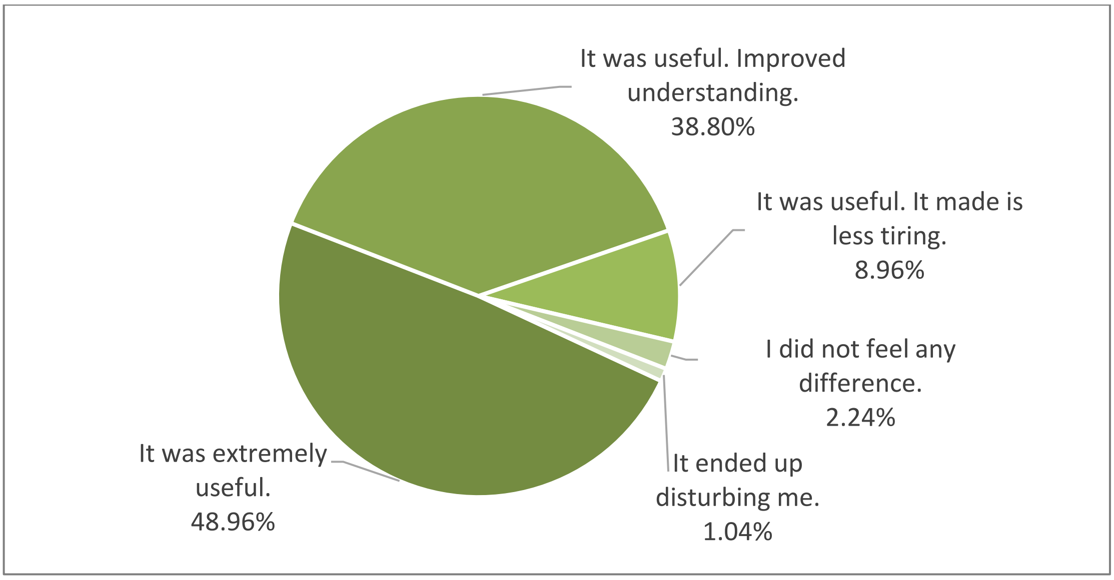

Fig. 5. Results obtained from the question "To what extent did multimedia resources aid in your learning?"

The results highlight that most students recognized multimedia resources as essential for their learning. The largest portion of students, 612 (48.96%), stated that the multimedia resources provided in the course were "extremely useful." Additionally, 485 students (38.8%) assessed the resources as helpful in enhancing their understanding of the covered topics. A smaller percentage, representing 112 students (8.96%), reported that the resources were beneficial in making the study less tedious. In contrast, a small proportion of students, 28 (2.24%), indicated that they did not perceive a significant difference regarding the use of multimedia resources in their learning. An even smaller number of students, 13 (1.04%), reported that the resources hindered their comprehension of the topic.

These results demonstrate that the use of multimedia in the course lessons played a significant role in enhancing the understanding of the educational content, emphasizing the importance of integrating various media formats for more effective learning. Data analysis reveals that visual resources facilitated the assimilation of complex concepts, complementing theoretical learning and reinforcing the effectiveness of the multimodal approach adopted in scientific outreach aimed at high school students.

4. CONCLUSIONS

The Nuclear Explorers course has proven highly effective in enhancing high school students' understanding and acceptance of nuclear science through its multimedia-based approach. The significant increase in students' self-reported knowledge and the positive shift in their perceptions of nuclear energy highlight the course's success. With 97.76% of students reporting increased knowledge and a marked rise in support for nuclear energy, the course has proven to be a powerful tool in addressing misconceptions and reinforcing the benefits of nuclear technology.

Feedback on the multimedia resources used in the course indicates their crucial role in facilitating learning. Most students found these resources to be highly effective in improving comprehension and engagement. Overall, the course demonstrates the value of multimedia in educational outreach, emphasizing its potential to foster informed and supportive perspectives on complex scientific topics.

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