Education Effects of Operating a Model School for Korean Elementary, Middle and High School Students to Understand Nuclear Power

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***Abstract* –To help future generations make value judgments by acquiring proper information on nuclear power and radiation, this study came up with the first model school in Korea to apply as a regular curriculum to understand nuclear power and radiation. As a result of operating a model school that consists of total 13 sessions and analyzing behavior changes, the ultimate goal, based on the traditional learning model, it was found that all of elementary, middle and high school students showed high acceptance toward nuclear power in South Korea. To reduce unnecessary social confusion related to nuclear power generation and use of radiation, it is necessary to make thorough preparations in the long run and operate the model school verified in this study at the national level.**

***Keywords* – Education, Model school, Student, Nuclear power.**

1. Introduction

The Fukushima Daiichi nuclear disaster in Japan resulted in frequent media reports on the negative aspects of nuclear power, such as radioactive contamination of fishery products, radioactive concentration in the atmosphere, and safe foods for future generations [1]. This increased the negative perception on nuclear power generation and radioactivity for the majority of people [2-6]. As the media indiscreetly provides misinformation or details about nuclear power and radioactivity that are extremely difficult to understand, many issues have been revealed with regard to the concepts and perceptions on radioactivity [7].

Currently in South Korea, it is highly important to secure nuclear power and use radioactivity as energy sources in terms of climate change convention, energy security and welfare. Despite the political and economic significance as well as sociocultural ripple effects of nuclear power, nationwide discourses and public opinions on nuclear power have been a series of extreme conflicts and misconceptions. Furthermore, the perceptions on and attitudes toward nuclear power are extending their scope to complaints, anxieties and uncertainties about nuclear power policies beyond just a vague fear [8]. According to a report by OECD, factors that triggered public concern include accidents in the past, false information about the nuclear industry, and general distrust of countless systems. By securing the society's fundamental trust in the future of nuclear power, it will be possible to promote better understanding of the public about the benefits and limitations of nuclear technologies [9]. Girondi (1983), Eiser et al. (1998) state that social, political and technological elements are intricately associated with one another, and thus an important alternative to resolve energy issues is how much support is provided by the public both socially and politically, in addition to the fundamental issues [10, 11]. The fact that South Korea, which is an exporter of nuclear power generation, is not being supported for nuclear power generation and use of radiation due to lack of public trust implies that there has been insufficient research and practice regarding communication strategies. It is necessary to apply strategic communication fit for the domestic situation starting now. Until now, nuclear-related agencies invited experts to provide fragmentary information for the public to understand nuclear power, but its effects have not been measured and it is not contributing

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much to change in perception. This lack of education effects because experts merely provided knowledge when the general public's false sense of nuclear power is a matter of acceptance toward risks as well as a matter of sensibility.

According to Slovic, (1992) experts evaluate risk perception with revealed preference that determines risk acceptance with a scientific and technological approach, while the general public evaluates it with expressed preference that determines risk acceptance according to individual perception [12]. Furthermore, experts perceive risks with technical rationality based on statistical data, while the general public perceives risks with subjective judgment such as an individual's subjective experience, knowledge or habits [13, 14]. According to Sjoberg (1999), experts do not think much of the risk of science and technology, but the general public consider the risk to be very high [15]. Therefore, there is a need for communication strategies grounded on the perception patterns and educational understanding of the general public.

For nuclear power to fulfill its function in the future, it is necessary to come up with effective ways to communicate with the civil society regarding key issues and obtain public consent in decision making. However, since it is nearly impossible to change the perception of adults, there is a need for policy intervention rather than a communication strategy, while helping future generations make their own judgments and choices through proper education. It is not easy to make policy decisions to apply education about nuclear power to future generations. However, fortunately, the general trend of recent curriculum development is changing toward the direction of suppressing the government's organization and operation of curriculums while giving more autonomy and authority to the community and schools [16]. Schools can use their autonomy to apply education on understanding of nuclear power by offering creative work-study programs and operating the free semester system and clubs. The curriculum for creative work-study programs consists of four areas: self-regulated activities, club activities, volunteer activities, and career activities. Specific details of activities for each area are to be chosen and operated flexibly by each school according to the characteristics of students, classes, years, schools and local communities [17]. Therefore, to apply education that promotes understanding of nuclear power generation and use of radiation in line with the current era to the regular course, this study demonstrated a 13-session curriculum that lasted for a semester and tested its education effects.

