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Comparison between a 13-session and One-time Program on Korean Elementary, Middle and High School Students' Understanding of Nuclear Power

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ABSTRACT

Background: To help future generations make accurate value judgments about nuclear power generation and radiation, this study will provide an effective education plan suitable for South Korea by applying and analyzing programs for the understanding of nuclear power within the diversely operated programs in the current Korean education system.

Materials and Methods: This study analyzed the difference in educational effects by operating a 13-session regular curriculum for one semester and a one-session short-term curriculum from March to July 2016.

Results and Discussion: As a result of operating a 13-session model school and a one-time educational program to analyze behavior changes against the traditional learning model, it was found that all elementary, middle and high school students showed higher acceptability of nuclear power in South Korea. The variation was greater for the model school than the short-term program.

Conclusion: To prevent future generations from making biased policy decisions stemming from fear regarding nuclear power, it is necessary to bolster their value judgments in policy decisions by acquiring sufficient information about nuclear power generation and radiation through educational programs.

Keywords: Nuclear power, Education, School, Student, Understanding

Original Research

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Introduction

Despite energy production and supply being a key determinant of human civilizations' success throughout history [1], South Korea is facing severe social conflicts related to nuclear power such as the decision to shut down its first nuclear power reactor in Kori, and difficulties establishing a high-level radioactive waste disposal repository. Nuclear power provides socioeconomic usefulness by producing energy, but it also carries risks related to uncertainty of accidents and radioactive waste and waste [2]. Moreover, considering the level of severity of nuclear power plant accidents, safety of these facilities must be supported by all stakeholders. Risks regarding radiation are often unfamiliar to the general public [3, 4] due to their technical nature, thereby generating fear due to ignorance [5]. Because South Korea requires nuclear power for national energy security and economic growth, it is important to promote social acceptability of nuclear power, and the country's nuclear power facilities and policies are based on the acceptability of local residents [6]. A negative perception of nuclear power and radioactivity increased after the Fukushima nuclear disaster [7-11], implying that the perception of nuclear power's risk is driven by cognitive anchoring from powerful and negative images as well as insufficient mediation following such a disaster. Thus, the public perception and acceptability of risk is predominantly influenced by nuclear power technologies or facilities themselves [12, 13], rather than by scientific and technical assessment [14].

To avoid such socio-scientific issues, science education researchers are emphasizing that it is necessary to cultivate the ability to make value judgments and take rational measures based on understanding of science and technology, rather than from negative visual stimuli [15-19].

Since energy's social, political and technological elements are intricately associated with one another, the resolution of energy-related issues is dependent on the level of support that is provided by the public—both socially and politically—in addition to understanding the fundamental issues regarding nuclear power [20, 21]. However, it is difficult to improve adults' acceptability through education; thus, there is a need for a special policy decision. Before the failure to secure social acceptability caused by ignorance about nuclear power and radiation leads to misdirected political influence, schools must provide accurate and easily understandable information for future generations to make their own value judgments. Fortunately, the general trend of recent curriculum development in South Korea is leaning toward suppressing the government's operation of and influence on school curricula while providing more autonomy and authority to the community and school administrations [22]. The appropriate curriculum in schools can help students understand nuclear power generation and radiation; in particular, recently implemented school curricula offer various programs such as creative work-study programs, a free semester system and club activities. The curriculum for creative work-study programs consists of four areas: self-regulated activities, club activities, volunteer activities and career activities. Specific details of the activities for each area are chosen and operated by each school according to the characteristics of students, classes, years, and local communities]. Therefore, to help future generations make accurate value judgments about nuclear power, this study will provide an effective education plan suitable for South Korea by applying and analyzing programs for the understanding of nuclear power and radiation within the diversely operated programs in the current Korean education system.

Research Methods

Two types of education programs have been applied: one is a model school that aims to help elementary, middle and high school students understand nuclear power and radiation within the regular curriculum (i.e. 13 sessions), and the other is a one-time, short-term education program. In summary, this study analyzed the difference in educational effects by operating a 13-session regular curriculum for one semester and a one-session short-term curriculum from March to July 2016. One-session short-term curriculum were held for one or two hours of instruction.

