Evaluation of the Effectiveness of Nuclear Energy Understanding Education on Teachers' Perception Change

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1. Introduction

Nuclear education, the cornerstone of energy education, is essential for shaping accurate perceptions and values during adolescence, which is the starting point of school education. However, the 2015 revised curriculum lacks any nuclear-related content in elementary school textbooks, and in middle and high school textbooks, nuclear energy is described less frequently and more negatively compared to renewable energy sources. Furthermore, teachers themselves exhibit a lack of knowledge and anxiety regarding nuclear energy. An analysis of elementary school teachers' perceptions revealed that negative perceptions and anxiety prevail over accurate information or knowledge about nuclear energy [1, 2]. This suggests that teachers are not making judgments about nuclear energy based on sufficient knowledge, which acts as an obstacle to nuclear power development despite its various advantages. Therefore, there is an urgent need for a balanced nuclear energy understanding education program targeting teachers.

The importance of nuclear energy understanding education is emphasized to ensure the continuous development of the domestic nuclear industry and enhance public acceptance [3]. In particular, teacher training programs are highlighted as an effective means. Teachers play a crucial role in conveying knowledge about nuclear energy to students; therefore, nuclear energy understanding education for teachers can contribute to improving overall perception of nuclear energy.

However, there is a lack of objective evaluation studies on the effectiveness of nuclear energy understanding education to date. While existing studies suggest that nuclear education can induce positive changes, most have relied on qualitative research or simple surveys, lacking rigorous quantitative analysis.

This study aims to quantitatively analyze the impact of nuclear energy understanding education on teachers' perception changes using pre- and post-education survey data and to propose effective educational strategies. Specifically, we will compare perception changes before and after education and analyze significant differences using statistical techniques such as paired sample t-tests. Through this, we intend to objectively verify the effectiveness of nuclear education and provide foundational data necessary for the development of future educational programs.

2. Materials and Methods

2.1 Research Participants

The study participants consisted of 99 elementary and secondary school teachers. Participants were recruited through online announcements, and selection prioritized teachers currently instructing science, technology and home economics, and social studies at the secondary level, followed by general secondary school teachers, and then elementary school teachers.

2.2 Education Program

The educational program consisted of two sessions, each lasting four hours. The curriculum included: balanced energy education (1 hour), education on natural radiation (1 hour), analysis of nuclear energy content in the 2015 revised textbooks (1 hour), and a Q&A session (1 hour). Nuclear energy experts served as instructors.

2.3 Survey Questionnaire

To evaluate the effectiveness of the nuclear energy understanding education, a nuclear energy perception survey was developed as shown in Table I, comprising 28 items using a 5-point Likert scale. The survey questions encompassed ten key areas: interest in nuclear energy, importance, necessity, reliability, acceptability, information credibility, radiation safety, the inclusion of nuclear energy content in the national curriculum, and the need for nuclear energy education for students and teachers.

To evaluate the internal consistency reliability of the questionnaire used in this study, Cronbach's alpha coefficients were calculated for the pre- and post-surveys. The Cronbach's alpha for the pre-survey was 0.795, and for the post-survey, it was 0.791. The similar values of Cronbach's alpha coefficients between the pre-

