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Preservice primary teachers' positions on nuclear power before and after a role play

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ABSTRACT

Role-playing games (RPGs) are considered a useful way of addressing socioscientific issues (SSIs) in the science classroom insofar as they allow learners to engage with an issue and possibly change their opinions on it. This study analyses changes in preservice primary teachers (PPTs) personal positions on nuclear energy following participation in an RPG that simulated a televised debate about the proposal to close nuclear power plants in Spain. The 78 PPTs had to state their position on this issue both before and after the RPG, choosing from among the following three options: (i) immediate closure of nuclear plants, (ii) gradual phasing out of nuclear plants or (iii) continuing indefinitely with nuclear plants. The majority of students were initially against the future use of nuclear energy, but almost half changed their position following the RPG. Students' initial personal position and the extent to which this disagreed with the position they had to defend in role were factors related to opinion change, both in terms of its direction (towards a position more in favour of or more against nuclear power) and its magnitude (abrupt: from one extreme position to the other; or moderate: from the intermediate to an extreme position, or vice-versa). The analysis also showed that students' personal position after the RPG tended to be closer to that of the role they had portrayed. These aspects should be borne in mind when designing RPGs to address SSIs in the science classroom.

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Introduction

The ability to make judgments and decisions about socioscientific issues (SSIs) is considered a necessary prerequisite for the cultivation of scientifically literate citizens (Zeidler et al., 2003). SSIs are controversial, ill-structured social questions and they do not have precise and clear answers (Karakaş, 2022). They have substantive connections to scientific ideas and for which an understanding of science is necessary but not enough to offer complete solutions (Foult et al., 2020), because of SSIs involve a

variety of stakeholders (e.g., scientists, politicians, economists, the general public). Therefore, addressing these issues in an educational context implies taking into account a range of different views.

Role-playing games (RPGs) are considered a particularly useful way of addressing SSIs in the science classroom (Agell et al., 2015) insofar as they allow pupils to learn about an issue by adopting a particular perspective (i.e., the role they are assigned), while simultaneously requiring them to engage with the alternative perspectives, considering the multiple stakeholders related to the issue addressed (Kumnuanek et al., 2022), represented by classmates (Inouye & Kling, 2020). This encourages debate and exposes them to different ideas. The use of RPGs also allows academic content to be aligned with complex scenarios that relate to learners' daily lives (Green & Cassani, 2020), and they are a powerful way of exposing learners to complex decision-making (Powell et al., 2020) and helping them become more sensitive to other points of view (Taplin et al., 2018).

Some authors have also considered how the use of RPGs may facilitate opinion change (Achiam et al., 2021; Simonneaux, 2001). This aspect has not been widely investigated, which is noteworthy given that developing and possibly changing one's opinion is central to the process of making well-informed decisions when negotiating SSIs; importantly, research suggests that many young people show an inadequate understanding of how to make such decisions, particularly in contexts linked to environmental problems (Garrecht et al., 2020). A change of opinion implies that a person has modified their thinking, beliefs or perceptions. According to Archibugi et al. (2021), it is driven by several factors, although the following are particularly relevant: a gain in knowledge through discussion, and exposure to different points of view. In this regard, Simonneaux (2001) suggests that it may be the expression of one's own point of view and the confrontation with opposing arguments that helps students to clarify their thinking.

With respect to the SSI of nuclear energy, a small number of studies have examined preservice teachers' views regarding its use (Ates & Saracoglu, 2016; Cansiz & Cansiz, 2015; Saglam & Eroglu, 2022), and some have analysed changes in students' personal positions on this issue after participating in role-play-based educational activities (Evren & Aycan, 2018; Martini et al., 2021). However, these studies do not include a detailed analysis of the magnitude of any opinion changes, their nature or their relationship to the role adopted by students in the role-play activity, which may or may not be in line with their personal position on the issue. If roles are assigned randomly, it is possible that some students will have to defend a position contrary to their personal position, while others will be defending a position that reflects their own. This raises questions about how and to what extent participation in role-play activities on SSIs, such as the use of nuclear energy, may influence students' personal positions. A greater understanding of these possible influences would be useful for teachers when it comes to designing and planning educational activities of this kind. It is important to note that the aim of such activities is not to encourage students to change their personal view, but rather to create a learning context that allows for the expression of a wide variety of viewpoints and which, through debate, enables students to reach a well-informed position on a given issue (Kolstø, 2000).

In light of the above, it is important, in our view, to develop a better understanding of how the use of RPGs may facilitate opinion change in relation to SSIs, and in particular to identify the factors (both student- and activity-related) that appear to influence this. To this end, the present study examines the position adopted by preservice primary teachers (PPTs) on the SSI of nuclear power, prior to and following their participation in an RPG on this topic. This SSI was chosen due to its importance on the European political agenda and the considerable attention it is attracting within the media (Alderman & Pronczuk, 2022).

Theoretical Framework

RPGs and Decision-Making

In RPGs, which may be defined as a system for creating stories based on rules (Grande de Prado et al., 2020), a group of individuals adopt roles in order to represent a situation in a realistic

way (Avin et al., 2020). According to Hammer et al. (2018), it is through the portrayal of characters that participants in an RPG may come to appreciate and understand the psychological points of view of others and to feel as though what they experience during the game happened to them. Other authors have similarly suggested that role-playing can foster empathy and tolerance towards others by requiring participants to learn about and understand other people's opinions, which in turn encourages them to reflect on their own basic assumptions and prejudices (Belova et al., 2015). Studies have also found that following participation in RPGs, they appear more engaged in class activities and communicate with peers more often (Yang & Guo, 2020).

