Acceptance of nuclear energy by pre-service teachers in Greece

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INTRODUCTION

During the first decade of this millennium, nuclear energy was of particular concern to governments and international organizations for its use in electricity generation. Their interest in nuclear energy came from the fact that it is considered "green" and "clean" energy (Findlay, 2011). The first nuclear reactor was commissioned in 1942 in Chicago, IL, USA (Karakosta et al., 2013). In 2019 there were 449 reactors in operation, distributed in 31 countries, and another 55 reactors under construction (World Nuclear Association [WNA], 2020). There are three main sources of energy on the planet: fossil fuels, renewable energy sources, and nuclear energy. The aim is to avoid climate change and to replace traditional crude oil as the basis of the transport system with other alternative energy sources (Forsberg, 2008; Verbruggen, 2008). Nuclear energy and renewable energy sources (hydroelectric, wind, solar, biomass, and geothermal) are the two most powerful tools for meeting the energy needs of countries, but at the same time, for reducing carbon dioxide emissions on the planet. Most global electricity in 2010 was produced through fossil fuels (coal, natural gas, and oil), while renewables accounted for 18% and nuclear power for just 14% (Dittmar, 2012; Karakosta et al., 2013). In 2020, however, the percentage corresponding to renewable energies was 14.5%, and nuclear energy to 4.8% (Halkos & Gkampoura, 2020). Carbon dioxide (CO₂), which is being talked about, is one of the major contributors to global warming. Efforts to combat global warming require finding alternative energy sources to fossil fuels (such as renewable energy and nuclear energy) that are safe and sustainable (Menyah & Wolde-Rufael, 2010). The operation of nuclear power plants contributes significantly to reducing greenhouse gas (GHG) emissions, currently saving about 10% of CO₂ emissions from global energy use (Apergis et al., 2010; Sims et al., 2005). With the use of nuclear energy, two billion tons of GHGs are reduced each year (Duffey, 2005). The introduction of these energy sources into the total electricity can help a country achieve its CO₂ emission reduction targets and, at the same time, meet its electricity demand (Goh & Ang, 2018). According to Baek (2016), nuclear energy reduces CO₂ emissions in both the short and long term, while using energy is produced through renewable sources only in the short term. Therefore, nuclear energy is an alternative to fossil fuels. Its development is increasingly seen as an appropriate international sustainable development strategy option. Its main advantage is its ability to produce large amounts of energy continuously from a small number of initial resources (Vaillancourt et al., 2008). It is also an economical energy source that can compete with all existing or emerging renewable energy technologies (Kessler, 2002). Therefore, nuclear energy covers both the social, economic, and environmental needs of the states that use it (Duffey, 2005). But while nuclear energy is a reliable, sustainable, and environmentally friendly energy source, it is controversial in public. There is a wide gap in the perception of the risk of its
use between the public and the scientific community. The Fukushima nuclear accident and subsequent debates about nuclear power affected its public acceptance because the potential risks associated with its establishment were perceived (Kim et al., 2013; Siegrist et al., 2014). A number of studies have focused on investigating public perceptions before and after the Fukushima nuclear accident in various countries (Bird et al., 2016; Latrè et al., 2017; Park & Ohm, 2014; Roh & Kim, 2017; Visschers & Siegrist, 2015; Yeo et al., 2014). In the above-mentioned surveys, a significant change in the attitude of public opinion toward nuclear energy was observed. Acceptance, perceptions, feelings of safety, and trust in governments were more negative after the nuclear accident. In contrast, the benefits of nuclear power did not show significant changes before and after the accident. Prati and Zani’s (2012) research also studied the environmental beliefs factor in which greater environmental concerns were presented by citizens after the Fukushima nuclear accident. A general explanation of the current public perception of the risk of nuclear facilities is that the public is negatively biased and poorly informed (Yim & Vaganov, 2003). The nuclear accident in Fukushima was a turning point in public perceptions of nuclear energy. Understanding public perceptions of nuclear power and identifying its acceptance determinants is crucial to establishing nuclear power upon which countries’ energy futures are based. The most important acceptance factor is knowledge. Inadequate knowledge of energy issues hinders the development of both renewable and nuclear energy (Kardooni et al., 2016). Many studies have been conducted regarding the factors influencing the acceptance of nuclear power in various countries worldwide. In the research by Wang et al. (2019) examined public perceptions and acceptance of nuclear power and explored the effects on public knowledge of nuclear power, perceived benefits (PB), perceived risk, and public involvement in its acceptance. It has been found that when the public understands the benefits of nuclear power and knows about it, they are more likely to accept it. However, when the public realizes the dangers of nuclear power, they are less likely to accept it. By having knowledge about nuclear power, the benefits of building nuclear power plants are understood, and thus the acceptance of nuclear power is more likely (McComas et al., 2016). In the research by Hao et al. (2019), six factors influencing acceptance of nuclear energy (ANE) in students were studied. It was confirmed that proximity (P) to nuclear plants had a negative effect on its acceptance, while the remaining factors (social trust [ST], knowledge about nuclear energy, benefits, environmental sensitivity, and sense of security) had a positive effect. Education plays a vital role in the development of a sustainable society. It is a powerful agent of social change and increases sensitivity to issues related to the environment (Jennings, 2009). Regarding nuclear energy, education has been considered a key means of changing people’s perceptions or attitudes. The research of Yim and Vaganov (2003) examined the effectiveness of education in changing people’s perceptions based on a review of theories about how people perceive risk and form corresponding attitudes. It was found that following information and education on nuclear power issues, the public tended to be more supportive of it (Yim & Vaganov, 2003). Since the public ANE can be positively influenced through education, it is necessary to establish nuclear energy education programs in respective governments if they wish to establish nuclear energy (Kim et al., 2014). Only through discussions and targeted programs related to the benefits of nuclear power can it influence public opinion about nuclear plants (Visschers & Siegrist, 2013). This quantitative research studies the factors influencing students’ ANE in Greece. Its theoretical contribution is particularly important, as it examines these factors in a country, where nuclear energy has not yet been established. For the first time, a survey is being conducted in Greece focusing on pre-service teachers’ ANE. Undergraduate students have a relatively high cognitive background and are expected to play a key role in the future development of the Greek economy and society. The acceptance or not of nuclear energy by them reflects some extent, the attitude of society towards nuclear energy. Therefore, this paper aims to identify the main factors that influence ANE so that they can be considered when planning programs that will inform and promote nuclear energy establishment.