Table I: Nuclear Energy Perception Survey

No.	Questionnaire items

1	I am interested in energy issues
2	I am interested in climate change and carbon neutrality.
3	I am interested in radiation/nuclear power generation.
4	Radiation is used beneficially in our daily lives, such as in the medical and food industries.
5	Nuclear power generation is economical compared to other energy sources.
6	Nuclear power generation helps preserve the global environment.
7	Nuclear power generation has contributed to improving industrial competitiveness by lowering electricity rates in our country.
8	Nuclear power generation is important from an energy security perspective.
9	I approve of using nuclear power to generate electricity in our country.
10	The proportion of nuclear power used for electricity generation in our country should be increased.
11	I think renewable energy and nuclear power should go together for a stable power supply.
12	Our country has excellent technology in nuclear power generation.
13	I trust the nuclear energy-related organizations in our country.
14	I support the government's energy policy.
15	I am aware of being exposed to natural radiation in daily life.
16	Radiation is dangerous, no matter how small the amount (-).
17	I can receive radiation tests or treatments for my health.
18	Living near a radioactive waste disposal site is not dangerous.
19	I agree with the construction of a nuclear power plant in my area.
20	Spent nuclear fuel is being safely managed.
21	I trust the information on nuclear energy/radiation provided by mass media such as newspapers and broadcasts.
22	I trust the information on nuclear energy/radiation on the internet.
23	I trust the information on nuclear energy/radiation provided by civic groups.
24	The current national curriculum reflects balanced energy education content.
25	The current national curriculum is sufficient for students to develop nuclear knowledge literacy.
26	Balanced energy education is necessary for students.
27	Education on natural radiation and nuclear energy is needed from upper elementary school grades.
28	It is necessary to strengthen energy/nuclear education in teacher training programs and teacher in-service training.

and post-surveys indicate that both surveys consistently measured the same concept. This provides evidence that the measurement tool has high internal consistency and stability.

2.4 Analysis Methods

This study employed a comparative analysis of pre- and post-education results to verify the effectiveness of the nuclear energy understanding education. Out of 99 survey questionnaires collected, 94(94.9%) were selected as valid, excluding 5 questionnaires due to missing responses or abnormal response patterns. The collected surveys were analyzed using Microsoft Excel to measure the mean changes in pre- and post-education responses. Paired t-tests were conducted to determine whether the differences between pre- and post-education responses were statistically significant. All statistical significance tests were performed at a significance level of 0.05 ($p < 0.05$).

3. Results and Discussion

3.1 General Characteristics of Teachers

The general characteristics of the teachers who participated in this study are as follows: The majority of participants were female, accounting for 69.1% (n=65), while males represented 30.9% (n=29). Regarding school levels, 58.5% (55) were secondary school teachers, and 41.5% (39) were elementary school teachers.

In terms of subjects taught, "other" subjects constituted the largest group at 55.3% (n=52), followed by science at 31.9% (n=30), social studies at 7.4% (n=7), and technology and home economics at 7.4% (n=7).

3.2 Evaluation of the effectiveness of nuclear energy education

3.2.1 Descriptive Statistical Analysis

Table II presents the results of changed in teachers' perception before and after education by comparing and analyzing the mean and standard deviation of pre- and post-education questionnaires. As shown in table, the analysis revealed a statistically significant increase in the mean scores for all items except item 24. This suggests that the nuclear energy education program positively contributed to enhancing participants' knowledge and understanding of nuclear energy.

3.2.2 Paired Samples t-Test Analysis

The paired samples t-test demonstrated a statistically significant improvement in teachers' perceptions regarding nuclear energy (interest, usefulness, reliability, radiation safety, acceptability, information reliability, curriculum integration, and educational necessity) after participating in the nuclear energy education program ($p < 0.05$). Furthermore, a trend of increased positive attitudes towards nuclear energy was observed. This indicates that the observed changes in perception were not due to random chance, but rather a result of the educational intervention.