RPGs would appear, therefore, to be an ideal context for studying decision making and opinion change (Achiam et al., 2021). For a decision to be regarded as well-informed, the process of reaching it should include consideration of contrary opinions and positions (Kolstø, 2000), and this is also something that RPGs allow. Notably, however, few empirical studies have analysed changes of opinion or position following participation in an RPG or similar activity. In one recent study, Martini et al. (2021) reported that around half of students changed their opinion about construction of a nuclear power plant in Indonesia following a classroom debate. For her part, Simonneaux (2001) observed changes of opinion among vocational education students following role-play or debate on the issue of animal transgenesis, whereas such changes had not occurred following other kinds of learning sequences (e.g., visits to exhibitions) in which students had not been asked to discuss issues orally. These findings suggest that RPGs may facilitate a change of opinion in relation to SSIs.

Nuclear Power as an SSI and its Use with Preservice Teachers

The question of how countries should meet their energy needs continues to arouse controversy in discussions around climate change. This is illustrated in the ongoing public debate around the risks and benefits associated with the production and use of nuclear energy, an issue which therefore fulfils the criteria for consideration as an SSI (Herawati & Ardianto, 2017). Notably, one even finds differences of opinion on this issue within the environmental movement, with some against (e.g., Greenpeace, 2023) and others in favour of nuclear power (e.g., Villarreal, 2019). The situation in Europe has been further complicated by the war in Ukraine, which has thrown a spotlight not only on the continent's reliance on Russian gas but also on the supply chain for uranium, forcing governments to ramp up the transition to renewable energy generation and to consider an increased use of coal-fired stations as a near-term option (Harvey, 2022). A related debate here concerns the decision of the European Commission to recognize nuclear energy as green energy until at least 2045 (De Miguel & Abril, 2022), which appears to have divided countries into two blocks, one pro-nuclear (exemplified by France and Finland) and the other (e.g., Spain and Germany) against (Euronews, 2021). Public opinion in Europe also appears to be evenly split on the issue of nuclear power (European Commission, 2009).

Clearly then, nuclear power is an issue underpinned by social dilemmas with conceptual and technological ties to science (Sadler et al., 2004), and hence citizens need to be aware of the science in order to reach well-informed opinions. Achieving this goal requires that teachers are adequately trained to address this SSI with their pupils. Only a small number of studies have specifically examined the issue of nuclear energy with preservice science teachers (primary or secondary). Cansiz and Cansiz (2015) explored the views and knowledge of PPTs, who are not science specialists, about the construction of a nuclear power plant in Turkey, concluding that, in general, they were moderately knowledgeable and held negative opinions on this issue. By contrast, another study in Turkey by Ates and Saracoglu (2016) found that the majority of preservice science teachers were in favour of nuclear energy. In the same vein, Saglam and Eroglu (2022) examined the perspectives of preservice science teachers about the construction and use of nuclear power plants, founding that 68% of them approached it positively, while 21% had a negative perspective. Also in Turkey, Evren and Aycan (2018) analysed the decisions and positions of preservice teachers about whether nuclear power plants should continue to be established in that country. They found that 47% of them changed their position

(in most cases from a position of undecided or in favour of continuation to a position against) following participation in a series of instructional activities related to this SSI.

In our country, Spain, the topic of nuclear energy does not form part of the core primary curriculum (6-12 years) (Ministry of Education and Vocational Training, 2022). However, it is suitable for the cognitive level of undergraduates, as well as being a topic with which the public are familiar via the media (Saad, 2022). Consequently, it may be considered an interesting and challenging SSI to be addressed with PPTs (Atabey & Arslan, 2020; Crujeiras-Pérez et al., 2020; Ozturk & Yilmaz-Tuzun, 2017).

RPGs on Nuclear Power

A number of studies have described the use of role-playing activities in the classroom to address issues related to nuclear energy. For example, Freire et al. (2016) used an RPG about construction of a nuclear power plant with 8th grade pupils (average age 13 years). They concluded that the activity helped to make the topic more relevant for them and that their learning was facilitated through having to search for relevant information to support their assigned position in the RPG. In another more recent study involving PPTs, Crujeiras-Pérez et al. (2020) designed an RPG about the proposed creation of a nuclear waste repository close to the university campus. They found that students in the different roles were able to formulate arguments and justify their reasoning, and also that they made greater use of social and scientific/technological knowledge when attempting to reach a consensus decision.

These experiences demonstrate the suitability of RPGs as a way of addressing the use of nuclear energy as an SSI, although further research is needed on the question of whether – and if so, how – participants' opinions or positions may change as a result of participating in activities of this kind. The present study aims to address this question by analysing the personal position of a sample of PPTs on the future use of nuclear power, prior to and after participating in an RPG about an agreement reached by the Spanish government and the country's major electricity companies to gradually phase out nuclear energy production (RTVE, 2019).

Research Questions

The specific research questions were as follows:

1. What was students' initial position on the future use of nuclear energy prior to participating in the RPG and how did it relate to the position they had to defend in role?
2. Is there a relationship between students' initial position on this issue and a change in their position following the RPG?
3. If students' personal positions on the future use of nuclear power do change as a result of participating in the RPG, what form do these changes take?
4. Are changes in students' personal position related to the position they had to defend in role?
5. Are changes in students' personal position related to whether or not their initial position was in agreement with the one they had to defend in role?

Method

This was a multidimensional, non-experimental study involving pre- and post-test data collection, the analysis of which enabled a quantitative description of tendencies, attitudes, and opinions in the sample (Creswell, 2014).

Participants

Participants were 125 students (age 20-21 years) in their third year of the Bachelor of Primary Education, a four-year degree offered by the University of Málaga. They were distributed across two class groups (A = 69 PPTs, B = 56), both enrolled in the *Teaching Science* module during the 2018-2019 academic year. All these students had studied science during high school up to age 15-16 years, but only a small number had more advanced knowledge (to age 18, immediately prior to entering university). This was therefore a convenience sample, with participants being recruited on the basis of enrolment in the aforementioned course module (Creswell, 2014). For the RPG, each class group was sub-divided in two, with each sub-group performing the same activity. Data collection and analysis therefore corresponds to a total of four RPGs.