This study selected one elementary school, one middle school and one high school for application of the model school, carrying out a total of 13 sessions during the regular semester. The one-time program targeted students from a total of 30 schools (10 for each level) in the same grades as the model school: elementary school students in their 6th year, middle school students in their 2nd year and high school students in their 1st year. The subjects of the 13-session model school consisted of 52 elementary school students (41%), 42 middle school students (33%), and 33 high school students (26%). The subjects of the short-term education consisted of 272 elementary school students (33%), 280 middle school students (34%) and 271 high school students (33%).

The educational content of the model school was organized into 13 sessions for a total of two years (2014-2015) as shown in Table 1. The curriculum and contents of the textbook used are based on data developed by HAN (2014, 2015) [23, 24]. Various methods of content implementation were used, such as lectures by experts and science teachers, cloud chamber experiments, measurement of natural radiation, observation of changes in irradiated food, discussions and presentations. Suitable methods were applied according to the characteristics of each session and the school level.

The one-time session consisted of content from the model school, such as theoretical content including advantages and disadvantages of nuclear power generation, principles and statuses of medical radiation and use of irradiated food, as well as practical training in measuring natural radiation. The content of one-time session is similar in elementary, middle and high schools. To analyze the difference in educational effects between the model school and the one-time program, a survey was distributed in order to categorize students' knowledge, attitudes and behaviors based on the traditional learning model; in addition, their knowledge about

Table 1. Contents of Education in the Model School by School Level

Subject (Target)	Radiation and Life (For elementary school students)	Nuclear Energy and Radiation (For middle school students)	Nuclear Energy and Radiation (For high school students)
Table of Contents	Chapter 1. What is nuclear energy and radiation? Chapter 2. Who discovered the nuclear energy and radiation? Chapter 3. Why is nuclear energy and radiation important? Chapter 4. Is nuclear energy and radiation dangerous? Chapter 5. Let's learn about what to do when an incident occurs. Chapter 6. How are nuclear energy and radiation used? Chapter 7. What is the nuclear power generation? Chapter 8. Why is radiation used for food? Chapter 9. What is medical radiation? Chapter 10. What kind of irradiated products are in our daily lives? Chapter 11. What jobs are related to nuclear energy and radiation? Chapter 12. What are energies of future? Chapter 13. Concept of Talk-Talk	Chapter 1. Nuclear energy Chapter 2. Nuclear energy technology Chapter 3. Uses of nuclear energy Chapter 4. Radiation Chapter 5. Risks of radiation Chapter 6. Uses of radiation in food Chapter 7. Household products using radiation Chapter 8. Radiation in life Chapter 9. Nuclear bombs Chapter 10. Misunderstandings and truths about radiation Chapter 11. Progress in nuclear energy research Chapter 12. Pros and cons in the debate on n clear energy and radiation Chapter 13. Energy in the future	Chapter 1. History of nuclear energy and radiation Chapter 2. Nuclear energy and radiation Chapter 3. Misunderstandings and truths about radiation Chapter 4. Types of radiation Chapter 5. Nuclear power generation Chapter 6. Uses of radiation in food Chapter 7. Medical radiation Chapter 8. Uses of industrial radiation Chapter 9. Radiation in scientific research Chapter 10. Current domestic and overseas status of radiation Chapter 11. Radiation incidents and radiation contamination Chapter 12. Expert opinions about the use of nuclear energy and radiation Chapter 13. Group discussion about the use of radiation and nuclear energy

Table 2. Difference in Behavioral Changes between Model School and Short-term Education: Frequency (%)

