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FOOD IRRADIATION: COMMUNICATION STRATEGIES TO BRIDGE THE GAP BETWEEN SCIENTISTS AND THE PUBLIC

Denise S. Levy[1,2], Anna Lucia C. H. Villavicencio[1]

[1]Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN-SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP, Brazil
villavic@ipen.br

[2]Omiccron PG LTDA
R. João Pires 412
12942-500, Atibaia, SP, Brazil
denise@omiccron.com.br

ABSTRACT

Brazil is a major food producer and food exporter. Still, a large part of the Brazilian population faces hunger, food insecurity and malnutrition. From agriculture to the consumer's table, a significant part of the production is lost during post-harvest, transport, storage and commerce, due to the deterioration of food products. These are some of the main Brazilian issues and nuclear techniques present alternatives to this demand. Nevertheless, Brazilian consumers fear ionizing radiation and misunderstand its real benefits. Consumers do not know the difference between irradiated food and radioactive food and the public has major concerns about the negative health effects and environmental contamination. This article brings the authors' experience on science communication about Food Irradiation to teach fundamental concepts and answer to the most Frequently Asked Questions about processes, safety, advantages, limitations, possibilities, impacts on human health and impacts on the environment. The content includes global aspects of food irradiation, laws and regulations, nuclear techniques in agriculture and the potential value of nuclear technology to contribute to national economy and public health. This paper describes the different tools used for outreach different audiences, to assist other experts on planning strategies to communicate nuclear science. Food irradiation improves the quality of daily life, but it is not enough to have innovation and technology if there is no information. Scientific community is expected to communicate science outside academia, informing the public and qualifying opinion-makers. It is a must to educate future problem solvers and actual decision-makers, including producers, industry, commerce and consumers.

1. INTRODUCTION

Population-Food Supply is one of the major Brazilian issues. Brazil is a major food producer and food exporter. Still, a large part of the Brazilian population faces hunger, food insecurity and malnutrition [1]. From agriculture to the consumer's table, a significant part of its production is lost during post-harvest, transport, storage and commerce, due to the deterioration of food products [2]. Brazil fights against hunger and malnutrition and nuclear techniques present alternatives to respond to this demand. Food irradiation is a safe and effective preservation technique to eliminate insects and parasites and reduce disease-causing microorganisms. The process helps to inhibit sprouting and delay ripening, prolonging the shelf-life of fresh fruits and vegetables. Food irradiation contributes to human health, food safety, environment issues and international commerce. Nevertheless, there is still great misunderstanding about the peaceful applications of nuclear science among a great fraction of

Brazilian population [3]. Most often the media and social networks tend to associate radiation to major accidents, soil contamination and the exposure of plants and animals to radioactive pollutants. Society´s judgments and decision making are directly linked to perceived benefits and risks and people fear harmful effects of ionizing radiation to human health and environment.

This article brings the authors' experience on science communication of Food Irradiation in different educative actions to teach fundamental concepts on food irradiation and answer to the most frequently asked questions about processes, safety, advantages, limitations, possibilities, impacts on human health and impacts on the environment. The main purpose of these educational actions was to bring together society and science, combating misinformation and omission of the media, demystifying unfounded fears and promoting reconstructive questioning about issues that directly impact on society's everyday life.