Description of the RPG on the Topic of Nuclear Power

The approach used in this study is similar to that described by Crujeiras-Pérez et al. (2020) and consisted of three parts: (i) introduction to the RPG and assigning roles to students; (ii) preparation of roles by students; (iii) performing the RPG.

(i) The first step involved introducing students to the idea of RPGs as a teaching strategy and to the SSI they were going to explore (i.e., the future use of nuclear power). The specific focus for the latter was a news report broadcast on Spanish national television and radio in 2019 (RTVE, 2019) regarding an agreement reached by the government and the country's major electricity companies to gradually phase out nuclear energy production over the period 2025-2035. After being presented with this news item, students were told that they would be performing an RPG designed to simulate a televised debate involving various stakeholders with different positions on the proposal to phase out nuclear power. Towards this end, each of the aforementioned sub-groups was further divided into teams of 2-4 students, with each team being assigned a different role in the debate. At this point, each team was given a role card containing a brief description of the role they would be performing; these cards had been created in advance by teaching staff (the first two authors of this article). They were not given any other information or material apart from the role card, and hence it was left to them to prepare for the RPG by searching for information of relevance to their role. Teams chose one member to act as spokesperson for their assigned role, while the others would act as advisors; the task for advisors was to take notes during the debate, plan debating strategies, and support the spokesperson. The rationale for this approach was to ensure that all students were active participants both in preparing their team's presentation and in the subsequent debate. The RPG was designed to include a total of ten roles. Those in favour of nuclear power plants remaining operational indefinitely were: a government politician, a manager of a nuclear plant, a manager of a nuclear waste repository, a worker from a nuclear plant, and a nuclear scientist. Those against the continued use of nuclear energy were: a renewable energy scientist, a member of the public, an ecologist, a solar energy entrepreneur, and a politician from an opposition party. One team also represented the role of programme presenter, whose position on the issue was neutral.

(ii) Following this introductory session, student teams had one week in which to prepare for the debate. This involved searching for relevant information and listing on a worksheet the arguments they would initially present in the RPG. Students did this preparatory work in their own time outside scheduled classes.

(iii) The RPG itself lasted for approximately one hour and consisted of three parts. First, the spokesperson of each team was given three minutes in which to present their initial arguments and position with respect to the proposed phasing out of nuclear energy. This was followed by a five-minute break in which the spokesperson and advisors of each team prepared counterarguments to the arguments put forward by teams representing other roles. The final

part of the RPG, which lasted around 30 minutes, involved an exchange of counterarguments and rebuttals moderated by the spokesperson of the team representing the programme presenter; in some cases this ended with the programme presenter team summing up the key points raised in the debate.

Data Collection and Analysis

Data were gathered using a survey sheet containing a single closed question that students were asked both before the RPG (pre-test) and afterwards (post-test). The question was: *Do you agree with the proposal to phase out nuclear energy production over the period 2025-2035?* In answering this question, students had to choose one of three response options: (i) *No, I don't agree with the proposal, I think nuclear energy production should continue indefinitely*; (ii) *Yes, I agree with the proposal to phase out nuclear energy production over the period 2025-2035*; or (iii) *No, I don't agree with the proposal, I think nuclear energy production should cease immediately, in 2020*.

Hereinafter, these options will be referred to as: (i) Indefinite (option A), (ii) Short-term 2025-2035 (B), and (iii) Immediately 2020 (C). These options reflect a range of possible positions regarding the proposed phasing out of nuclear energy production, from a position most strongly in favour of nuclear power to a position most strongly against. The option labelled here as Immediately 2020 is similar to the position adopted, among others, by environmental groups in Spain (20 Minutos, 2020), whereas the Indefinite option reflects the view, among others, of those with links to the nuclear industry (Spanish Nuclear Society, 2021). The intermediate option, Short-term 2025-2035, reflects the position expressed in the agreement reached by the Spanish government and the country's major electricity companies (RTVE, 2019). The pre-test survey was administered during the aforementioned introductory session, after presenting students with the news item about the proposed phasing out of nuclear energy production but before explaining the role play activity. Students completed the post-test survey immediately after the role play ended. In both cases, the survey was administered in the classroom and took around 10 minutes to complete. During the duration of the role play activity (including the preparation of roles), students did not receive any additional instruction related to nuclear energy, and neither were there any further news reports related to this issue. Consequently, it is reasonable to assume that any position changes are attributable to their participation in the role play (both the preparatory stage and the subsequent debate in role).

The first step in data analysis involved calculating frequencies and percentages for each response option at both pre-test and post-test. Contingency tables were then constructed, applying either the chi-square or Fisher's exact test, as appropriate, to determine whether there were any statistically significant differences in these descriptive data.

The next step was to establish the level of disagreement, defined as the difference between a student's personal position (reflected in their response to the aforementioned question) and the position they had to defend in role. Here it should be pointed out that the description of roles shown on the role cards that students were given had been worded by the researchers to reflect one of the three possible response options (i.e., it was made clear which of the three positions – A, B or C – would have to be defended in a given role). Thus, for example, if a student who marked option A (Indefinite) to indicate their personal position had to defend in role a position that matched option B (Short-term 2025-2035), this student had a level of disagreement of 1. If a student who marked option A (Indefinite) to indicate their personal position had to defend a position that matched option C (Immediate 2020), then this student had a level of disagreement of 2. If a student's personal position was the same as that of the role they had to portray, the level of disagreement was 0. Having identified the level of disagreement for individual students, the mean level of disagreement was then calculated for each of the roles represented in the debate; the value of this mean ranged from 0 to 2, with values close to 0 and 2 indicating, respectively, a low level and a high level of disagreement between students' personal position and that of the role they had to defend. The analysis of levels of disagreement was conducted for both pre-test and post-test data.