Table II: Evaluation Results of Nuclear Understanding Education

Item		M	SD	t	P
1	pre-test	4.372	0.451	-3.290	p < 0.01
	post-test	4.596	0.308		

2	pre-test	4.479	0.424	-1.782	0.078 (p 〉0.05)
	post-test	4.596	0.329		
3	pre-test	4.181	0.580	-4.538	p < 0.001
	post-test	4.479	0.360		
4	pre-test	4.415	0.353	-3.961	p < 0.001
	post-test	4.660	0.313		
5	pre-test	4.383	0.518	-3.324	p < 0.001
	post-test	4.628	0.430		
6	pre-test	3.787	0.922	-7.253	p < 0.001
	post-test	4.426	0.484		
7	pre-test	4.394	0.585	-3.863	p < 0.001
	post-test	4.670	0.245		
8	pre-test	4.383	0.454	-4.814	p < 0.001
	post-test	4.702	0.254		
9	pre-test	4.053	0.696	-6.090	p < 0.001
	post-test	4.511	0.446		
10	pre-test	3.628	1.290	-7.473	p < 0.001
	post-test	4.362	0.599		
11	pre-test	4.426	0.276	3.613	p < 0.001
	post-test	4.702	0.482		
12	pre-test	4.415	0.482	-3.915	p < 0.001
	post-test	4.681	0.241		
13	pre-test	4.170	0.702	-4.477	p < 0.001
	post-test	4.489	0.511		
14	pre-test	3.617	1.078	-4.108	p < 0.001
	post-test	4.021	0.795		
15	pre-test	4.096	0.582	-4.978	p < 0.001
	post-test	4.532	0.316		
16	pre-test	2.904	1.184	-3.706	p < 0.001
	post-test	3.447	1.691		
17	pre-test	4.191	0.716	-2.809	p < 0.01
	post-test	4.457	0.487		
18	pre-test	2.756	1.370	-4.555	p < 0.001
	post-test	3.404	1.361		
19	pre-test	2.702	1.308	-4.473	p < 0.001
	post-test	3.149	1.440		
20	pre-test	3.309	1.054	-4.577	p < 0.001
	post-test	3.766	1.192		
21	pre-test	3.202	0.873	-3.074	p < 0.01
	post-test	3.511	1.156		
22	pre-test	3.223	0.735	-1.768	0.080 (p 〉0.05).
	post-test	3.415	1.149		
23	pre-test	3.309	0.646	-1.603	0.112 (p 〉0.05)
	post-test	3.468	1.004		
24	pre-test	3.255	0.988	0.870	0.164 (p 〉0.05)
	post-test	3.234	1.579		
25	pre-test	2.628	0.946	-2.048	0.043 (p 〉0.05).
	post-test	2.883	1.438		
26	pre-test	4.564	0.292	-2.613	p < 0.01
	post-test	4.723	0.245		
27	pre-test	4.234	0.547	-2.747	p < 0.01
	post-test	4.479	0.489		
28	pre-test	4.191	0.544	-4.899	p < 0.001
	post-test	4.585	0.289		

In particular, the perception that nuclear power contributes to environmental protection increased significantly (item 6). This can be interpreted as a result of the education content emphasizing the contribution of nuclear power to carbon neutrality and environmental protection, thereby increasing positive perceptions. It also appears that while teachers already had some understanding of the eco-friendliness associated with nuclear technology, the education enhanced their understanding of nuclear power, rather than renewable energy, as a potentially environmentally friendly option.

In the item "The proportion of nuclear energy used for electricity generation in Korea should be increased" (item 10), the mean change was 0.734, showing the largest increase, and a statistically significant change was observed ($p < 0.0001$). This suggests that teachers developed a more positive perception of the necessity and role of nuclear energy through the education. As the education conveyed that nuclear energy plays a crucial role in stable power supply and national energy policy, it appears that support for the expansion of nuclear energy increased.

The item "It is not dangerous to live near a radioactive waste disposal site" (item 18) measures the perception of risk that a radioactive waste disposal site poses to the living environment. The pre-education average response value was 2.756, indicating that teachers tended to perceive living near a radioactive waste disposal site as somewhat dangerous. However, the post-education average response value significantly increased to 3.404. The t-test results confirmed that there was a statistically significant change ($p < 0.0001$). This suggests a reduction in anxiety regarding nuclear energy and radioactive waste management, which can be interpreted as a result of understanding the associated risks and safety measures through education. It appears that trust in nuclear power plants and radioactive waste management has increased.

The item "I agree with the construction of a nuclear power plant in my area" (item 19) assesses regional acceptance of nuclear power plant construction. The pre-education average value was 2.702, indicating that respondents had a somewhat negative attitude towards nuclear power plant construction. However, the post-education average value increased to 3.149, which is considered a result of increased understanding of the necessity and safety of nuclear power plants through the education. The t-test results showed $p < 0.001$, confirming that there was a statistically significant change.

For the item "Balanced energy education is necessary for students" (item 26), the pre-education average score was 4.564, indicating that respondents already highly valued the necessity of energy education. However, the post-education average score for this item slightly increased to 4.723, and the paired samples t-test showed a p-value of 0.0105, confirming a statistically significant difference ($p < 0.05$). This suggests that the education contributed to further emphasizing the necessity of energy education for teachers.