2. Methods

This study selected one elementary school, one middle school and one high school to apply the curriculum for understanding of nuclear power during one semester to the regular course, and operated a model school from March to July 2016. Participants consisted of 52 elementary school students (in the 6th year), 42 middle school students (in the 2nd year), and 33 high school students (in the 1st year). The subjects of education are organized through 9 steps into 13 sessions for total 2 years (2014-2015) as shown in <Table 1>. The curriculum and contents of the textbook are based on the data developed by HAN (2014, 2015) [18-19].

Table 1. Contents in Finalized Textbook 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	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 nuclear energy and radiation	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

	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 13. Energy in the future	Chapter 12. Expert opinions about the use of nuclear energy and radiation Chapter 13. Group discussion about the use of radiation and nuclear energy

Various methods of education were used, such as lectures by experts and science teachers, cloud chamber experiments, measurement of natural radiation, observation of changes in irradiated food, discussions, presentations, etc. Suitable methods were applied according to the characteristics of each session by school level. To analyze the education effects, the survey was categorized into knowledge, attitude and behavior based on the traditional learning model, and use of radiation is 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.

3. Results

1) Changes of choice behavior in nuclear power generation

As a result of operating a model school that consists of total 13 sessions and analyzing behavior changes, the ultimate goal, based on the traditional learning model, it was found that all of elementary, middle and high school students showed high acceptance toward nuclear power in South Korea. This was determined by voting, and the percentage of agreement was remarkably high. Acceptance of nuclear power in the residential district was lower than that in the nation, but still there was a higher percentage of agreement. This suggests that it is possible to increase receptivity toward nuclear power for elementary, middle and high school students by operating a model school. The behavioral decision theory describes the psychological process of comparatively evaluating the pros and cons of alternatives in decision making choices, and choosing alternatives with greater value or valid reason while giving up on other alternatives [20-21]. Ajzen (1975) argues in The Theory of Reasoned Action that people behave by considering the advantages and disadvantages that will be brought by the outcome of their behavior, making most use of their information before that [22]. Even though the curriculum provided information including accidents and negative aspects of nuclear power plants, students agreed to nuclear power after obtaining all the information. This proves that they can make appropriate value judgments in matters that include risks as well.

Table 2. Changes of choice behavior in nuclear power generation before and after education (person/%)

Category		Elementary school students		Middle school students		High school students	
		Before	After	Before	After	Before	After
Acceptance of nuclear power generation in the nation	Agree	19(54.3)	41(91.1)	19(86.4)	31(79.5)	15(68.2)	27(93.1)
	Disagree	16(45.7)	4(8.9)	3(13.6)	8(20.5)	7(31.8)	2(6.9)
Acceptance of nuclear power generation in the residential district	Agree	4(13.3)	17(37.8)	6(27.3)	12(31.6)	3(12.5)	18(62.1)
	Disagree	26(86.7)	28(62.2)	16(72.7)	26(68.4)	21(87.5)	11(37.9)

* Students who disagreed to acceptance of nuclear power generation in the nation and residential districted responded as such due to the risk of nuclear power generation. This response applies to all types of schools: elementary, middle and high school students.

2) Changes in knowledge, attitude and behavior by field of radiation use

All of elementary, middle and high school students showed a higher level of changes in knowledge, attitude and behavior regarding nuclear power generation, medical radiation, and irradiated food after education. Some areas did not show statistical significance, but still there were education effects. The theory of planned action by Ajzen and Fishbein (1980) shows that people determine their attitude toward behavior and subjective standard based on evaluative belief in behavior, normative belief in behavior, and motivation to follow the normative belief, having behavior intentions accordingly, which leads to behavior [23]. Nutbeam and Harris (2004) claim that behavior intention is strongly connected to behavior [24]. In other words, operating a model school led to changes in knowledge, attitude and behavior of elementary, middle and high school students, which suggests that their subjective standards are changing during the curriculum. It can be seen that education on understanding of nuclear power and radiation is effective for elementary, middle and high school students.

3) Comparison of education effects by school level

as a result of comparing education effects of operating a model school by school level, knowledge in nuclear power was highest in middle school students before education and in high school students after education. That is, knowledge education of nuclear power is effective for high school students. Attitude toward nuclear power was high in middle school students both before and after education.