For the analysis of statistically significant differences in these variables, it was first necessary to test whether the data were normally distributed. Because the sample included more than 50 cases, this was done using the Kolmogorov-Smirnov test, which indicated that the data did not follow a normal distribution. Consequently, two non-parametric tests were applied: the Wilcoxon signed-rank test for related samples (pre-test vs. post-test) and the Mann-Whitney U test to compare independent samples (differences between the different roles and between the groups of roles in favour vs. against the continuation of nuclear power). In the case of contingency tables of qualitative variables, the chi-square (χ^2) test was used to detect the possible existence of statistically significant differences, which if identified were interpreted by calculating adjusted standardised residuals (ASR). An ASR value greater than 1.96 indicates that the cell of a contingency table contains more cases than expected under the hypothesis of independence of variables, whereas a value below -1.96 indicates that it contains fewer cases than expected under this hypothesis. The level of significance was set at 0.05 for all tests. The effect size (ES) was also calculated to determine the magnitude of any statistical differences, using the Phi (ϕ -ES) method in the case of double-entry tables and Cramer's V (V-ES) for tables larger than 2x2 (Rivera, 2017). Effect sizes were interpreted as follows: small ($0.10 \leq ES < 0.30$), medium ($0.30 \leq ES < 0.50$) or large ($ES \geq 0.50$) (Cohen, 1998). In the case of Fisher's exact test for 2x2 tables, the ES was calculated based on the odds ratio (OR), whose value ranges from zero to infinity and which is interpreted as follows: negative association ($OR < 1$), no association ($OR = 1$) or positive association ($OR > 1$). The further the OR value moves away from 1, the greater the strength of the association. The ES for the Wilcoxon signed-rank and Mann-Whitney U tests were calculated using the expression z/\sqrt{N} (Pallant, 2011). The analysis of results described in the next section is based on the responses of the 78 PPTs who indicated their personal position on the issue of nuclear power at both pre-test and post-test (i.e., prior to and following participation in the RPG).

Results

The presentation of results follows the order of the research questions (RQs).

RQ1: What Was Students' Initial Position on the Future Use of Nuclear Energy prior to Participating in the RPG and How Did It Relate to the Position They Had to Defend in Role?

Prior to participating in the RPG, 8 PPTs (10.2%) were in favour of nuclear power plants remaining operational indefinitely, 35 PPTs (44.9%) were in favour of phasing out nuclear power in the short term, and 35 PPTs (44.9%) were in favour of immediately ceasing nuclear energy production. These results indicate that the large majority of students (89.8%) were initially in favour of either phasing out or immediately ceasing nuclear energy production, and hence they started from a personal position that was inclined to be against the future use of nuclear power.

Regarding the role assigned to the PPTs, Table 1 shows the number of students whose initial personal position agreed or disagreed with the one they had to defend in role, categorised according to whether this role was in favour of or against the future use of nuclear power.

Table 1*Distribution of Students according to Their Initial Personal Position and That of the Role They Portrayed*

	Role in favour of nuclear power		Role against nuclear power		Total	
	n	%	n	%	n	%
PPTs whose initial personal position agreed with that of their role	7	9.6	13	17.8	20	27.4
PPTs whose initial personal position disagreed with that of their role	37	50.7	16	21.9	53	72.6

Note. Fisher's exact test for Table 1: $p = .014$; OR = .238; N = 73 (the role of programme presenter was not taken into account).

The majority of students (72.6%) had to defend in role a position that disagreed with their own personal position on the issue of nuclear power (either for or against its future use). Disagreement was especially marked among students whose role required them to argue in favour of nuclear power plants remaining operational indefinitely (50.7% of whom held an opposing personal view). When students' personal position agreed with that of the role they were assigned, the pattern of results was different, insofar as agreement was more likely to involve positions against the continuation of nuclear power (17.8% of students). These differences are statistically significant (Table 1).

RQ2: Is there a Relationship between Students' Initial Position on this Issue and a Change in their Position Following the RPG?

Table 2 shows the number of PPTs who changed or maintained their initial position according to what that personal position was.

Table 2*Change in Students' Personal Position Following the RPG According to What Their Initial Position Was*

		Change of personal position			
		Yes		No	
Personal position at pre-test	Indefinite	n	%	n	%
	Short-term 2025-2035	7	87.5	1	12.5
	Immediately 2020	10	28.6	25	71.4
	Immediately 2020	19	54.3	16	45.7
Total		36	46.2	42	53.8

Note. Chi-square test for Table 2: $\chi^2 = 10.788$; $p = .0045$; Cramer's V-ES = .372; N = 78. Percentages per row.

It can be seen in the table that almost half of the PPTs (46.2%) changed their personal position on the future use of nuclear power following participation in the RPG. Notably, all but one of the students (87.5%) who were initially in favour of nuclear power plants remaining operational *indefinitely* changed their opinion following the RPG. Among those who initially considered that nuclear energy production should cease *immediately* or in the *short-term*, the proportion who changed their position following the RPG was 54.3% and 28.6%, respectively. Further analysis showed that the proportion of students who changed their position following the RPG differed significantly depending on what their initial position was. These significant differences were due to the higher number of changes among PPTs who initially chose the *Indefinitely* option (ASR = 2.5) and the smaller number of changes among those who initially chose the *Short-term* option (ASR = -2.8). In all the cases the effect sizes were medi-