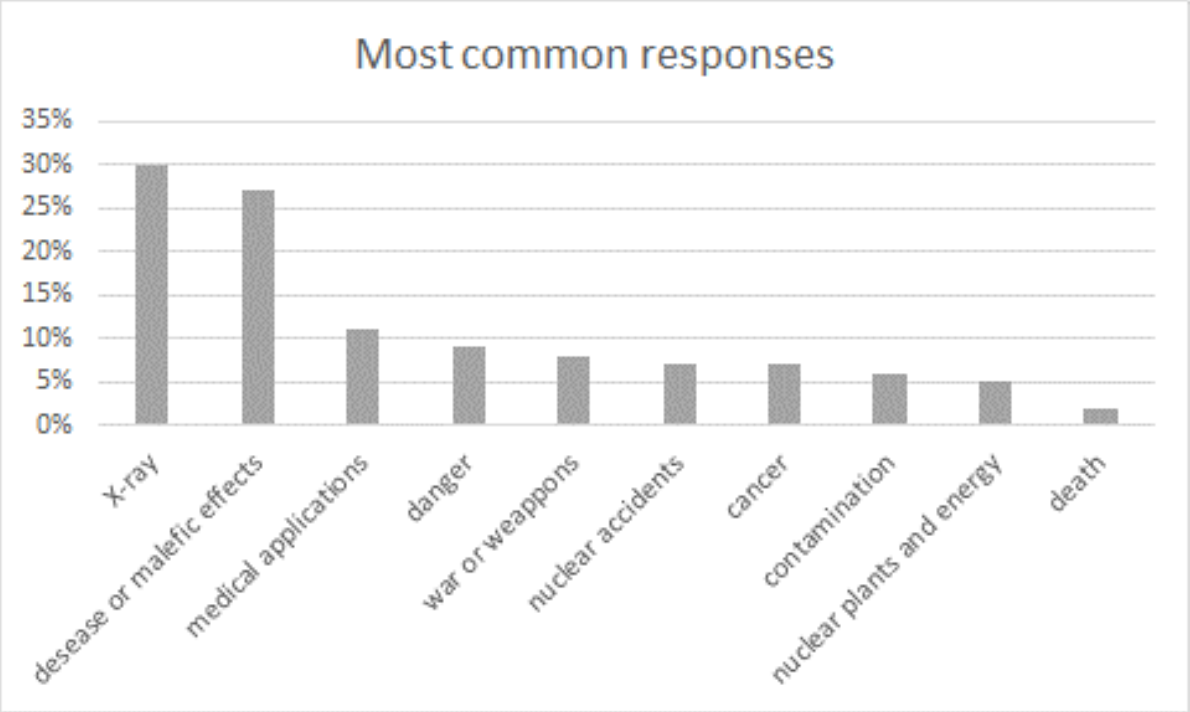
The work was developed in three distinct stages. The first step was to verify the citizens' previous knowledge about food irradiation, identifying conceptual flaws and common prejudices that are part of the popular imaginary when it comes to nuclear sciences [4]. The second step comprised a comprehensive study regarding the possibilities of access to the Information and Communication Technology (ICT) throughout the country [5 – 7]. In a globalized world where the Internet seems to be the largest vehicle for information, ICT can potentialize science divulgation reaching geographic distant people in Brazil, this large country with continental dimensions. This research work has enabled the collection of quantitative and qualitative data that allowed us to define the best interfaces tools and resources for these educational actions. Finally, the third step was focused on creating and implementing a web-based educational solution, monitoring and evaluating results, identifying new strategies and new plans of action for improving the effectiveness of nuclear science education and communication.

2. METHODOLOGY

2.1. The citizens' previous knowledge about food irradiation

The methodology applied in this first phase was a qualitative face-to-face survey based on open-ended questions which allowed our work group to collect accurate responses from a pre-defined group of respondents. The survey entitled "Science and Society" was designed to detect previous knowledge of the general public through free-form survey questions which allowed the respondents to answer complete and subjective answers based on their knowledge, perception and understanding about the given topic of discussion. The first survey was conducted in 2016, when there were invited individuals from the general public between 20 and 70 years old, living in São Paulo City, including teachers (50% of the respondents) and other professionals pertaining to several work areas [4].

When asked about the first thought that comes in mind when they think of radiations, 55% of the respondents associate radiations to wars, contamination, nuclear accidents, danger, cancer or death (see Figure 1).