School level	Education	Voting results	Acceptability in Korea		Acceptability in residential district	
			Before	After	Before	After
Elementary school students	Model school	Agree	19 (54.3)	41 (91.1)	4 (13.3)	17 (37.8)
		Disagree	16 (45.7)	4 (8.9)	26 (86.7)	28 (62.2)
	Short-term program	Agree	119 (69.2)	147 (74.6)	52 (31.3)	91 (46.4)
		Disagree	53 (30.8)	50 (25.4)	114 (68.7)	105 (53.6)
Middle school students	Model school	Agree	19 (86.4)	31 (79.5)	6 (27.3)	12 (31.6)
		Disagree	3 (13.6)	8 (20.5)	16 (72.7)	26 (68.4)
	Short-term program	Agree	99 (54.1)	137 (68.5)	31 (16.1)	71 (34.6)
		Disagree	84 (45.9)	63 (31.5)	162 (83.9)	134 (65.4)
High school students	Model school	Agree	15 (68.2)	27 (93.1)	3 (12.5)	18 (62.1)
		Disagree	7 (31.8)	2 (6.9)	21 (87.5)	11 (37.9)
	Short-term program	Agree	150 (64.1)	186 (78.5)	37 (16.4)	99 (42.5)
		Disagree	84 (35.9)	51 (21.5)	189 (83.6)	134 (57.5)

the use of radiation was categorized into three areas: nuclear power generation, medical radiation, and irradiated food. Statistical analysis was conducted with SPSS/WIN 15.0 on frequency, percentage, mean, standard deviation, *t* test and one-way ANOVA.

Results

1. Changes in acceptability of nuclear power according to model school and short-term programs

As a result of operating a 13-session model school and a one-time educational program to analyze behavior changes against the traditional learning model, it was found that all elementary, middle and high school students showed higher acceptability of nuclear power in South Korea. The frequency was greater for the model school than the short-term program. There was a higher rate of approval for nuclear energy after education than before education as shown in Table 2. Acceptability of nuclear power generation in the residential district was lower than the national average, but there was still a higher percentage of agreement following the programs. This suggests that it is possible to increase acceptability in nuclear power for elementary, middle and high school students by operating both the model school and short-term educational program. The Theory of Reasoned Action is that people behave by considering in advance the advantages and disadvantages that will be brought by the outcome of a future behavior [25]. Even though this study compared the results after providing education about both aspects—advantages and disadvantages—of nuclear power generation and

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Table 3. Comparison of Knowledge and Attitude Changes between Model School and Short-term Education

Category			Elementary school students		Middle school students		High school students	
			Mean±SD	*t*(p)	Mean±SD	*t*(p)	Mean±SD	*t*(p)
Knowledge	Nuclear power generation	Model school	3.69±0.875	2.569	3.95±0.764	4.447	4.14±0.639	2.309
		Short-term program	3.23±1.229	(0.011)*	3.32±1.300	(0.000)**	3.81±1.231	(0.025)*
	Medical radiation	Model school	2.58±1.444	1.798	3.71±1.293	5.337	2.96±1.170	-1.313
		Short-term program	2.22±1.259	(0.073)	2.39±1.526	(0.000)**	3.28±1.427	(0.197)
	Irradiated food	Model school	2.53±1.689	2.193	3.83±1.223	7.805	4.03±0.906	6.309
		Short-term program	2.00±1.560	(0.029)*	2.15±1.648	(0.000)**	2.78±1.707	(0.000)**
Attitude	Nuclear power generation	Model school	4.27±0.795	2.609	4.71±0.508	8.139	4.24±0.830	.056
		Short-term education	3.88±1.026	(0.010)*	3.94±0.883	(0.000)**	4.23±0.780	(0.956)
	Medical radiation	Model school	2.72±0.599	2.46	2.80±.507	2.295	2.93±0.371	2.138
		Short-term program	2.43±0.802	(0.014)*	2.59±0.704	(0.025)*	2.77±0.537	(0.038)*
	Irradiated food	Model school	2.25±0.874	.989	2.45±0.764	2.5	2.90±0.409	5.93
		Short-term program	2.14±0.766	(0.323)	2.12±0.810	(0.013)*	2.37±0.725	(0.000)**