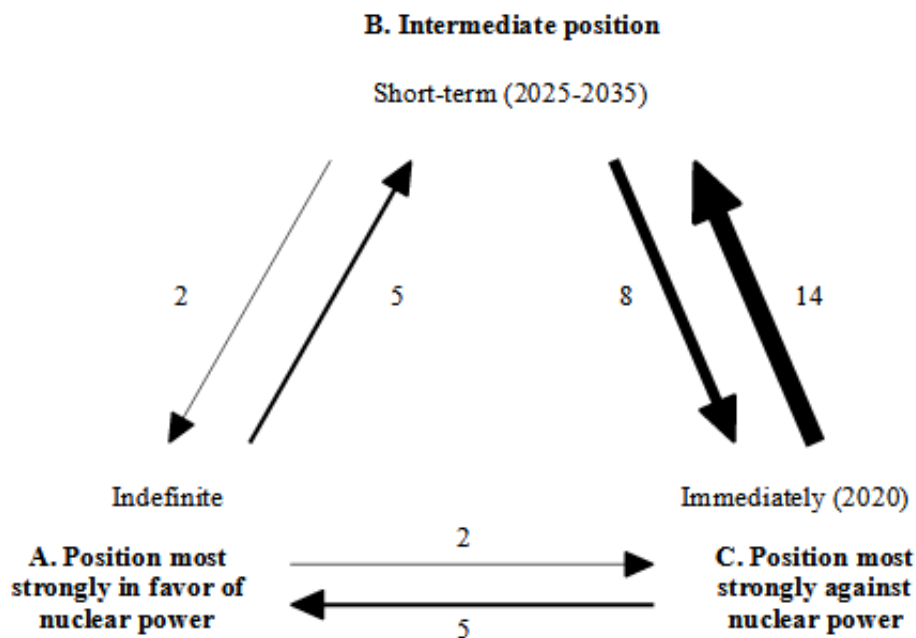
um. Overall, these results suggest that students' initial position on the issue of nuclear energy production was a factor in whether or not they changed their position following the RPG.

RQ3: If Students' Personal Positions on the Future Use of Nuclear Power do Change as a Result of Participating in the RPG, What Form Do these Changes Take?

By examining students' responses to the question they were asked before and after participating in the RPG (i.e., which of the three response options they endorsed at the two time points), it is possible to distinguish two concomitant qualities of position changes. One concerns the magnitude of change (referred to below as either moderate or abrupt), while the other refers to the direction of change (towards a position more in favour of or more against the future use of nuclear power). The results obtained when analysing these two aspects are described below and are summarised graphically in Figure 1.

Figure 1

Diagram Showing the Different Types of Position Change



- Moderate changes of position: a change from an extreme position (A or C) to the intermediate one (B), or vice-versa. The majority of position changes observed were of this kind (29 PPTs), and they can be further sub-divided as follows:
 - Moderate change towards a position more strongly against the future use of nuclear power: change from position A to B (five PPTs), or from B to C (eight PPTs). Both these changes imply a shift of opinion toward reducing the period of time in which nuclear power plants remain operational.
 - Moderate change towards a position more in favour of nuclear power: change from position C to B (14 PPTs), or from B to A (two PPTs). Both these changes imply a shift of opinion toward extending the period of time in which nuclear power plants remain operational.
- Abrupt changes of position: a change from one extreme position to the other (A to C, or C to A). There were fewer changes of this kind (seven PPTs), and they can be further sub-divided as follows:

- Abrupt change towards a position more against nuclear power: two PPTs who initially thought nuclear power plants should remain operational indefinitely changed their opinion to one in favour of immediate closure (position A to C).
- Abrupt change towards a position more in favour of nuclear power: five PPTs who initially thought nuclear power plants should be closed immediately changed their opinion to one in favour of their remaining operational indefinitely (position C to A).

These results show that position changes following participation in the RPG were mostly of moderate magnitude and that changes of this kind tended to imply a shift towards a more favourable view of nuclear energy production. The chi-square test revealed no significant differences when analysing the direction of change (i.e., towards a position more in favour or more against) according to the magnitude of change (moderate or abrupt).

RQ4: Are Changes in Students' Personal Position Related to the Position They Had to Defend in Role?

The possible effect of role on position change may be examined by analysing changes in personal position according to the position that students had to defend in role. The results are shown in Table 3.

Table 3

Changes in Personal Position Following the RPG According To the Role That Students Portrayed

Position of the role with respect the future use of nuclear power	Role (n)	Position of the role in terms of the three possible positions	Total number of changes		Change to position more against		Change to position more in favour		Abrupt changes		Moderate changes	
			n	%	n	%	n	%	n	%	n	%
Against	E (8)	Immediate (C)	5	62.5	3	37.5	2	25.0	1	12.5	4	50.0
	SE (5)	Immediate (C)	1	20.0	1	20.0	0	0.0	0	0.0	1	20.0
	RS (8)	Short-term (B)	3	37.5	1	12.5	2	25.0	0	0.0	3	37.5
	P (6)	Short-term (B)	1	16.7	1	16.7	0	0.0	0	0.0	1	16.7
	PO (2)	Short-term (B)	1	50.0	0	0.0	1	50.0	0	0.0	1	50.0
Total (29)			11	37.9	6	20.7	5	17.2	1	3.5	10	34.5
For	NS (8)	Indefinite (A)	5	62.5	1	12.5	4	50.0	1	12.5	4	50.0
	GP (13)	Indefinite (A)	9	69.2	3	23.1	6	46.2	3	23.1	6	46.2
	WRM (10)	Indefinite (A)	5	50.0	3	30.0	2	20.0	0	0.0	5	50.0
	NPM (8)	Indefinite (A)	4	50.0	1	12.5	3	37.5	1	12.5	3	37.5
	W (5)	Indefinite (A)	2	40.0	1	20.0	1	20.0	1	20.0	1	20.0
Total (44)			25	56.8	9	20.5	16	36.4	6	13.6	19	43.2
Neutral	P (5)	Neutral	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

Note. The roles were as follows: E = ecologist; SE = solar energy entrepreneur; RS = renewable energy scientist; P = member of the public; PO = politician from the opposition; NS = nuclear scientist; GP = government politician; WRM = nuclear waste repository manager; NPM = manager of a nuclear plant; W = worker from a nuclear plant.