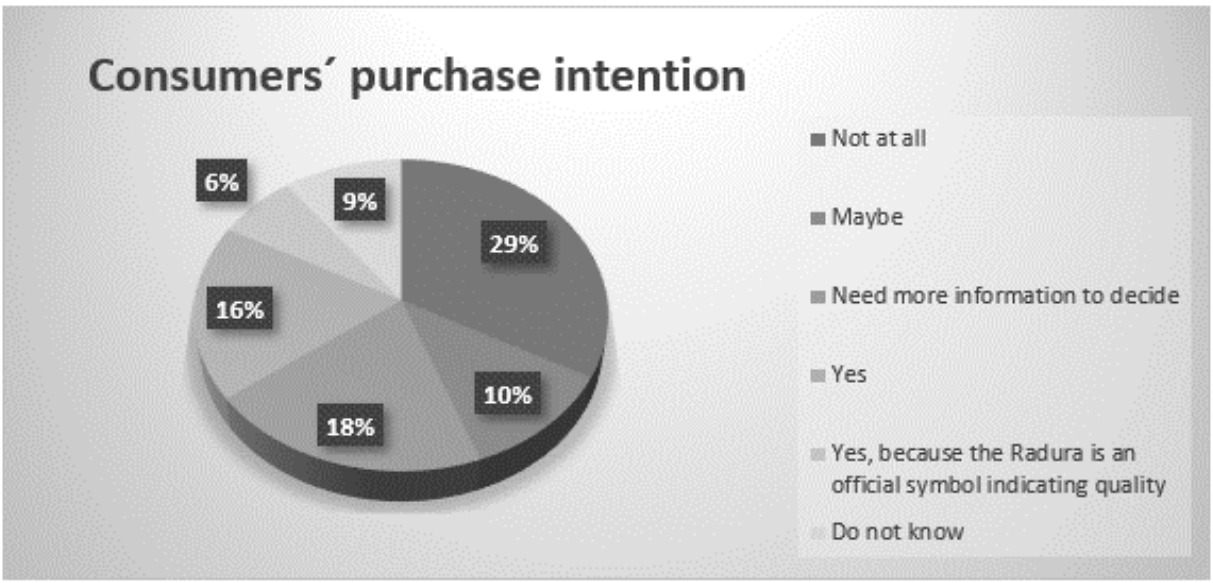


Source: author´s collection

Figure 1: Most frequently used words or phrases

To the question “have you ever tried irradiated food”, respondents tend to answer (1) yes, but not knowing the food had been irradiated, or (2) yes, because much of the food we eat comes from contaminated soil. After introduced to the symbol of Radura, 67% assume they have never seen it before and 21% recognizes the symbol but do not know what it represents. Respondents were informed that the Radura symbol indicates that a food product has been irradiated and asked if they would buy irradiated food. 29% answered no, 18% answered no unless they had more accrued information, 6% associated the symbol to criteria of quality and safety, as seen in Figure 2. Respondents were given a quick explanation about this preservation technique to eliminate insects and parasites and reduce disease-causing microorganisms, as well as the difference between “irradiated food” and “contaminated food”.

This study was conducted to investigate the effect of information on the acceptability and purchase intention of irradiated food. Therefore, respondents were asked twice whether they would purchase irradiated food. Before receiving any explanations about the issue, only a relatively small fraction of respondents (15%) expressed purchase intent of irradiated food, while 29% strongly demonstrate to reject irradiated foods, as seen in Figure 2.



Source: author´s collection

Figure 2: Consumers' purchase intentions before being properly informed

After explanation, respondents were invited to re-answer if they would or not choose irradiated food. 70% of the responders answered yes, they would choose and even suggest it to other people. 16% said yes, since they have more accrued information about the process and the effects to health and environment [4]. This was a good example of how education and information can affect consumers' attitudes toward irradiated food.

2.2. Literature review of the official publications: ICT access and possibilities in Brazil

Methodology applied in this work was a bibliographical research about Internet access in Brazil, according to the official reports published by the Internet Steering Committee in Brazil[1]. This Committee was created with the purpose of coordinating and integrating all Internet service initiatives in Brazil, as well as promoting technical quality, innovation and the dissemination of the best practices. The Internet Steering Committee in Brazil promotes studies and recommendations for Internet uses and development, establishing strategic guidelines that allow a high level of technical quality in Internet projects [5 – 7].

