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USP UNIVERSITY STUDENTS SOCIAL REPRESENTATIONS AND VIEWS ON NUCLEAR POWER AS ENERGY OPTION

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ABSTRACT

The Nuclear Energy Research Institute (IPEN) is located on the campus of the University of São Paulo and has long been publishing nuclear science projects in order to improve public opinion and disseminate nuclear energy issues. However, few studies have investigated the perception of university students concerning nuclear energy. This study questioned whether the location of a nuclear research facility, as well as divulgation scientific projects, can positively influence student opinion when the nuclear research reactor is on campus and used purely for research purposes. This study further investigated the students' understanding of the terms “nuclear energy” as well as their perception of the social issues involved. Free evocations of words were produced and collected starting from the stimulative inductor “Nuclear Energy. In this test, the interviewees are asked to associate five words and answer a questionnaire. A total of 124 students were interviewed for this study: 62 from the Chemistry, Pharmacy, Environmental Chemistry, Chemical Engineering and Nutrition Departments, 29 from the Oceanography Department and 33 from the Economics, Business Administration and Accounting Department. A total of 78% of the interviewed students answered that they had basic or average knowledge of nuclear energy, 46% claimed to have no knowledge of IPEN and the remainder students have answered that IPEN´s activities were aimed at research in energy and production of radiopharmaceuticals, which shows little knowledge of the activities of the Institute. However, these students indicated Nuclear Energy as a strong for the diversification of energy sources. It should be noted that this study was undertaken before the nuclear accident caused by the 2011 Japan tsunami and earthquake.

1. INTRODUCTION

During II World War and after 67 Japanese cities were bombed intensely for a period of six months, the atomic bomb codenamed "Little Boy" was dropped on the city of Hiroshima on a Monday. Three days later, on August 9, 1945, "Fat Man" was dropped on the city of Nagasaki. On April 26, 1986, technicians in Pripyat, Ukraine attempted to perform a test at the Chernobyl plant and ended up causing a chain reaction that triggered an explosion in one of the nuclear reactors. The Chernobyl accident has led to a part of the population developing an inadequate perception of radiation risk, which has caused psychological problems and, as a consequence, a deterioration in public health and quality of life [1]. On September 13, 1987, in Goiânia, Brazil, the dismantling of an abandoned cesium 137 capsule was the cause of a serious radiological accident in the country. In 2011, an nuclear disaster at a Japanese nuclear power plant in the city of Fukushima caused by a strong earthquake was considered one of the most serious accidents since Chernobyl. The entire plant was flooded by the 15 m (49 ft) tsunami wave, including low-lying generators and electrical switchgear in reactor basements and external pumps for supplying cooling seawater. The connection to the electrical grid was broken as the Tsunami destroyed the power lines. All power for cooling was lost and reactors started to overheat, owing to natural decay of the fission products created before shutdown.

These are only four examples but they that can be used to illustrate the phenomenon of Social Representations (SR) [2]. Our image of nuclear energy use was changed after these events and now most people associate this technology to danger and war.

Despite this negative public image and a period of relative stagnation in the 1980s and 1990s, the world witnessed in the following decades the emergence of movements controversial about nuclear issue. On the one hand, a broad social movement strongly opposed to nuclear technology was gaining ground worldwide [3]. On the other hand, environmental concern strengthened the argument to use nuclear energy for electricity generation in many countries.

According to the movement in opposition to the use of nuclear technology, especially with regard to nuclear power generation, its expansion will increase the uncertainties and difficulties for the non-proliferation of atomic artifacts, will increase environmental impacts caused by uranium mining and in the case of accidents, as well as increase the volume of nuclear waste, of which its storage is still the target of much controversy [3].