A change of personal position was observed among students in each of the roles, although to varying degrees. It was most common among students who had been assigned to the pro-nuclear role of government politician (69.2% changed their position following the RPG), and least common among those who portrayed a member of the public who was in favour of phasing out nuclear power in the short term (16.7% of students). It should also be noted that none of the five students in the (neutral) role of programme presenter changed their personal position following the RPG. Comparison of the two broad groups of roles (i.e., in favour of vs. against the future use of nuclear power) showed that the mean proportion of position changes was higher among students who represented one of the pro-nuclear roles (56.8% changed their position, compared with 37.9% of students in a more anti-nuclear role), although the proportions of position change by role varied more widely in the anti-nuclear group (from 16.7% of students who portrayed a member of the public to 62.5% of those in the role of ecologist; see Table 3). However, there were no statistically significant differences in the frequency of position changes according to the role portrayed (in favour of vs. against the future use of nuclear power), the magnitude of position changes (moderate or abrupt) or the direction of change (towards a position more in favour of or more against the future use of nuclear power).

Although the role itself does not appear to be a determining factor in whether or not students changed their personal position, a further analysis was conducted to examine whether the level of disagreement between students' personal position and the position they had to defend in role was a relevant factor.

RQ5: Are Changes in Students' Personal Position Related to whether or not their Initial Position Was in Agreement with the One They Had to Defend in Role?

The main focus of interest here was to determine whether the level of disagreement between students' initial position and the position associated with their role was a factor influencing opinion change and the form that this change took. The analysis also examines the mean level of disagreement between the position defended by students in role and their initial personal position at both pre-test and post-test

Influence of the Level of Disagreement on Opinion Change

Table 4 shows the number of students who changed or did not change their personal position following the RPG, according to the level of disagreement between their initial position and the position they had to defend in role.

Table 4

Changes of Position Following the RPG According to the Level of Disagreement Between Students' Initial Personal Position and the Position They Had to Defend in Role

Level of disagreement between students' initial personal position and the position they had to defend in role	Change of personal position	
	No	Yes
Level 0	10	10
Level 1	20	11
Level 2	7	15

Note. Chi-square test for Table 2: $\chi^2 = 5.509$; $p = .064$. Fisher's exact test for levels 1 and 2 ($p = .027$; OR = 3.790). $N = 73$ (the role of program presenter was not taken into account).

It can be seen in the table that there is no clear relationship between the level of disagreement at pre-test and a change of position after the RPG, and there were no significant differences when considering the three levels as a whole (chi-square test). However, Fisher's test indicated that the proportion of students who changed their position after the RPG was significantly higher for level 2 in comparison with level 1.

Influence of Level of Disagreement on the Form that Change Took

Table 5 shows the results obtained when analysing the magnitude (moderate or abrupt) and direction of position changes (more in favour of vs. more against the future use of nuclear power) according to the level of disagreement between students' initial position and the position they had to defend in role.

Table 5

Types of Position Change According to the Level of Disagreement between Students' Initial Personal Position and the Position They Had To Defend in Role

Level of disagreement between students' initial position and the position they had to defend in role	Type of change			
	Moderate		Abrupt	
	More against	More in favour	More against	More in favour
Level 0	7	2	1	0
Level 1	6	14	0	0
Level 2	0	0	1	5

Note. Fisher's exact test for Table 5: ($p = .000$; OR = null). N = 36 (only the PPTs who changed their position).

Given the significant differences between levels in the types of position change, separate analyses of the relationship between levels of disagreement and each of the two aspects of position change were conducted: direction (more in favour of vs. more against the future use of nuclear power) and magnitude (moderate or abrupt).

The statistically significant differences shown in Table 6 indicate that the proportion of students whose opinion shifted in the anti-nuclear direction was significantly greater among those whose initial position agreed with that of their role (level 0), as compared with students whose initial position disagreed with that of their role (levels 1 and 2).

Table 6

Direction of Position Change According to the Level of Disagreement Between Students' Initial Personal Position and the Position They Had To Defend in Role

Level of disagreement between students' initial position and the position they had to defend in role	Direction of change	
	More against	More in favour
Level 0	8	2
Level 1	6	14
Level 2	1	5

Note. Fisher's exact test for Table 6: ($p = .016$; OR = null). Fisher's exact test for levels 1 and 2 ($p = .019$; OR = 8.568); levels 0 and 2 ($p = .035$; OR = 15.469). N = 36 (only the PPTs who changed their position).

With respect to the magnitude of position changes (Table 7), Fisher's exact test again showed significant differences. These results indicate that the proportion of abrupt changes of opinion was significantly greater among students whose initial position disagreed most strongly with that of the role they portrayed (level 2), as compared with students whose initial view was closer to that of their role (levels 0 and 1).