According to the official publication entitled "Research on the use of information and communication technologies in Brazilian households", published in 2016 by the Internet Steering Committee in Brazil, despite the regional and socioeconomic inequalities, there was an important breakthrough in the use of ICT in Brazilian households. According to data from the ICT Households surveys *"there are 94.2 million Internet users in the country, which corresponds to 55% of the population 10 years old or older. In 2008, this figure was only 34%."* [5]. Table 1 brings ICT Households survey results regarding Internet access by region in Brazil.

[1] Created by Interministerial Ordinance 147, on May 31st 1995, amended by Presidential Decree 4,829 on September 3rd 2003.

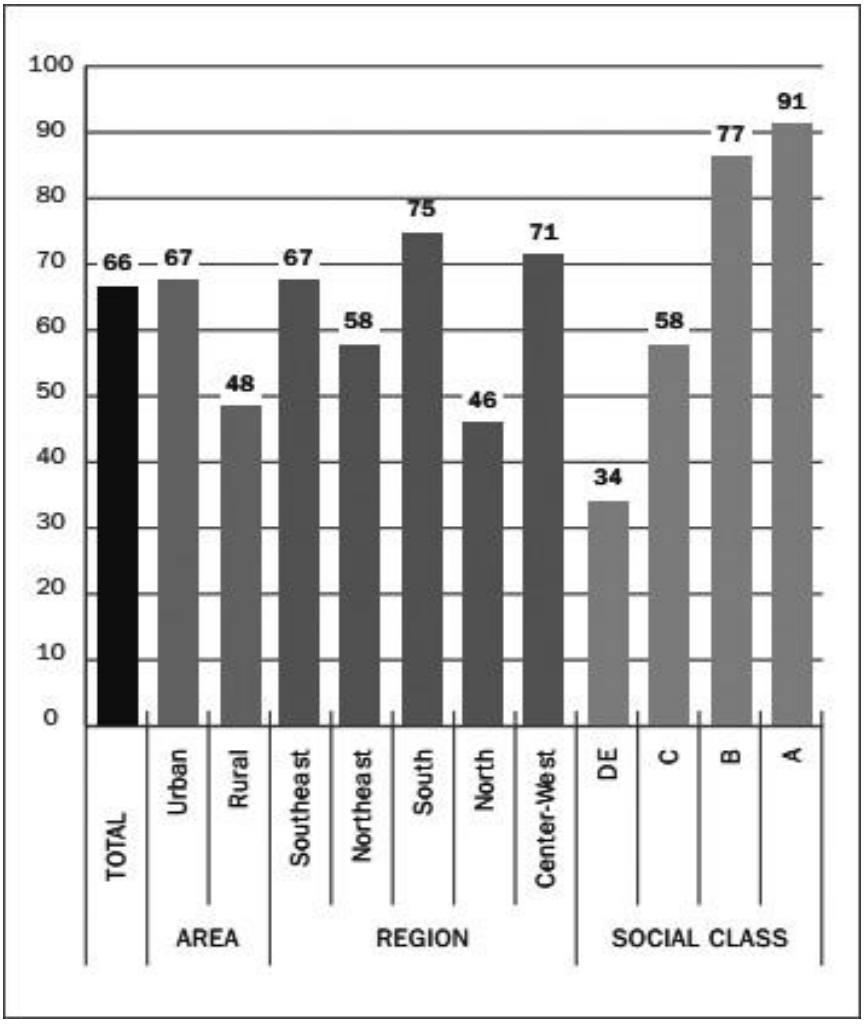
Table 1: Households with internet access by region proportion and estimate in millions Source: ICT Householders Survey 2014