The item "Education on living radiation and nuclear energy is necessary from the upper grades of elementary school" (item 27) showed that the pre-education average response score of teachers was 4.234, but increased to 4.479 after the education. The t-test results showed a p-value of 0.007, confirming a significant difference ($p < 0.05$). This means that the perception that education on nuclear energy and radiation is necessary from the upper grades of elementary school was further strengthened through the education.

However, no significant differences were found in the interest in climate change and carbon neutrality (item 2), the credibility of information from the internet and civic groups (items 22, 23), and the perception of nuclear energy content integration into the national curriculum (item 24) ($p > 0.05$).

The observed lack of significant change in certain areas, despite the overall positive impact of the nuclear energy education program, can be attributed to several distinct factors.

Firstly, the absence of a notable shift in interest regarding climate change and carbon neutrality suggests a high level of pre-existing engagement among the teacher participants. It is plausible that these educators, prior to the intervention, already possessed a robust understanding and concern for these issues, thus rendering the educational content supplementary rather than transformative in this specific domain.

Secondly, the persistent stability in the perceived credibility of information sourced from the internet and civic groups points towards an entrenchment of individual belief systems. This entrenchment implies that the evaluation of information credibility is deeply rooted in personal biases and interpretive frameworks, which are less susceptible to modification through short-term educational interventions. Consequently, the education's influence on these pre-established perceptions was limited.

Lastly, the consistent negative perception concerning the adequacy of balanced energy education content within the national curriculum underscores a persistent critical view held by the teachers.

4. Conclusions

This study aimed to comprehensively analyze the impact of nuclear energy education on teachers' perceptions of nuclear energy and radiation, and to evaluate the effectiveness of the education through multifaceted approaches. The findings can be discussed comprehensively as follows:

First, nuclear energy education had a positive effect on changing teachers' perceptions of nuclear energy development in a multi-layered manner. By providing teachers with balanced information on not only the technical aspects of nuclear energy development but also the environmental aspects, the education corrected existing biased perceptions and enhanced multi-dimensional understanding. Furthermore, it increased scientific understanding of radiation, alleviating vague anxieties and enabling rational judgment. This demonstrates that the education was effective in inducing teachers' cognitive changes beyond simple knowledge transfer.

Moreover, the education contributed to enhancing social acceptability by improving teachers' trust in nuclear energy-related institutions and government energy policies. The positive changes observed in the items related to nuclear energy acceptability suggest that the education was effective in reducing vague anxieties about nuclear energy development and forming rational acceptance attitudes. These affective changes show that education can also positively influence teachers' social perception changes.

However, the credibility of all information channels did not increase equally. While the credibility of information through mass media increased, the credibility of information through the internet and civic groups did not show significant changes. This suggests that information from the internet and civic groups is closely related to individuals' existing beliefs and values, making it difficult to change credibility through short-term education alone.

Meanwhile, teachers consistently perceived that the national curriculum lacked balanced energy education content. This strongly suggests the need to improve the current national curriculum and implies that energy education should aim to foster critical thinking and rational decision-making skills on social issues, rather than simply transmitting knowledge. Additionally, teachers perceived that the current curriculum was insufficient for students to develop nuclear energy literacy, indicating that a thorough review and improvement of nuclear energy education content is necessary.

These results demonstrate that nuclear energy education is an important foundation for fostering future generations' ability to solve energy problems and for building social consensus. Balanced nuclear energy education is essential for the sustainable development of future society, and providing objective and balanced information can contribute to preventing social conflicts and making rational energy policy decisions.

In conclusion, this study confirmed that nuclear energy education has a positive effect on teachers' perception changes and the enhancement of social acceptability. However, there are also challenges that need to be improved, such as differences in credibility formation mechanisms for each information channel and limitations of the national curriculum. Future nuclear energy education should continue efforts to enhance critical acceptance skills for various information channels, improve the curriculum, and build social consensus based on the results of multi-layered analysis.

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