Table 7

Magnitude of Position Change According to the Level of Disagreement between Students' Initial Personal Position and the Position They Had to Defend in Role

Level of disagreement between students' initial position and the position they had to defend in role	Magnitude of change	
	Moderate	Abrupt
Level 0	9	1
Level 1	20	0
Level 2	0	6

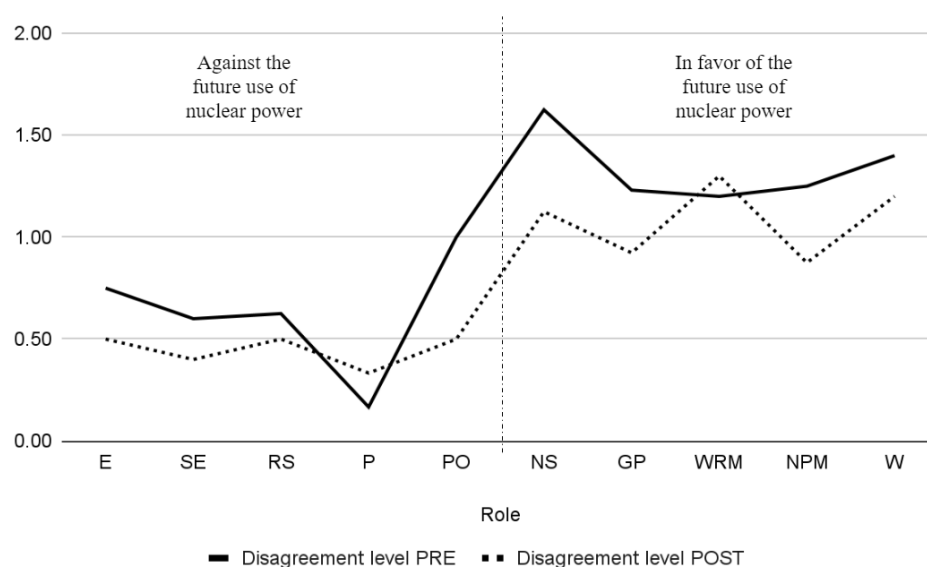
Note. Fisher's exact test for table 7: ($p = .000$; OR = null). Fisher's exact test for levels 0 and 2 ($p = .000$; OR = infinity); levels 1 and 2 ($p = .000$; OR = infinity). $N = 36$ (only the PPTs who changed their position).

Mean Level of Disagreement between the Position Defended by Students in Role and their Initial Personal Position

Figure 2 displays the results obtained when analysing the mean level of disagreement between students' initial personal position and the position defended in role, at both pre-test and post-test levels. In the figure, the roles are organised into two broad groups: against vs. in favour of the future use of nuclear power.

Figure 2

Mean Level of Disagreement between the Position Defended By Students in Role and Their Initial Personal Position, at Both Pre-Test and Post-Test



Note. Wilcoxon signed-rank test by role: $Z = -2.398$; $p = .019$; $ES = .855$). Mann-Whitney U test by role: pre-test ($Z = -2.611$; $p = .009$; $ES = 1$); post-test ($Z = -2.643$; $p = .008$; $ES = 1$). $N = 73$.

It can be seen in Figure 2 that with the exception of two roles (P, corresponding to a member of the public in favour of phasing out nuclear energy production in the short term; and WRM, a nuclear waste repository manager in favour of nuclear power plants remaining operational indefinitely), the degree of disagreement between students' personal position and the position they had to defend in role was lower at post-test (after the RPG) than at pre-test. The Wilcoxon signed-rank test showed significant differences between pre-test and post-test, with a large effect size, indicating a significant decrease in the level of disagreement. This suggests that after participating in the RPG, students' personal position tended to move closer to that of the role they had portrayed.

Analysis of the level of disagreement in each of the two broad groups (i.e., roles in favour of vs. against the future use of nuclear power) also revealed significant differences, with a large effect size, at both pre-test and post-test. In both cases, the level of disagreement was lower for the group of anti-nuclear roles. These results indicate that the level of disagreement between students' personal position and the position associated with their role was greater at both pre-test and post-test when the role implied arguing in favour of the future use of nuclear power.

Discussion

The large majority of PPTs who took part in this study were initially in favour of either phasing out or immediately ceasing nuclear energy production, and hence they started from a personal position that was against the continued use of nuclear power. This view is consistent with the findings of sociological surveys conducted over the past decade in the Spanish general population (Martínez, 2017). With respect to other studies involving PPTs, this initial profile of opinion is similar to that reported by Cansiz and Cansiz (2015) and Evren and Aycan (2018), but they are not in line with the results described by Ates and Saracoglu (2016), who found that the majority of preservice science teachers were in favour of nuclear energy, and by Saglam and Eroglu (2022), who reported that most of them positively approached the construction and use of nuclear power plants.

Almost half of our participants (46%) changed their personal position on nuclear power following the RPG, supporting the view of Simonneaux (2001) that the use of role play may facilitate opinion change among students. The proportion of PPTs who changed their personal position is also similar to that reported in other studies focusing on the issue of nuclear energy: 42% of students in the study by Martini et al. (2021) and 47% in that by Evren and Aycan (2018). These results, together with our own, suggest that debate and role play on the issue of nuclear power can lead a considerable proportion of students to revise their opinions. As to why RPGs of the kind used here may facilitate opinion change, possible factors include exposure to different points of view (Herawati & Ardianto, 2017), the possibility of discussing issues orally (Simonneaux, 2001), and becoming better informed through access to new information (Martini et al., 2021). In this regard, it is worth noting that the majority of students in the present study had to defend in role a position that disagreed with their own personal position, and this disagreement was especially marked among students whose role required them to argue in favour of nuclear power plants remaining operational indefinitely.

When analysing changes in personal position that occurred following participation in the RPG, two concomitant qualities of opinion change were identified: one concerns the direction of change (i.e., towards a position more in favour of or more against the future use of nuclear power), while the other refers to the magnitude of change (moderate or abrupt). In terms of the direction of change, no clear trend was observed, which was also the case for the preservice science teachers in the study by Evren and Aycan (2018). However, with regard to the magnitude of change, and in line with the results of Evren and Aycan (2018), it was found that when students can express their position across a range of three options, a change of opinion is more likely to be moderate than abrupt (80.6% of changes in our study were moderate, compared with 75% in Evren and Aycan, 2018).