Households with internet access by region	Southeast	Northeast	South	Center-West	North
Percentage (%)	60	37	51	44	36
Estimate (Millions)	18,3	6,6	5,2	2,4	1,5

This research aims to "*support the company with official data on the socioeconomic impacts of ICTs, contributing to more effective and efficient public policies and the development of the Internet in Brazil*" [5]. Among the 65,129,753 households that responded to the survey, in all Brazilian states, 92% of respondents reported having mobile phone for Internet access. 50% reported having computers at home. Among the 32,881,928 households that own a computer, 56% reported having desktop computer, 60% have a portable switch and 33% have tablets. 39% have more than one computer.

When categorized in class, reported having computer: 98% of households in the class; 82% of households in Class B; 48% of families in the C class and 14% of the D class families. As for the connection speed, the vast majority has broadband access; only 2% have dial-up and 25% also has mobile broadband (3G). 17% claims to have connection between 256 Kbps and 1 Mbps; 13% between 1 Mbps and 2 Mbps; 9% between 2 Mbps and 4 Mbps; 8% between 4 Mbps and 8 Mbps. 23% of households with computers have connection speeds up to 8 Mbps. 66% of families have Wi-Fi.

The research also includes data on the proportion of Internet users by activities in the search for information. 47% of respondents reported using the Internet for the purpose of academic research and information; 38% seek information on encyclopedia site; 33% study on the Internet on their own and 11% seek distance courses. Regarding the device used to access individual, 76% of users claim to use the phone. Figure 3 brings the proportion of households with internet access by presence of Wi-Fi. Given all these data, the team was able to design the system intelligence and the development of distance interactive activities for science divulgation.



Source: ICT Householders Survey 2014

Figure 3: Percentage of total households with Internet access in 2014

2.3. Web-based interactive activities for nuclear science divulgation

Due to the fact that the general public does not have enough understanding about all these issues, the "Nuclear Energy Institute Research" started a web-based education program to inform the general public about the contributions of nuclear science to improve food safety. The content includes agriculture applications, food irradiation, national and international issues, economic gains, social gains and radiological protection.

All interactive material has been developed according to the most modern educational concepts and last generation internet resources, in order to replace instructor absence and enable individuals to learn with quantitative and qualitative achievement. The content includes concepts, definitions and theory in addition to many interactive activities and exercises, as seen in Figure 4.

Source: author´s collection

Figure 4: Interactive material for nuclear science communication

Moreover, the project counts on responsive instruction design tools and can be easily accessed either from computers or mobile technologies, from any conventional Internet point, with good performance even via not high-speed connection. In this sense, the instructional project includes not only the adaptability to mobile media, but also a responsive system. The system is able to identify the type of screen used by the visitor. According to the equipment and resolution of the screens, the layout automatically adjusts for best viewing and better use of educational resources designed for the transmission of each content, as seen in figure 4. The next challenge involved the monitoring of this web-based educational experience, evaluating results, identifying new strategies and new plans of action for improving the effectiveness of educational actions for science divulgation.

3. RESULTS AND DISCUSSION

3.1. Implementing a web-based educational solution for science divulgation

There is still great misinformation about the peaceful applications of nuclear technology among Brazilian population. From agriculture applications to food irradiation, nuclear techniques contribute in many ways to improve food safety. Nevertheless, members of the public fear what they cannot understand and consumers´ purchase intention for irradiated food are frequently resumed to intuitive risk judgements about people´s perceptions to nuclear technology and unfounded fears about environmental and health impacts [4]. The population does not know

the difference between irradiated food and radioactive food and the general public has major concerns about the negative health effects and environmental contamination [4]. The web-based interactive material was created to invest in information to the whole society, including producers, industry, commerce and consumers. The whole material was developed in Portuguese.