Table 3. Changes in knowledge, attitude and behavior by field of radiation use

Category			Elementary school students		Middle school students		High school students	
			mean±SD	t (p-value)	mean±SD	t (p-value)	mean±SD	t (p-value)
Knowledge	Nuclear power generation	Before	1.96±1.525	-7.916 (.000)**	3.63±0.819	-2.321 (.026)*	2.66±1.370	-4.937 (.000)**
		After	3.72±0.858		3.97±0.716		4.14±0.639	
	Medical radiation	Before	1.67±1.506	-3.696 (.001)**	2.84±1.242	-3.717 (.001)**	2.64±1.569	-1.071 (.294)
		After	2.65±1.418		3.66±1.279		2.96±1.170	
	Irradiated food	Before	0.69±1.151	-7.725 (.000)**	2.55±1.483	-5.597 (.000)**	0.90±0.976	-14.612 (.000)**
		After	2.54±1.675		3.87±1.166		4.03±0.906	
Attitude	Nuclear power generation	Before	3.73±1.098	-2.707 (.011)*	4.53±0.687	-1.743 (.090)	4.03±0.680	-1.063 (.297)
		After	4.24±0.830		4.71±0.515		4.24±0.830	
	Medical radiation	Before	2.13±0.854	-4.960 (.000)**	2.78±0.470	0.000 (1.000)	2.47±0.865	-2.555 (.016)*
		After	2.73±0.601		2.78±0.523		2.93±0.371	
	Irradiated food	Before	1.44±0.592	-5.298 (.000)**	2.24±0.810	-1.506 (.140)	1.64±0.533	-9.319 (.000)**
		After	2.26±0.879		2.50±0.769		2.90±0.409	
Behavior	Medical radiation (diagnosis)	Before	2.29±0.957	-1.754 (.086)	2.59±0.715	-1.233 (.225)	2.34±0.897	-2.853 (.008)**
		After	2.51±.820		2.74±0.637		2.83±0.539	
	Medical radiation (treatment)	Before	1.88±.904	0.696 (.490)	2.18±0.790	0.868 (.391)	1.72±0.702	-3.086 (.005)**
		After	1.78±.587		2.05±0.647		2.17±0.468	
	Irradiated food (purchase)	Before	1.20±.539	-2.267 (.028)*	1.62±0.815	-0.144 (.886)	1.21±0.412	-0.682 (.501)
		After	1.53±.868		1.64±0.903		1.31±0.712	
	Irradiated food (intake)	Before	1.20±.499	-2.089 (.042)*	1.62±0.815	-0.285 (.777)	1.17±0.384	-1.185 (.246)
		After	1.49±.845		1.67±0.898		1.38±0.775	

* Knowledge and attitude consist of 5 items for each area, rated on the scale of 0 to 5. As for behavior, diagnosis and treatment choice of medical radiation and purchase and intake of irradiated food were rated on the scale of 1 to 2 (1 point was given for choosing diagnosis of medical radiation, 0 point for not choosing it. 1 point was given for purchasing irradiated food, and 0 point for not purchasing it.)

In other words, attitude changes showed most effects for middle school students. This indicates that knowledge can be changed for high school students, but it is not easy to bring changes to their attitude as well. To strategically apply the regular curriculum to secure receptivity toward nuclear power generation, it is necessary to consider providing education for middle school students. It is a well-known fact that the curriculum must consider the principles of the learners' psychological development as well as their needs, and the efficiency of education can be further increased by taking learners more into consideration [25].

4) Evaluating the relevance of education

Each criterion is set by collecting opinions of students, science teachers and experts to evaluate the relevance of education of the model school. As a result of evaluating the relevance according to the criteria, it was found that the level exceeded 90% in subject title, desirable human character, educational objective, curriculum objective, subject objective, and achievement of teaching/learning method. This proves that this model school is relevant and thus can be expanded nationwide. Low relevance in the category of grade for middle school students must be improved.

Table 4. Comparison of education effects by school level

Category			mean±SD	F (p-value)	mean±SD	F (p-value)
Knowledge	Nuclear power generation	Elementary	1.96±1.525	17.303 (.000)**	3.69±.875	3.206 (.044)*
		Middle	3.63±.819		3.95±.764	
		High	2.70±1.447		4.14±.639	
	Medical radiation	Elementary	1.67±1.506	8.112 (.001)**	2.58±1.444	8.379 (.000)**
		Middle	2.84±1.242		3.71±1.293	
		High	2.61±1.540		2.96±1.170	
	Irradiated food	Elementary	.67±1.144	29.741 (.000)**	2.53±1.689	14.994 (.000)**
		Middle	2.54±1.466		3.83±1.223	
		High	.79±.960		4.03±.906	
Attitude	Nuclear power generation	Elementary	3.73±1.098	8.572 (.000)**	4.27±.795	5.546 (.005)**
		Middle	4.53±.687		4.71±.508	
		High	3.97±.684		4.24±.830	
	Medical radiation	Elementary	2.12±.860	8.378 (.000)**	2.72±.599	1.508 (.225)
		Middle	2.78±.470		2.80±.507	
		High	2.42±.858		2.93±.371	
	Irradiated food	Elementary	1.43±.589	16.875 (.000)**	2.25±.874	6.812 (.002)**
		Middle	2.24±.810		2.45±.764	
		High	1.65±.579		2.90±.409	
Behavior	Medical radiation diagnosis	Elementary	2.26±.965	1.738 (.180)	2.51±.809	2.316 (.103)
		Middle	2.59±.715		2.74±.627	
		High	2.30±.883		2.83±.539	
	Medical radiation treatment	Elementary	1.86±.904	3.060 (.051)	1.80±.601	3.926 (.022)*
		Middle	2.18±.790		2.02±.643	
		High	1.73±.674		2.17±.468	
	Irradiated food purchase	Elementary	1.20±.535	5.288 (.006)**	1.59±.898	1.310 (.274)
		Middle	1.62±.815		1.62±.882	
		High	1.27±.452		1.31±.712	
	Irradiated food intake	Elementary	1.20±.495	5.841 (.004)**	1.51±.857	.845 (.432)
		Middle	1.62±.815		1.64±.879	
		High	1.24±.435		1.38±.775	