*Knowledge and attitude are rated on the scale of 0 to 5. Knowledge consists of three items for each area.
Nuclear power generation: Nuclear power generation is one way to produce energy. Radiation exists everywhere including in sunlight, on the schoolyard and in the classroom. South Korea is currently operating nuclear power plants. Residents near nuclear power plants are exposed to more radiation than those living in other regions (Wrong question). The US, Canada, France and Germany also operate nuclear power plants.
Medical radiation: Radiation is used in hospitals to diagnose and treat illnesses, and the type used here does not subject the public to exposure (Wrong question). Radiation used for testing and cancer treatment is not harmful to the human body (Wrong question). The amount of radiation received in a hospital is much less than the amount received around a nuclear power plant (Wrong question). Advanced countries also use radiation to diagnose and treat illnesses.
Irradiated food: Irradiated food discharges radiation because is contaminated by radioactive substances (Wrong question). Irradiation is one way to store and process foods. Irradiation is permitted in gochujang (red pepper paste), doenjang (soybean paste) and soy sauce powder in South Korea. Globally, irradiation is permitted in potatoes, wheat and flour.) In order to increase the reliability of the question, the right and wrong questions were measured together.

radiation use, the acceptability of nuclear power in South Korea increased. Generally, the higher the perceived benefits of nuclear power, the greater its acceptability [26, 27]. However, various factors such as emotions, experiences, socio-cultural environment and value systems also play an important role in people's value judgments [28, 29]; thus, it is necessary to help people make independent, rational judgments by providing a wealth of information across categories. In general, attitude changes toward nuclear power were found to vary among the general public of different nations [30, 31], but the public's attitude toward science also differs depending on the level of knowledge (i.e. the more knowledge one has, the more likely it is that he or she will be able to make a rational judgment) [32]. Therefore, regardless of the type of educational delivery, it is necessary to provide balanced information about nuclear power. In addition, an individual's level of risk acceptance is determined by his or her perception, and this study predicts that there have been some changes in perception as a result of the educational programs [33, 34].

2. Comparison of knowledge and attitude changes between model school and short-term program

As a result of operating a 13-session model school and a one-time educational program to compare levels of knowledge and attitudes regarding nuclear power generation, medical radiation and irradiated food, it was found that the 13-session model school showed higher levels than the one-time program in all three areas for elementary, middle and high school students as shown in Table 3. There was a statistically significant difference excluding certain areas; that is, a greater educational effort was necessary to apply the 13-session model school than the short-term program across all school levels in order to effect change in knowledge and attitudes toward nuclear power generation and radiation use. The current era demands programs that can improve students' social and moral empathy toward socio-ethical issues related to science, and this requires not only an understanding of science and technology, but also an effective teaching strategy to promote understanding, such as embracing diverse viewpoints. Since the educational effect of the 13-session model school was found to be greater than that of the one-time program in this study, the former seems more suitable in promoting understanding of diverse viewpoints. Shower (1995) compared different levels of knowledge and attitudes of high school students regarding nuclear energy and discovered that persuasion is effective in effecting change [35]. This study verified that the model school using various educational implementation methods and the one-

Table 4. Comparison of Knowledge and Attitude Changes by School Level between Model School and Short-term Education