However, the movement in favor of nuclear power argues that apart from reducing the discharge of carbon dioxide into the atmosphere, the radioactivity level of nuclear waste drops to one billionth of the level of when it was removed from the reactor over a period of 175 years, according to the Canadian radioactive waste policy, unlike other waste chemicals such as mercury, which does not lose its toxicity over time. The volume of nuclear waste, compared to coal waste, is also significantly lower. The former would fit in a soda can, if the reference is all the electricity used in the lifetime of an individual that only used nuclear energy and the latter would generate 69 tons of solid waste and over 77 tons of carbon dioxide emissions. In addition, a nuclear thousand-megawatt plant requires less than one square kilometer, which means that to generate the same amount of power using eolic energy, an area 600 times greater is required [4].

And caught in the middle of these two movements is the population, which is torn between its fear of the potential danger that a war or a nuclear accident represents and its increasing need for energy. With this in mind, this study investigated the perceptions of students at the University of São Paulo (USP) regarding this theme based on the term inducer "Nuclear Energy," highlighting the structure of the SR on the subject. The initial assumption was that students at the USP campus would be better informed about the subject due to the proximity of the Institute of Energy and Nuclear Research (IPEN) and this proximity would positively influence the energy matrix option of these students in relation to nuclear energy.

2. METHODOLOGY

This research is aimed at describing the SR of nuclear energy and at analyzing of the relationship between this technology and other energy options in accordance with the undergraduate students at the University of São Paulo. According to Spink (1999) [3], the investigation of SR can be made from spontaneous processes, regardless of if they are "by induced issues, expressed freely in interviews, or already crystallized in social productions such as books, documents, materials or memories of newspapers and magazines". The plural methodological character of research in the field of SR is presented by Farr (2002) [5], who states that the theory is compatible with the use of a wide variety of different research methods. In this study, the data had been collected by free evocation of words technique [6] and oriented and structured questions.

Data analysis has been conducted with the EVOC statistical program that was created in 2000 by Pierre Verger [7] as a computational tool to investigate the centrality of representations of the elements by means of a framework of four quadrants. The words are analyzed in terms of its definition range, frequency, hierarchical level and average order in the evocation process.

The initial assumption is that the terms that meet the criteria of frequency and order of evocation, in other words, appearing more often and in first place, are supposed to have greater importance in the cognitive schemata of the individuals and would, therefore, be candidates for the core of representation [8].

A total of 124 students from the following departments were interviewed: Chemistry, Pharmacy, Environmental Chemistry, Chemical Engineering and Nutrition Departments (62), Oceanography Department (29) and Economics, Business Administration and Accounting Department (33), from June to August 2010. The profile of respondents consisted of 47.6% female and 52.4% male, 69% graduated in private schools, and the average of 21 years old.

3. RESULTS AND DISCUSSION

3.1. Free evocation of words technique

With respect to freely evoked words, the results showed that the respondents performed the requested task by producing 394 evocations from 36 different words or expressions. The number of words mentioned by students is considered to be relatively low, which may mean

that some elements were shared by the group at the expense of other elements that are more idiosyncratic.

For the construction of the quadrants, words that were mentioned only once or twice were removed since such represented a percentage of less than 10%, which is considered insignificant. A little over 90% of the words evoked were used and this enabled the analysis to be considered more consistent, representative and "clean." From this *corpus*, we calculated the average frequency of the words, by dividing the total (394) by the number of different words (36). We obtained the average frequency of 10. The average order was obtained by dividing the number of evocations per respondent by the number of respondents. Every interviewee evoked 5 words, the average order was 2.5 evocations per person. Based on these criterions, it was possible to construct the diagram with four quadrants (Table 1).

The top ten most evoked words corresponded to 46.5% of the total with emphasis on two words in the first quadrant: bomb and radiation. Since every representation is organized around a central core that defines it, its significance and internal organization is related to one central and peripheral system [5, 7]. It is observed that these two words possibly represent the central core of the nuclear theme. This is because the elements belonging to the central system of the SR are those that occurred most frequently, with quick evocation and are located in the upper left quadrant of the diagram, while the peripheral elements are those located in the other quadrants.