This work was developed at the Nuclear Energy Institute Research (IPEN) and counted on the partnership and support of several institutions and individuals. The interactive material was first offered in Portuguese through the virtual platform LANENT, a platform created for the dissemination of nuclear knowledge throughout Latin America and Caribbean region[2]. In fact, this original high-quality material proved its potential to be useful not only in Brazil, but in all Latin America and Spain. In 2018 the Rincón Educativo of the Foro Nuclear[3] provided our workgroup the translation of all content in Spanish language. Working together with foreign institutions, our team enlarged its networks and the Brazilian interactive materials for nuclear science divulgation can be also found in Spanish, delivering information through Internet to Spanish-spoken-countries.

3.2. New strategies and plans of action to improve nuclear science divulgation

The above web-based solution focused mainly the general public, such as producers, industry, commerce and consumers. Nevertheless, public acceptance of food irradiation seems to require other urgent actions. The surveys repeated every year, with similar results, clearly demonstrates that misinformation and preconceived ideas impact heavily on the acceptance of irradiated food. Even though nuclear science is part of the regular curriculum at schools, teachers themselves are not well informed.

Therefore, in 2019 our workgroup initiated some actions focusing on nuclear science communication to educate educators, children and teenagers. This new project includes both actions:

- a didactic book to enhance the public´s understanding of nuclear science, providing accessible scientific information, inter-related to the several disciplines in Elementary and High School;
- improving quality in teacher 's continuing professional development, through lectures, workshops and interdisciplinary articles for teachers and educators [8 – 10].

Indeed, these new strategies seem to be in compliance with the National Common Curriculum Base (BNCC), which is a normative document that defines the requirements of essential learning, competences and skills of basic education for all Brazilian schools. The document that defines the stages of the elementary education was approved in 2017, and in 2018 there were approved the stages for High School Education. The BNCC does consider themes related to nuclear sciences, demanding the development of skills and competencies for a fair understanding of nuclear reactions and their applications [11]. According to these recommendations, our group initiated the development of an interdisciplinary pedagogical proposal that can be incorporated into the Basic Education, in a transversal and integrating way, demystifying nuclear science and explaining food irradiation in a contextualized and significant way. The material consists of an illustrated book for students, a book for teachers

[2] Campus Virtual Lanent: https://plms.lanentweb.org/m2/login/index.php

[3] Plataforma Rincón Educativo: https://www.foronuclear.org/es/formacion/rincon-educativo

and a manual with activities that can articulate nuclear science to different disciplines: Portuguese, Mathematics, Science, Art, English, History and Geography. The books are prepared with high scientific rigor and articulate nuclear technology with topics of interest to society in the most diverse spheres, such as food supply, public health, food safety and foreign trade. The objective of this pedagogical proposal, to be submitted to the Brazilian Secretary of Education, is to assist teachers and students in the collective construction of knowledge, encouraging research in nuclear sciences, allowing new meanings to daily life, expanding the horizons of the new generations.

3. CONCLUSIONS

The popularization of science is a must and a challenge. Food irradiation is a safe and effective preservation technique to eliminate insects and parasites and reduce disease-causing microorganisms. The process helps to inhibit sprouting and delay ripening, prolonging the shelf-life of fresh fruits and vegetables. Nevertheless, among a great fraction of Brazilian population, there is still great misunderstanding about the peaceful applications of nuclear science. This article presents some considerations about Brazilian consumers´ perceptions of irradiated food, as well as the need of improving science education and communication. Consumers´ judgments and decision making depend on their perception about benefits and risks. The scientific community must build new bridges between nuclear science and the general public, offering a wider and scientifically based perspective on the benefits and risks resulting from ionizing radiation in everyday life. In the so-called information society where Internet seems to be the most used source of information, the workgroup has chosen Information and Communication Technology (ICT) to extend the dialogue between scientific community and society. In order to successfully achieve our goals, there was performed a comprehensive analysis of the official publications of ICTs access possibilities in Brazilian households. The growing possibilities of ICT shall impact positively on science education, engaging society in issues pertaining to the impact of nuclear science on social, technological, economic and political contexts. The web-based interactive material for nuclear science divulgation was first implemented in Portuguese in an international platform, regarding the communication with producers, industry, commerce and consumers. Nevertheless, it is also essential to invest in communication with Brazilian schools, to increase the dialogue between nuclear science and the new generations. Education is the basic foundation of every society and teachers play a vital role as opinion-makers. Despite the new National Common Curriculum Base contemplates the beneficial applications of nuclear science, teachers most often are unaware of the issue. Nuclear technology can contribute to respond to some of the country's social, economic and health issues, but it is not enough to have innovation and technology if there is no communication. Scientific community is expected to communicate science outside academia, building bridges between research and the society, qualifying teachers and opinion-makers, educating future problem solvers and actual decision-makers. The access to information is a fundamental citizenship right. It is expected that scientific divulgation improves critical thinking, enabling abilities and confidence to analyze situations, examine media information and construct their own opinions, preparing people to participate as active citizens in the world around them.