Category			Model school				Short-term education			
			Before		After		Before		After	
			Mean±SD	F (p)	Mean±SD	F (p)	Mean±SD	F (p)	Mean±SD	F (p)
Knowledge	Nuclear power generation	Elementary	1.96±1.525	17.303 (0.000)**	3.69±0.875	3.206 (0.044)*	1.74±1.458	56.644 (0.000)**	3.23±1.229	16.333 (0.000)**
		Middle	3.63±0.819		3.95±0.764		2.25±1.457		3.32±1.300	
		High	2.70±1.447		4.14±0.639		3.00±1.151		3.81±1.231	
	Medical radiation	Elementary	1.67±1.506	8.112 (0.001)**	2.58±1.444	8.379 (0.000)**	1.65±1.429	52.675 (0.000)**	2.22±1.259	42.213 (0.000)**
		Middle	2.84±1.242		3.71±1.293		2.08±1.618		2.39±1.526	
		High	2.61±1.540		2.96±1.170		2.98±1.480		3.28±1.427	
	Irradiated food	Elementary	0.67±1.144	29.741 (0.000)**	2.53±1.689	14.994 (0.000)**	0.75±1.219	10.213 (0.000)**	2.00±1.560	16.883 (0.000)**
		Middle	2.54±1.466		3.83±1.223		0.94±1.315		2.15±1.648	
		High	0.79±0.960		4.03±0.906		1.27±1.469		2.78±1.707	
Attitude	Nuclear power generation	Elementary	3.73±1.098	8.572 (0.000)**	4.27±0.795	5.546 (0.005)**	3.87±0.934	13.549 (0.000)**	3.88±1.026	11.678 (0.000)**
		Middle	4.53±0.687		4.71±0.508		3.79±0.966		3.94±0.883	
		High	3.97±0.684		4.24±0.830		4.19±0.891		4.23±0.780	
	Medical radiation	Elementary	2.12±0.860	8.378 (0.000)**	2.72±0.599	1.508 -0.225	2.16±0.879	24.728 (0.000)**	2.43±0.802	15.996 (0.000)**
		Middle	2.78±0.470		2.80±0.507		2.29±0.862		2.59±0.704	
		High	2.42±0.858		2.93±0.371		2.63±0.645		2.77±0.537	
	Irradiated food	Elementary	1.43±0.589	16.875 (0.000)**	2.25±0.874	6.812 (0.002)**	1.65±0.731	3.609 (0.028)*	2.14±0.766	8.92 (0.000)**
		Middle	2.24±0.810		2.45±0.764		1.66±0.683		2.12±0.810	
		High	1.65±0.579		2.90±0.409		1.79±0.673		2.37±0.725	

*Knowledge is rated on a scale of 0 to 5, and attitude on a scale of 1 to 5. Both consist of three items for each area.

time program using only lectures and measurement experiments both were effective in resulting attitude changes. In order for students—as future citizens—to adopt proper socio-political behaviors, it is necessary to consider their value systems and include them in the curriculum development and implementation so that they can actively participate in problem-solving discourses that affect society [36, 37]. However, since the regular South Korean curricula are focused on entrance exams, it is difficult to include subjects that require complicated value judgments like nuclear power generation and radiation. The most challenging aspect of organizing a curriculum that includes these topics is to select the contents [22], as they must be accessible to all students and respond to particular needs. For example, they must arouse the interest and attention of students while also evoking and satisfying their curiosity [38]. The contents must be crucial to solving problems and achieving prescribed goals. In addition, the curriculum must consider the learners themselves more implicitly in content creation (e.g. their principles and psychological development) as well as their needs [39].

3. Comparison of knowledge and attitude changes by school level between model school and short-term program

As a result of operating a 13-session model school and a one-time educational program to compare levels of knowledge and attitude regarding nuclear power generation, medical radiation, and irradiated food by school level, it was found that there were statistically significant differences in educational effects. High school students in the one-time program showed higher levels of knowledge and a more positive attitude than students in elementary and middle school who participated in the same program. The level of positive attitude toward nuclear power in the 13-session model school was higher with statistical significance for middle school students than participants in elementary and high school levels. In most areas, elementary school students showed lower levels of knowledge and attitudes than middle and high school students as shown in Table 4. As such, the 13-session model school may be seen as more effective for middle school students, while one-time education may be more effective for high school students.

Conclusion

To prevent future generations from making biased policy decisions stemming from fear regarding nuclear power generation and radiation, it is necessary to bolster their value judgments in policy decisions by acquiring sufficient information about nuclear power through educational programs.

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As a result of operating curricula that meet students' needs in the form of the 13-session model school and one-time program, it was found that both methods had educational effects, and the model school was relatively more effective, especially for middle school students. As such, this 13-session program is desirable if the host school provides a sufficient educational environment. Operating a one-time program, then, would be the alternate choice if the conditions for the model school cannot be met. These programs can help students make proper value judgments about nuclear power generation and radiation, though a curriculum will not be effective if it is merely well-planned; rather, significance can only be achieved when concepts are actually applied in class [40, 41]. Therefore, it would be possible to operate efficient curricula by applying the educational contents and methods verified in this study to creative work-study programs, a free semester system and club activities across school levels.

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