



## Role-Playing as an Activity to Work on Students' Perceptions of Nuclear Energy and Its Risks

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### Abstract

*The consumption of non-renewable energy and the energy crisis can be treated as a socio-scientific issue due to the ever-increasing demand for energy and the likely depletion of non-renewable fuels. Society must keep abreast of these issues, and preservice elementary science teachers (PESTs) in particular have to make an extra effort to understand and fix misconceptions about nuclear energy and balance its advantages and disadvantages as a source of energy. Some studies have highlighted numerous misconceptions of preservice students as regards their understanding of nuclear energy and its risks, whereas others have focussed on high school students and their perceptions. This paper presents a role-playing activity as part of a training programme in argumentation to reflect and raise awareness about the consumption of nuclear energy. A pre-test and a post-test were used to analyse the understanding and perception of nuclear energy of PESTs before and after the activity. The findings show that PESTs learn the basic concepts of nuclear energy by searching for evidence in order to be able to put forward good and reasoned arguments. One of the reasons for this was the need to defend their role's point of view about the acceptance or rejection of this energy source. This activity was performed without the participation of the teacher.*

**Keywords:** Role-playing, pre-service elementary science teachers, nuclear energy, perceptions, argumentation, socio-scientific issue

### 1. Introduction

The scarcity of non-renewable energy resources and increasing consumption thereof may lead to a global energy crisis and increased CO<sub>2</sub> emission to the atmosphere, which in turn leads to global warming [1]. The literature shows that a deeper and longer-lasting learning occurs from a very early age [2]. As such, a civic awareness that leads to favourable and long-lasting attitudes as regards conservation of the planet needs to be created. In this sense, various authors have proposed activities with a socio-scientific and socio-political focus for primary school students [3].

In order to be aware of and actively participate in the energy policies of a country, its citizens must be taught some basic facts concerning energy resources. Nuclear energy is a non-renewable source the use of which is controversial in our society and complex to understand as a result of various uncertainties [4]. Some studies have evaluated the preconceptions of students regarding nuclear energy in order to determine the conceptual errors and identify the possible lack of scientific understanding that would allow them to form an opinion [5].

Role-playing games represent an interesting resource in science teaching as they allow contents that can be discussed from various viewpoints to be studied [6]. Various authors have highlighted the importance of treating socio-scientific problems in science classes using activities, such as role-playing, in which debating plays a key role [7-8]. One key aspect of role-playing is that it requires dialogue between the participants during both preparation for the game and the staging thereof [8]. It also allows problems to be identified, information to be searched for and solutions proposed [9]. One of its main characteristics is that different opinions and the criteria supporting them are represented [10], and these aspects are particularly suitable for identification of both the point of view being defended and other perspectives, with the corresponding attitudes and values, which may help to clarify opinions concerning a given problem and, on occasions, lead to a change of opinion [8]. In role-playing games, the ability to debate by linking explanations and evidence becomes important when preparing the roles and their staging [7], and also motivates students to learn contents related to the problem concerned, which may help students to perceive science as a less abstract and distant topic [11].

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This study proposes a role-playing game based on the socio-scientific problem of nuclear energy use to empower citizens for responsible decision-making regarding important aspects of their lives and the future of the planet. It also aims to foster the idea that science requires an understanding of how to debate, evaluate and provide evidence to support the ideas being defended rather than simply absolutist thinking [12].

## 2. Research Question

The aim of this study was to determine whether, using a role-playing game in the context of a current socio-scientific problem in Spain, it is possible to improve the argumentation skills of preservice elementary science teachers (PESTs). An additional aim is to improve the understanding of PESTs of nuclear energy and present role-playing games as an interesting educational resource for primary education.

## 3. Methods

Herein we present a preliminary study involving 48 PESTs with ages ranging from 20 to 21 years, all of whom were third-year students from the Primary Education Teaching Degree at the University of Málaga (Málaga, Spain). These PESTs undertook a role-playing activity as part of a training programme [13] aimed at improving argumentation. The activity was carried out over two sessions separated by a period of one week (figure 1).

