

IMPACT OF A ROLE-PLAYING GAME ABOUT NUCLEAR ENERGY ON THE SCIENTIFIC KNOWLEDGE OF PRE-SERVICE ELEMENTARY TEACHERS

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Abstract: Participation in social debates with political repercussions requires scientific knowledge that helps to better understand and interpret the different positions of the controversies that appear in the media. An activity based on a role-play is shown in this paper in order to stage the social problem with a scientific basis that poses the dilemma of whether or not to close the nuclear power plants in Spain. The activity is based on a preliminary experience with the same problem but with a different design, to propose that depending on how the activity is designed, it can not only sensitize and motivate with the role-play but could also serve as an educational resource to help the learning of the scientific contents involved. 95 Spanish pre-service elementary science teachers from the University of Malaga participated in an improved role-playing game that fostered argumentation and counter-argumentation. Roles were included both for and against the problem posed (shareholder, businessperson, lobbyist, a villager, scientist, etc.), also giving a relevant role to the team of presenters, not only as mediators of the debate but also as responsible for giving an answer to the question posed. In order to learn about the effectiveness of role-playing in learning knowledge about nuclear energy, participants answered a questionnaire on scientific knowledge before and after the activity. The results were analyzed by categories, showing Wilcoxon's test that the role-playing game allowed them to improve the learning of different concepts, in this case, physical concepts about the emission of pollutants from a nuclear power plant, the process of heat generation and energy capture.

Keywords: Socioscientific Issues, Initial Teacher Education (Pre-service), Decision making

INTRODUCTION

The production of electricity from nuclear energy, as opposed to renewable energies, is a social issue that requires a scientific basis in order to be able to give a well-founded opinion (Sadler, 2004). In political debates, it is common to show graphs or data to justify a position in the face of these dilemmas (García-Mila et al., 2016). In this sense, citizens must have the scientific knowledge that helps them to empower themselves in these issues in order to be active citizens in our society (Reis, 2014), since if this knowledge does not exist or is scarce, and is not related to situations of daily life, personal opinions and beliefs will be used in the arguments instead of scientific knowledge (Macagno & Konstantinidou, 2013). Role-play as an educational strategy allows combining the game, the simulation of a current social and political scenario, together with the dramatization to motivate the students towards the investigation on social-scientific issues (McSharry & Jones, 2000). This study analyzes the possible impact that a role-play on nuclear energy may have on the scientific knowledge of Pre-service Elementary Science Teachers (PSESTs) in Spain. Specifically, the aim is to analyse the knowledge regarding the emission of pollutants into the atmosphere of a nuclear plant, the process of obtaining heat and the energy use of this type of plant.

METHOD

The sample consisted of 95 PSESTs of the University of Malaga whose ages ranged from 20 to 21 years. Their previous studies were in the field of humanities with low scientific knowledge. The proposed role-play is part of a broader training programme of scientific argumentation for PSESTs Cebrián-Robles, Franco-

Mariscal, & Blanco-López, 2018). Its design includes improvement proposals to solve the limitations detected in a preliminary study where the game with PSESTs was implemented (España-Ramos, Cebrián-Robles, & Franco-Mariscal, 2018). The scenario of the role-playing game is developed in a live television debate with the question: Do you think that the use of nuclear energy should cease in Spain? Following the Greenpeace campaign on the occasion of the cessation of the Garoña plant¹. PSESTs were randomly given different roles to play (shareholder, businessperson, lobbyist, a villager, scientist, etc.), which they had to prepare previously by carrying out an information search. During the TV show, the different roles had to defend their positions in a debate in which half are in favour of continuing with the Spanish nuclear power plants and the rest are not. Three questions from a larger questionnaire were used in order to study the evolution of PSESTs' knowledge about nuclear energy. This survey was filled in before and after the role-playing game. Concretely: (1) The gas leaving nuclear power plants is: a) Carbon dioxide, b) helium, c) water vapour, d) air, e) other gases, f) no gases leaving, g) no opinion / no replay. (2) The process of obtaining heat in a nuclear power plant is produced by: a) nuclear fusion, b) water evaporation, c) nuclear fission, d) combustion, e) no opinion / no replay. (3) Describes the entire process of obtaining energy in a nuclear power plant. The answers to the three questions were categorized into different levels (table 1). For questions 1 and 2 (closed), all inappropriate responses were included in level 2 and appropriate responses were included in level 3. For the categorization of question 3, a 6-stage scheme was drawn up that summarized the process of obtaining energy in a nuclear power plant. The different levels of the rubric for this question were developed taking into account whether or not the PSESTs mentioned the fission process and the number of stages they identified.

Table 1. The rubric used for categorization of responses

Question	Level 1	Level 2	Level 3	Level 4	Level 5
1	No answer and answer g)	Replies (a), (b), (d), (e) and (f)	Response (c)	-----	-----
2	No answer or answer e)	Replies (a), (b) and (d)	Response (c)	-----	-----
3	No opinion / no replay	They mention aspects not related to the process of obtaining nuclear energy	Identifies fission and/or fusion processes without mentioning any stage of the process	Identifies fission and/or fusion processes and some stage(s) of the process	Identifies the fission process as currently used for power generation and most process stages

SPSS v.21 was used for statistical analysis, comparing the responses to each question between pre-test and post-test with Wilcoxon's nonparametric test.

RESULTS

Table 1 shows the response percentages for each question and level and the Wilcoxon test. The percentage of PSESTs who did not give their opinion to question 1 (level 1) fell from 16.8% to 1.1% between pre-test and post-test. At the same time, there was a substantial change from inappropriate responses (64.2%, pre-test) to adequate responses (58.9%, post-test), showing the Wilcoxon test that this difference was statistically significant. A global evolution of PSEST responses was observed in question 2 in the sense that the majority in the pre-test was at levels 1 and 2 (55.8%) and in the post-test at level 3 (66.3%). Wilcoxon's test showed that this difference was statistically significant. Initially, in question 3, the majority response was at level 2 (57.9%), indicating that these PSESTs did not identify the fission or fusion processes, nor any

¹ News available at <https://goo.gl/4TwqHc>

of the stages of the process, producing a change in the post-test by doubling the percentages of the higher levels, including the last three levels to 54.8%. The Wilcoxon test resulted in statistically significant differences.

Table 1. Pre-test and post-test results.

Question	Level 1 (%)		Level 2 (%)		Level 3 (%)		Level 4 (%)		Level 5 (%)		X (Mdn)		Wilcoxon Test	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Z	p-value
1	16.8	1.1	64.2	40.0	18.9	58.9	--	--	--	--	2.02 (2)	2.58 (3)	-5.899	0.000
2	24.2	4.2	31.6	29.5	44.2	66.3	--	--	--	--	2.20 (2)	2.62 (3)	-4.376	0.000
3	3.2	3.2	57.9	42.1	14.7	11.6	10.5	22.1	13.7	21.1	2.74 (2)	3.16 (3)	-2.634	0.008

CONCLUSIONS

The results show that role-playing game led to PSESTs significantly improving certain knowledge about nuclear energy. It highlights the importance of role-playing method to achieve an improvement in the scientific knowledge involved in the activity and also to improve their attitudes towards science. This work shows how a method with a good collaborative approach, where the quality of the argumentation is paramount and supported by a training programme on argumentation, can bring PSESTs even closer to the scientific knowledge required to participate in social controversies that appear in the media daily and about which they might have to make decisions as citizens. In future papers, we intend to analyze the quality of the arguments and counterarguments used by the PSESTs during the role-play.

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