In addition to analysing the magnitude and direction of position changes, the present study also sought to identify factors associated with these changes. The specific focus here was on the possi-

ble influence of the role that students had to portray in the RPG, their initial personal position on the issue of nuclear power, and the interaction between these two variables. The results showed that students' initial position on this issue was a factor in whether or not their view changed after the RPG, insofar as position changes were proportionally more common when students started from one of the two extreme positions (i.e., in favour of the immediate closure of nuclear plants or of continuing indefinitely with nuclear power). Notably, all but one of the students who were initially in favour of nuclear power plants remaining operational indefinitely changed their position following the RPG. By contrast, the role that students had to portray did not appear to be a factor in whether or not they changed their position, although the analysis did suggest that their personal position after the RPG was closer to that of their role. This trend was observed for all but two of the ten roles that featured in the RPG, and did not depend on the position of the role with respect to the issue of nuclear power (i.e., in favour of or against its future use).

The results also showed that although the level of disagreement between students' initial position and that of the role they had to defend was not related to the overall proportion of position changes after the RPG, it was a factor in the magnitude of change (moderate or abrupt) and its direction (towards a position more in favour of vs. more against the future use of nuclear power). In general, and as Hammer et al. (2018) argue, the portrayal of characters encourages participants in a role-play to engage with and understand other points of view, and having to defend a certain position on an issue means that students must gather evidence to support it (building arguments, counterarguments, and refutations), as a result of which their own personal view may in the process move closer to that of the role they portrayed. Simonneaux (2001) has similarly hypothesised that a change of mind may be linked with the fact of acting out a part in a role-play. Our results here add nuance to this hypothesis, insofar as they suggest that opinion change results not from role-play per se but rather from there being some degree of disagreement between a student's initial position on an issue and that of the role portrayed.

Conclusions and Implications

The RPG described in this study enabled us to address the issue of nuclear power and its future use with two class groups of PPTs. With respect to the research questions examined, the following conclusions may be drawn:

1. Regarding research question 1, the large majority of students were initially against the future use of nuclear power, and most of them had to defend in role a position that disagreed with their own personal position on this issue. This was especially marked among students whose role required them to argue in favour of nuclear power plants remaining operational indefinitely.
2. Regarding research question 2, almost half of the PPTs changed their personal position on the future use of nuclear power following participation in the RPG. Furthermore, students' initial position was a factor in whether or not their view changed after the RPG, insofar as position changes were proportionally more common among those who started from one of the two extreme positions (in favour of the immediate closure of nuclear plants or of continuing indefinitely with nuclear power).
3. Regarding research question 3, both moderate and abrupt changes of opinion were observed, towards positions both more in favour of and more against the continued use of nuclear power. The majority of changes were moderate in magnitude, regardless of the direction of change.
4. Regarding research question 4, the role that students portrayed was not in itself a factor in whether or not they changed their personal position, although more changes of opinion were observed among those whose role required them to argue in favour of nuclear power.

5. Regarding research question 5, students' initial personal position and the extent to which this disagreed with the position they had to defend in role were factors related to changes of position, both in terms of their direction (towards a position more in favour of vs. more against nuclear power) and their magnitude (abrupt or moderate). Specifically, the majority of students whose initial personal position disagreed most strongly with that of the role they portrayed changed their position after the RPG; the proportion of students whose opinion shifted in the anti-nuclear direction was significantly greater among those whose initial position agreed with that of their role, as compared with students whose initial position disagreed with that of their role; and the proportion of abrupt changes of opinion was significantly greater among students whose initial position disagreed most strongly with that of the role they portrayed, whereas moderate changes of position were more common when students' own view was closer to that of their role. Finally, students' personal position after the RPG tended to be closer to that of the role they had portrayed.

The results of this research have both theoretical and practical implications. Regarding the former, the findings help to shed light on two aspects of opinion change following role-play that have not so far been analysed in depth in the literature, namely whether a change of view is influenced by students' initial position on an issue, and how opinion change is influenced by the level of disagreement between students' initial position and that of the role they are asked to portray. A key factor that brought greater nuance to the data in this respect was the fact that three possible positions on the issue being addressed were established, with students being asked to indicate both before and after the RPG the position that reflected their own; importantly, the role that each student was assigned in the RPG corresponded to one of the same three positions, and hence it could agree or disagree (to different degrees) with the student's personal view. On a practical level, the present study has employed a novel method of analysis that was able to identify the magnitude of opinion changes, their nature, and their relationship to the role adopted by students in the role play.

Recommendations and Suggestions

One aspect of the method used in the present study that we would recommend retaining in future research of this kind is to ensure that at least three different positions on an SSI are reflected in a role-play activity, as this can provide insight into the magnitude of any opinion changes among participants. However, although the method used enabled us to analyse changes in students' personal position following the RPG, and to examine the influence of the role they had to portray, the results tell us nothing about why these changes might have occurred. Consequently, the present analysis needs to be complemented by exploration of the types of reasoning that students employ to justify their initial and final position on the issue, in line with the approach described by other authors such as Simonneaux (2001) and Evren and Aycan (2018).

Finally, our results and conclusions derive from the use of an RPG to explore a specific SSI, namely the future of nuclear power, and it is possible that the nature of this issue and students' initial positions on it shaped the extent and/or kind of opinion change observed. The findings therefore need to be corroborated by further research involving different SSIs. It would also be useful to conduct studies on the same SSI in other countries, given that public opinion on the question of nuclear power is known to vary across national borders (European Commission, 2009).

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Declaration of Interests Statement

The authors declare no conflict of interests in relation to this study.

Ethical Statement

The University of Málaga did not have specific protocols for this type of studies when this research was carried out. Nevertheless, the participants were informed that their data would be treated exclusively for research purposes, and that it would be impossible to identify them in the publications derived from the study.

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