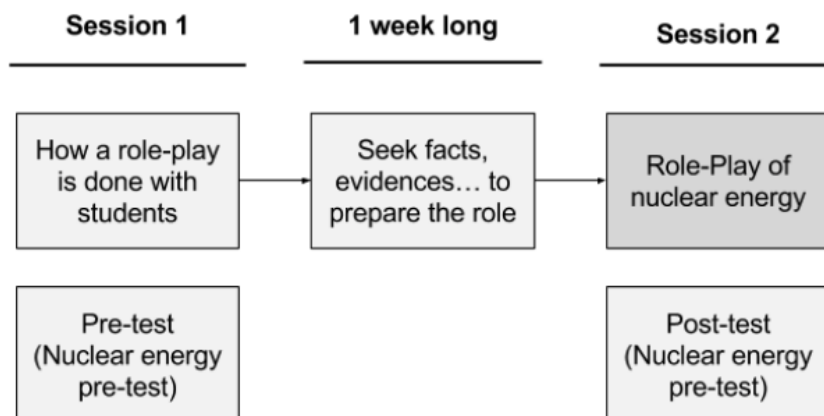


Fig. 1. Role-Playing sessions

Session 1: A question concerning their understanding of nuclear energy was administered to the PESTs as a pre-test. The nature of role-playing and why it is of interest in primary education, as well as the rules for playing the game, were presented and explained in the same session. PESTs were divided into groups, with each group being asked to participate in a role-play session by itself with one character as moderator (in this case the “minister” character). This character was a minister who must be convinced by the quality of arguments in order to make a reasoned decision. At that stage each PEST was assigned a role and asked to find and identify evidence that would allow them to defend their role, together with counter-arguments that would allow them to respond to potential rebuttals from their peers. They were given a week to do this and it was estimated that they would need to dedicate 8 h to this task. This evidence could be photographs, figures, scientific articles, news items, etc., which must be used in the debate to defend their point of view.

Their role must not be disclosed to any of their peers, not even outside class, as one of the goals of the game was to relate each PEST to their role based on evidence. The role-play concerned a current socio-scientific issue, namely the nuclear power plant in Garoña (Burgos, Spain). The game scenario was introduced as: “We are currently in a situation in which Spain has a caretaker government and it is difficult to make decision for the long term given the uncertainties inherent to such a situation. However, the nuclear power plant at Garoña is currently under the spotlight as there is an ongoing debate as to whether to reopen a plant that has already been operating for 45 years and has exceeded the permitted operating lifetime of 40 years. A meeting is to be held at which important decisions, which will affect both Garoña and all other nuclear power plants in Spain, regarding whether to extend the operating licence for such plants from 40 to 50 or 60 years will be taken.



The minister in each role-play group had to take a decision about whether to extend the plant's operating licence for a further 20–40 years or not. In order to take this decision, PESTs were randomly given different roles to play (shareholder, businessperson, lobbyist, villager, scientist, etc.). Besides delving further into the issue of nuclear energy, PESTs were shown an advanced aspect of argumentation, i.e., refutation of ideas to improve the quality of arguments. Thus, PESTs were motivated to prepare themselves very well by convincing not only those who were in the opposite position but also the minister, who acted as the jury and ultimately decided whether or not to extend the operating licence for the nuclear energy plant.

Session 2: The role-play was carried out in the second session. Each PEST argued their position without revealing the role they had been given. Meanwhile, the PEST who played the minister took notes of the different views and arguments and decided which of the two groups was stronger, and the reason why the operating licence for the nuclear plant should or should not be extended. All ministers (from all role plays) presented and argued their final decisions at the end of the session. Upon completing the role play, the initial questionnaire was administered again as a post-test. This study analyses three questions from the questionnaire (table 1).



Fig. 2. A group of PESTs doing the role-play

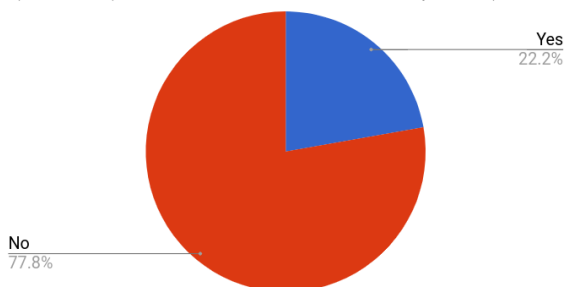
Table 1. Questions from the pre-test and post-test

Item	Topic	Question
1	Extension of plant operating licence	Imagine that you are an MP and you can vote to change laws. The nuclear power plant at Garoña has been operating for 45 years and the permitted lifetime for such plants is 40 years. In order for it to remain operating the law must be changed. Would you be in favour of changing the law and extending the operating lifetime for nuclear power plants to 50 or 60 years?
2	Understanding of nuclear energy	The gas emitted by nuclear power plants is: Air, Helium, No gases emitted, Contaminants
3		What is the process used by nuclear power plants called?