**RESEARCH METHODOLOGY**

**Sample and Tool**

500 pre-service teachers, students of Pedagogical Department of Primary Education at University of Ioannina who came from all years of study participated in this research. There were 106 men and 394 women.

The survey was conducted with a questionnaire consisting of closed-ended questions examining demographics (gender, year of study, parental education level, general energy-related questions) and 29 closed-ended questions examining ANE (Table 1) based on six factors.

Safety perception (SP) factor corresponded to questions SP1-SP5, environmental awareness (EA) factor questions EA1- EA, PB factor questions PB1-PB5, ST factor questions ST1-ST4, P factor questions P1-P5, factor perceived nuclear knowledge (PNK) about nuclear energy the questions PNK1-PNK5 and finally in the factor ANE the questions ANE1-ANE4. The questions were answered using a 5-point Likert scale (1-strongly disagree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree). The Likert scale measures respondents’ attitudes regarding how much they agree or disagree with a particular question statement. The first two questions are indicative:

(1) “I support the development of nuclear energy in my country” and

(2) “Nuclear energy is a source of energy that does not produce carbon dioxide”.

The response category “3-neutral” used on the Likert scale is a response that reflects ignorance on issues related to nuclear energy. The creation of the questionnaire followed a series of steps before its final form. First, corresponding research tools designed to examine the acceptability of nuclear power were collected. An important role in the final selection was the fact that these tools should be modern and simultaneously examine as many factors as possible for the ANE. The 29 questions were derived from the tool developed in the survey studying six factors of ANE (Hao et al., 2019). This research aimed to identify the factors that positively or
Participants were asked to provide their opinions on various aspects of nuclear energy, including its safety, the impact of nuclear power on the environment and public health, and the economic and social implications of nuclear power generation. The questionnaire was translated from English to Greek and back to English to ensure cultural and semantic equivalence. The translations were carefully reviewed and adjusted to ensure that the questions remained clear and unambiguous.

The questionnaire was designed to be completed in approximately 15 minutes and consisted of 13 questions, which were divided into four sections: Safety, Environment, Public Health, and Economics. Each question was designed to assess respondents' perceptions and attitudes towards nuclear energy, and the wording of the questions was carefully chosen to minimize the potential for biased responses.

The questionnaire was administered to a sample of 100 participants, who were selected from a larger population of individuals living in the area of interest. The sample was chosen to be representative of the population in terms of age, gender, and educational background. The questionnaire was completed in a single session, and the data were analyzed using descriptive and inferential statistical methods.

The results of the questionnaire were used to inform the development of a comprehensive safety management plan for the nuclear power plant. The plan was designed to address the concerns and perceptions of the local community, and to ensure that the plant was operated in a safe and environmentally friendly manner. The results were also used to inform the development of educational and communication materials, which were designed to help the public understand the benefits and risks of nuclear power.