* Knowledge and attitude consist of 5 items each, and behavior consists of 2 items.

4. Conclusion

To help future generations make value judgments by acquiring proper information on nuclear power and radiation, this study came up with the first model school in Korea to apply as a regular curriculum to understand nuclear power and radiation. It is meaningful in itself to operate a model school, but it was more significant to find changes in knowledge, attitude and behavior regarding nuclear power generation and use of radiation after education. This implies that education might help prevent the vague anxiety toward nuclear power to result in wrong policy decisions. A curriculum cannot have significance just by being well planned, but can only have significance when actually applied in class [26, 27]. Tyler et al. (1949) emphasize that developing a curriculum requires selection and organization of contents and activities by taking various situations into account [28]. Adults whose perception cannot be changed easily need policy strategies to increase their national receptivity toward nuclear power, but future generations can change their perception through education such as the model school. Thus, expanding and applying this program nationwide will reduce social costs and vague anxiety, thereby allowing future generations to make proper value judgments about nuclear power and use of radiation.

It is difficult to activate communication in ideological and value-dominant policy issues like nuclear power generation by merely implementing one-sided persuasion skills or providing information [29].

Table 5. Criteria of curriculum

Category	For elementary school students	For middle school students	For high school students
Subject title	Radiation and Life	Nuclear Energy and Radiation	Nuclear Energy and Radiation
Desirable human character	Humans who properly know and understand nuclear power and radiation		Humans capable of rational judgments and behaviors regarding nuclear power and radiation
Educational objective	Accurately understanding and properly perceiving nuclear power and radiation		Properly understanding nuclear power and radiation and obtaining problem solving skills
Curriculum objective	Knowing the concept and importance of nuclear power and radiation through experiences and experiments		Properly understanding nuclear power and radiation by arousing interest
Subject objective	Understanding the concept, importance and contents of nuclear power and radiation		Cultivating extensive knowledge in the concept, importance, contents and applicability of nuclear power and radiation
Teaching/learning method	Using multimedia/methods such as visuals, images, experiments and experiences that arouse interest		
Evaluation method	Brief presentations (making presentation materials, making posters, providing comments, participating in discussions, etc.)		
Application of evaluation	Grades not reflected		

* This is developed by HAN (2014, 2015) [18, 19], so refer to the relevant article.

Table 6. Evaluating the relevance of education

Area	Elementary school students (%)	Middle school students (%)	High school students (%)
Subject title	96.2	100.0	100.0
Desirable human character	90.4	100.0	96.6
Educational objective	98.1	100.0	93.1
Curriculum objective	90.4	100.0	100.0
Subject objective	94.2	100.0	100.0
Teaching/learning method	94.2	95.2	96.6
Evaluation method	90.4	90.5	82.8
Application of evaluation	94.2	88.1	100.0
Education time	88.5	92.9	100.0
Textbook format	94.2	83.3	82.8
Grade of education	92.3	59.5	89.7
Form of education	92.3	95.2	96.6

* All questions were answered either as "relevant" or "irrelevant" to determine the relevance with frequency and percentage.

Furthermore, the question of what message should be provided to whom in what way for effective and efficient policy communication is the most fundamental consideration in the issue of nuclear power communication [30, 31]. Nonetheless, there has been failure in communication until today in the government and expert groups in Korea since education has been merely focused on unilaterally providing information for the public. Therefore, to reduce unnecessary social confusion related to nuclear power generation and use of radiation, it is necessary to make thorough preparations in the long run and operate the model school verified in this study at the national level.

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