#### 4. Results and discussion

Figures 3, 4 and 5 show the results obtained for the pre-test and post-test for the above 3 questions.

a) Pre - test (PESTs who would extend the nuclear plant life)



b) Post - test (PESTs who would extend the nuclear plant life)

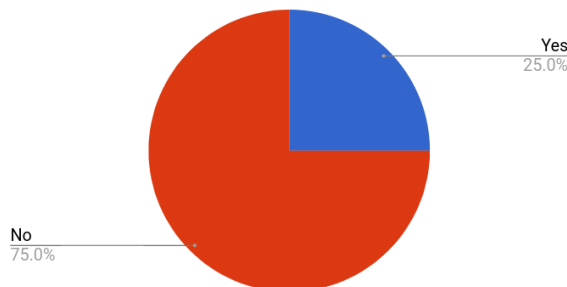




Fig. 3. PESTs who would extend the nuclear plant's operating licence: a) pre-test b) post-test

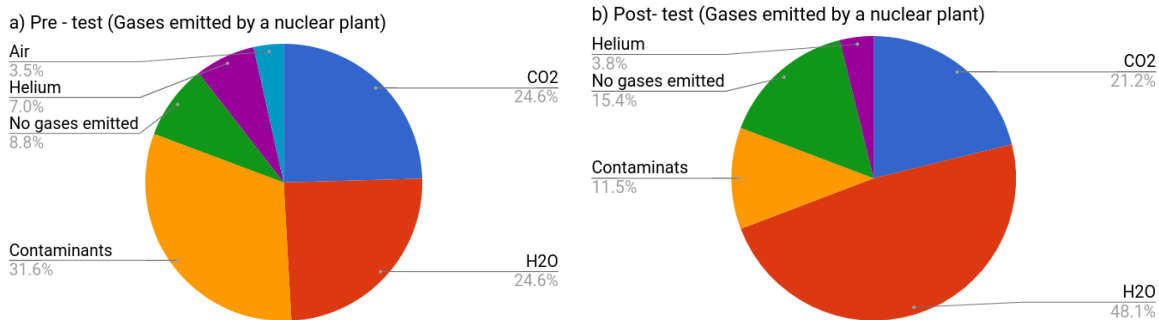


Fig. 4. Understanding of the gases emitted by a nuclear plant: a) pre-test b) post-test

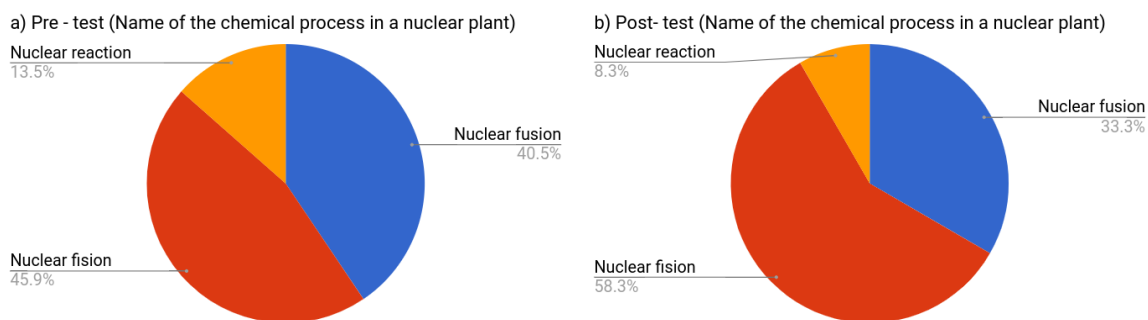


Fig. 5. Name of the chemical process in a nuclear plant: understanding a) pre-test b) post-test

No significant differences are seen between extension of the operating lifetime for the nuclear power plant before and after the role play (figure 3). The majority of students are against extending the lifetime of the plant for reasons such as: *"mainly because there is a high risk of contamination in the long term as a result of waste treatment and the costs involved are extremely high"* or *"I wouldn't change the law to close the plant. A law change would allow the plant to remain open for much longer, which would be detrimental to the health of people living close by"*; whereas those in favour reasoned: *"I think the law should be changed in order to create more employment and help overcome the economic crisis we are suffering"* or *"because we can extend the operating lifetime of this plant and not have to invest in new infrastructures"*.

Upon completion of the game, an improved conceptual understanding that some authors claim to be necessary for understanding by the general public is seen [5]. Role-playing allowed the understanding of some PESTs regarding the gases emitted by nuclear power plants to be improved (figure 4). One of the strongest beliefs concerning the gases emitted by a nuclear power plant is that several different pollutants are emitted (31.6%) compared with 24.6% for CO<sub>2</sub> emissions and 24.6% H<sub>2</sub>O. In the post-test, the percentage of PESTs who thought that various pollutants were emitted decreased to 11.5% and the correct response (H<sub>2</sub>O) increased to 48.1%. For question 3, 45.9% of participants were aware that the chemical process involved is nuclear fission, with this value increasing to 58.3% after the game.

## 5. Conclusions

The role-playing game allowed some concepts concerning nuclear energy to be improved in the absence of an explanatory teaching intervention in this regard. In future studies we intend to analyse how the quality of the argumentation used by PESTs improved by role playing. To that end we will use recordings made during the role-playing session and a series of tests provided to prepare the roles. In light of our experience, we encourage the use of role playing to promote and enhance the skills of PESTs in a collaborative and argumentative manner.



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