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REFERENCES

1. C. Maitra, "A review of studies examining the link between food insecurity and malnutrition". Technical Paper. Food and Agriculture Organization of the United Nations FAO, Rome. 70 pp. (2018).
2. M. M. Lana, "Perdas e Desperdicio de Hortaliças no Brasil" *In*: *Perdas e desperdício de alimentos: estratégias para redução*. Brasília, DF: Câmara dos Deputados, Edições Câmara (2018).
3. L. S. Guimarães, "O desafio da aceitação pública da energia nuclear" *Revista Marítima Brasileira* **Volume 135** n. 10/12 pp.115-116 (2015).
4. D. Levy, G.M.A.A. Sordi, A.L.C.H. Villavicencio, "Construindo pontes entre ciência e sociedade: divulgação científica sobre irradiação de alimentos" *Brazilian Journal of Radiation Sciences*, **Volume 6**, No 1 (2018).
5. "Pesquisa sobre o uso das Tecnologias de Informação e Comunicação nos domicílios brasileiros - TIC Domicílios 2014", https://www.cetic.br/publicacao/pesquisa-sobre-o-uso-das-tecnologias-de-informacao-e-comunicacao-nos-domicilios-brasileiros/ (2015).
6. "Pesquisa sobre o uso das Tecnologias de Informação e Comunicação nos domicílios brasileiros - TIC Domicílios 2016" https://www.cetic.br/publicacao/pesquisa-sobre-o-uso-das-tecnologias-de-informacao-e-comunicacao-nos-domicilios-brasileiros-tic-domicilios-2016/ (2017)
7. Pesquisa sobre o uso das Tecnologias de Informação e Comunicação nos domicílios brasileiros - TIC Domicílios 2017 https://www.cetic.br/publicacao/pesquisa-sobre-o-uso-das-tecnologias-de-informacao-e-comunicacao-nos-domicilios-brasileiros-tic-domicilios-2017/ (2018)
8. D. Levy, G.M.A.A. Sordi, A.L.C.H. Villavicencio, "Divulgación Científica: un desafío y una necesidad para aproximar Ciencia y Sociedad" Proceeding of *Segundo Simposio Internacional sobre Educación, Capacitación, Divulgación y Gestión del Conocimiento Nuclear*, Buenos Aires, Argentina, 13-17 November 2017 (2017).
9. D. Levy, T. M. Peralta, L.Pozzi,, I.P. de Tovar, A.L.C.H. Villavicencio, "Education and citizenship: contributions of psychopedagogical practices to popularization of science" *International Journal of Development Research*, Volume 07, issue 07, pp. 14157-14162 (2017).
10. D. Levy, T. M. Peralta, L.Pozzi,, I.P. de Tovar, "Teachers' multidimensional role towards meaningful learning: the potential value of interdisciplinary environments". *International Journal of Innovation Education and Research*, **Volume 6(2)**, pp. 179-187 (2018).
11. "Base Nacional Comum Curricular" http://basenacionalcomum.mec.gov.br/abase/ (2018).