Table 1. Diagram of the structure of social representations of nuclear university students at USP

	QUADRANTS I			QUADRANTS II		
	Average Order of Evocation < 2.5			Average Order of Evocation >= 2.5		
Frequency >=10	atomic	18	1.500	energy	36	2.556
	atom	15	1.533	explosion	11	3.182
	bomb	31	2.484	Iran	12	3.000
	fission	15	2.467	waste	17	3.353
	fusion	11	2.182	nuclear	17	2.588
	radiation	21	2.476	danger	17	2.882
	radioactivity	13	2.154	reactor	16	2.563
				technology	13	3.393
				uranium	41	2.585
				plant	13	3.231
	QUADRANTS II			QUADRANTS IV		
3<= Frequency <=10	alternative	5	2.400	research	4	3.750
	high	5	2.400	plutonium	5	2.600
	cost	3	2.333	policy	3	3.000
	economy	3	2.333	pollution	6	3.667
	clean	8	2.250	protons	4	2.500
	dangerous	3	1.667	chemistry	4	3.000
	radiative	3	1.000	renewable	3	3.000
	sustainability	4	2.250	waste	3	3.000
	plants	3	1.000	risk	5	3.600
				safe	3	2.667

The peripheral system of this condition, particularly the second quadrant, consists of elements that refer to the words of the first quadrant (explosion, Iran, waste, nuclear danger, reactor technology, plant and uranium). It is interesting to note that during the period in which the interviews were taking place (June-August 2010), Brazil was mediating negotiations with Iran over its nuclear program and this deal was widely covered by the press. The influence of this situation is reflected in the evocation of the word Iran (N = 12) in the second quadrant. If the interviews were carried out in the current period, words such as Japan and Fukushima would probably would be mentioned, emphasizing the importance of the press in the development or "reworking" of the social representations of the population. Information concerning the scientific process inherent in this theme appears only in the fourth quadrant and with low frequency.

Words such as IPEN, cícloton, radioisotopes, radiopharmaceuticals, etc. did not appear in any of the quadrants and even the word “research” appeared in the last quadrant with low frequency (N = 4), indicating a minimal or no knowledge of the activities carried out by the Institute of Energy and Nuclear Research (IPEN), located within the campus.

And what are the possible origins of these representations? It is known that one of the purposes of SR is to aid in understanding something that is unfamiliar, that is, an alternative classification, categorization and the naming of new events and ideas which are not previously known, thus enabling these ideas, values and pre-existing theories, that are internalized by us and widely accepted by society, to be better understood and manipulated. [1]. Therefore, we seek to understand by abstracting the meaning of new information and facts produced constantly from the proliferation of centers of scientific research, from the enormous wealth of ideas and "philosophies" facilitated by mass communication and also from those created by "streetwise" individuals or by common sense, and then operationalize them in our daily lives. The creation and transformation of information causes us to change our values, which in turn, influences our choices.

From this perspective, the students were also asked to choose which sources of scientific disclosure they had access to: FAPESP magazine, other magazines (*Super Interessante*, etc.), television (documentaries, educational programs, etc.), USP radio, newspapers, conferences, chats with friends, fairs/exhibitions, their own undergraduate course, Internet or others. Television was mentioned 59 times, magazines such as “*Super Interessante*” (46 times), their own undergraduate course (46 times) and Internet (25 times).

3.2. Analysis of structured and targeted questions

In addition to the free evocation of words technique based on the inducer term "Nuclear Energy," the study also included targeted questions to assess the extent of knowledge of these students on the subject of nuclear energy and whether they had heard or not of IPEN, as well as of the activities of the Institute. We also investigated the indication of nuclear energy as a possible energy source for the country and the knowledge these students had regarding the dangers of different energy sources.

When inquired about their knowledge of nuclear energy, 78% of the students reported having an limited knowledge or basic knowledge of the subject (Figure 1). A total of 54% of the 124 students said they had never heard of IPEN and did not even know that a nuclear reactor

existed on campus. Thus, it appears that IPEN´s efforts to positively influence public opinion (university students as well) in favor of nuclear energy have fallen short of their goal.