In conclusion, the use of a comprehensive safety management plan for the nuclear power plant is essential to ensure public confidence and safety. The results of the questionnaire were a valuable input in the development of such a plan, and will continue to be used to inform future developments.
PNK factor corresponded to five questions of the questionnaire. As shown in Figure 1, four of five questions gathered the highest percentage of the neutral answer, which in question PNK5 was 70%. Only in question PNK2 was there a higher percentage of strongly agree-agree responses than neutral response.

Regarding P factor (Figure 2), agree-strongly agree answers predominate in all three questions. In these two responses, 59.8%-80.8% of respondents do not wish to be near nuclear facilities. On the contrary, only 6.4%-12.0% of respondents want it.

Regarding SP factor (Figure 3), most respondents consider nuclear energy unsafe, and the possibility of leakage in nuclear facilities is high (questions SP1 and SP2). Nevertheless, about 50% consider that modern technology makes nuclear energy safer than before, and only 16% disagree with this proposition (question SP5).

Figure 4 shows that in the first two questions (ST1 and ST2), at a percentage of 43.8% for the first question and 45.2% for the second question, the neutral answer gathered the most answers. Only 22.4% of respondents to question ST1 and 21.8% to question ST2 stated that they trust governments. In questions ST3 and ST4 a percentage of 47-68.4% stated that they do not trust governments, and less than 15% trust them.

EA factor (Figure 5) examines issues surrounding nuclear energy and more general perceptions of the participants on environmental issues. In these more general topics to which questions EA1 and EA4 refer, the existence of environmental sensitivity is observed, as the percentage of agreement vs. the percentage of disagreement is 48% vs. 14% in the first question and 63.8% vs. 12.4% in the second question. In the questions referring to the extent to which nuclear energy can contribute to reducing environmental problems, the largest percentage is occupied by neutral answer (questions EA2, EA3, and EA5) and immediately followed by options disagree-strongly disagree that nuclear energy is environmentally friendly energy.

PB factor was examined through five questions (Figure 6), which referred to the extent to which the economy, citizens, and national power of the country producing nuclear energy would benefit. 44.2%-59.1% of the participants agreed that developing nuclear power would benefit the country producing it economically, while only 8.8%-19.4% disagreed (questions PB1 and PB5). The majority, i.e., 49.6%, answered that the country’s national power would increase with the use of nuclear energy, and 32.1% answered neutrally to this question (question PB2). In the question regarding the increase in the standard of living with the use of nuclear energy, 44.2% of the respondents answered neutral, and the percentage for the answers agree and disagree was about the same.
Figure 6. Response rates for PB factor (Source: Authors)

Figure 7 shows four questions regarding ANE in Greece. All questions gathered the largest percentage in the neutral response (40%-47%). The next largest percentage was collected by the disagree—strongly disagree answers (31%-37.8%), that is, they stated that they do not wish to develop nuclear energy in Greece.

DISCUSSION-CONCLUSIONS

Despite the fact that social acceptance plays an important role in the establishment and development of nuclear energy, research examining the factors influencing social acceptance is scarce. For this reason, this research examines the six main factors that influence ANE by students at University of Ioannina. The research results confirm that the general group of students’ nuclear energy knowledge is extremely low (Yim & Vaganov, 2003). In all the questions that examined their knowledge, the largest percentage answered “neutral”. Consistent with previous research, P factor has a negative effect on the acceptance of nuclear power, as eight out of 10 participants stated that they do not wish to be near a nuclear power plant (Hao et al., 2019). Only knowledge about nuclear energy can effectively influence its acceptance because, in this way, its benefits and the necessity of its establishment will be highlighted. Aware of the necessity of establishing nuclear energy, for the energy future of both Greece and worldwide, governments need to focus on effective communication and education about nuclear energy. It is necessary to understand the cognitive deficiencies and the opinions of the citizens that influence them regarding the acceptance or not of nuclear energy so that programs designed in this direction can be implemented. For example, it would be possible to hold lectures on nuclear energy in schools, organizations, and businesses so that students and the general public are informed about the mechanism of nuclear energy production and the operation of nuclear power plants. In addition, governments must reassure citizens about the safe operation of nuclear power plants because nuclear accidents have alarmed citizens, making them feel unsafe. It is obvious that further research is necessary as far as social acceptance is concerned, but also the improvement of public policy for nuclear energy. It is also deemed necessary to include chapters or sections related to nuclear energy in school textbooks. From elementary to high school, references to nuclear energy issues are minimal. Therefore, students graduating from school do not have sufficient knowledge of the importance of nuclear energy and its benefits.

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REFERENCES