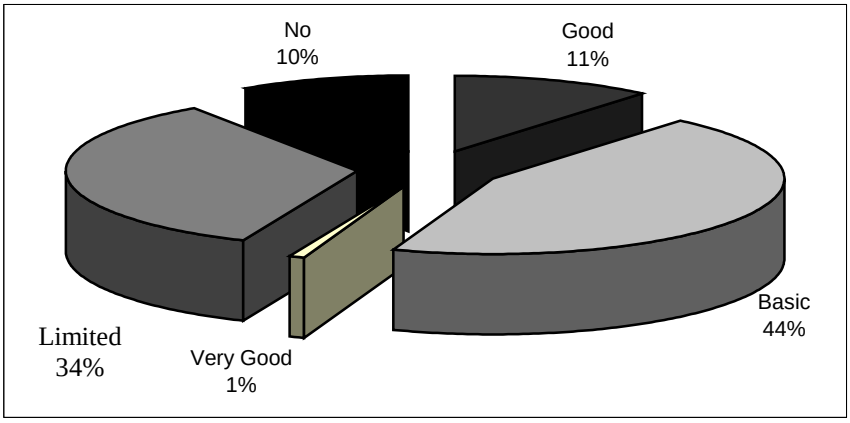

Figure 1. How would you assess your knowledge of nuclear energy?

The 46% of students that claimed to know IPEN and the existence of a nuclear reactor on campus, were also questioned regarding their knowledge of the main activities developed by the Institute. Of these, 46% answered that IPEN's main activity is the production of energy (Table 2). The answers that appeared only once or twice were grouped and summed 40%.

Table 2. Percentage of answers related to the activities developed by IPEN

Expressions	Percentage Contribution
Energy	46
Applications	7
Radiopharmacy	7
Sustainable energy Enrichment of uranium Teaching and research Fission/energy Nuclear fusion Materials New energy alternatives Energy research/research Research environment	40

Although the results show that the knowledge of students about nuclear technology is limited and also that they know little of the activities developed by IPEN, 39% indicated nuclear energy as a strong option for the energy matrix and 35% as a possible option. The rejection

was low, only 6% were categorical in rejecting nuclear power as an alternative source of energy for the country.

For students who did not indicate nuclear power as an alternative energy source, they were asked to choose other options (biomass, coal, fuel from waste, eolic, fusion, gas/oil, hydroelectric and solar) that should be the focus of research and investment in Brazil to expand and/or diversify of its energy matrix. The answers were divided into biomass and solar, very likely because the students believe that these forms of energy are not hazardous. This was confirmed by the next question, which referred to the dangers or not of different primary energy sources (biomass, coal, fuel from waste, eolic, fusion, gas/oil, hydroelectric and solar).

4. CONCLUSIONS

Energy has an important role in modern industrial and commercial society. All sectors currently rely on energy for simple day-to-day tasks, as well as for public services, lighting, air conditioning, kitchen appliances, radio and television, or even for the most basic necessities of life, such as clothing, food, housing and transport. This absolute dependence may be a possible explanation for the choice of nuclear energy as an option to diversify the energy matrix of the country, although the core of the SR of these students on this issue was negative and they showed little knowledge of the subject.

The option of obtaining energy from biomass and solar energy was more frequently mentioned by students who rejected nuclear energy, most likely due to the image of sustainability typically associated with these two sources of energy.

However, the studies on this subject from the standpoint of the SR Theory are still few, therefore inconclusive with regard to the establishment of a possible relationship between the presence of “Nuclear and Energy Research Institute” and the wider acceptance or not of nuclear energy as an option for the energy matrix. The results also show that the probable sources for the preparation or rework of SR in this group of students regarding the nuclear issue, derive mainly from television. Although Internet access in the country is widespread, this group of students showed that their main source of scientific knowledge is still the television.

As a suggestion for future work, it would be interesting to repeat this study after Fukushima in order to evaluate the restructuring of the SR after the event and its relationship with the news printed in the press.

Lastly, despite the fact that IPEN organizes scientific activities in schools at elementary and high school level in São Paulo with lectures and discussions that shed light on nuclear energy, as well as technical visits to the institute, the results show that activities of the Institute need to be disseminated further in order to reach the students of the campus.

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