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KOREAN STUDENTS' BEHAVIORAL CHANGE TOWARD NUCLEAR POWER GENERATION THROUGH EDUCATION

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As a result of conducting a 45 minute-long seminar on the principles, state of use, advantages, and disadvantages of nuclear power generation for Korean elementary, middle, and high school students, the levels of perception including the necessity ($p<0.017$), safety ($p<0.000$), information acquisition ($p<0.000$), and subjective knowledge ($p<0.000$), objective knowledge ($p<0.000$), attitude ($p<0.000$), and behavior ($p<0.000$) were all significantly higher. This indicates that education can be effective in promoting widespread social acceptance of nuclear power and its continued use. In order to induce behavior change toward positive judgments on nuclear power generation, it is necessary to focus on attitude improvement while providing the information in all areas related to the perception, knowledge, attitude, and behavior. Here, the positive message on the convenience and the safety of nuclear power generation should be highlighted.

KEYWORDS : Nuclear Power, Behavior, Educational Effect, Student, Change

1. INTRODUCTION

The rapid development of scientific technology has brought infinite potential and prosperity to human beings, but at the same time, has caused tremendous new risks which threaten the basis of human life. Due to the development of scientific technology, modern society is facing various socio-scientific issues such as the risk of accidents resulting from nuclear power generation; social problems resulting from energy exhaustion, moral problems regarding biotechnology, refugee problems resulting from climate change, and so on. As a result, science education researchers are highlighting the cultivation of the capability for value-based decision-making and rational coping based on the understanding of scientific technology [1, 2, 3, 4, 5, and 6]. However, students' scientific capability and sensitivity to socio-scientific issues are often lacking [6, 7, 8, 9, and 10]. In particular, risk perception of nuclear power tends to be cognitively anchored in negative images such as the Chernobyl nuclear accident and the Fukushima nuclear disaster, and insufficient responses after the accident. Public risk perception on nuclear power-related technologies or facilities is significantly affected as a result [11, 12]. One of the characteristics is that negative issues such as radioactive pollution of marine products, radioactive concentration in the air, safe food for future generations, as the direct or indirect influences of the Fukushima nuclear disaster, are often reported by media, and it is expected that such incidents will continue[13]. Due to such incidents, negative perceptions of nuclear power have increased [14, 15, 16, 17, 18, 19, and 20]. Thus, Korean people have expressed more concerns about nuclear power safety since the Fukushima nuclear accident in Japan [21, 22]. The public sentiment on new nuclear power plant construction is sharply divided between approval and disapproval [23]. If the Fukushima nuclear disaster in Japan is a sign of risk of nuclear safety, resulting in a philosophical on nuclear power generation safety, it may be inevitable that more fundamental doubts are raised about safety [24], which can cause tremendous social and economic damage. This indicates that education can be effective in promoting widespread social acceptance of nuclear power and its continued use [25]. One study stated the Fukushima nuclear disaster would not have any significant influence on future energy reduction, despite worldwide interest [26]. It argued that because energy is indispensable to humans, nuclear power is an economical and environmentally friendly energy effective for coping with infinite values of climate change, and its use is inevitable.

Nuclear power facilities are based upon their acceptability to local residents and citizens. In Korea, where nuclear power needs to be continuously used for national energy security and economic growth, it is important to enhance the social acceptability of nuclear power [21]. To do so, it is necessary to reassure Korean people and global nuclear power communities regarding safety. However, there is sharp division regarding the perception of nuclear power safety between the expert group of operators

and regulators on the one hand, and ordinary citizens, local residents, media, and anti-nuclear groups on the other [27]. There are no absolute answers on socio-scientific issues and such issues are unconstructed problems comprising various alternatives. Thus, the opportunities to understand and listen to various positions should be provided, and value-based decision-making should be encouraged. Through this process, not only scientific and technological understanding and their relationship to society could be cultivated, but also citizens' personal attitudes [9]. Various issues regarding nuclear power, and historically, environmentally, and geologically different factors between countries, should be comprehensively considered [28].

For this study, an experiment was designed to assess behavioral change. This was conducted as part of an educational strategy to enhance public understanding and to foster greater support for nuclear power generation appropriate. In order to provide fundamental evidence for planning an educational intervention strategy, this study analyzed the perception, knowledge, attitude, and behavioral change of elementary, middle, and high school students, who are then expected to have an impact on the education of the general population.

2. METHODOLOGY

In order to rationally change value judgments by providing accurate information on nuclear power generation, behavioral change was analyzed so that the grounds (perception, knowledge, attitude, and behavior) for educational intervention could be derived. As can be seen in [Fig. 1], the research consisted of five steps. The first was research design. In the process of designing the research, the subjects, method, content, and duration of the education, were determined. The Second involved sending official notifications and selecting final subjects, and then conducting a field trip. The third step was a pre-survey and step four involved conducting the lecture. Finally, the post-survey and vote on nuclear power plant construction was completed.

2.1 Subjects and Questionnaire Configuration

The research subjects were elementary, middle, and high school students, who will be the leaders in public sentiment regarding the use of nuclear power generation. A sample of 123 students from three schools in the capital area whose parents gave written informed consent was analyzed. There were 82 male students (66.7%) and 41 female students (33.3%) participating in the research. There were 43 elementary school students (35.0%), 45 middle school students (36.65), and 35 high school students (28.5%).

The questionnaire comprised questions on perception, knowledge, attitudes, and behavior related to nuclear power generation. The video and PowerPoint materials for the education, and ballot papers for the vote were prepared prior to the lecture. For the vote on nuclear power generation, potential construction venues for the hypothetical nuclear power plant were the entire nation and each participant's town. The education method included watching a video (10 minute long) and a lecture (25 minute long), which covered the principles, actual state, and current state of use of nuclear power generation. In order to minimize factual errors, one radiation expert was invited to conduct the education program for each class of subjects. The education was conducted from December 11 to 20, 2013.

As can be seen in [Fig 2], the contents of the survey were knowledge, attitude, and behavior according to the traditional learning model. In line with prior research, perception was analyzed for four factors: necessity, safety (dangerousness), information acquisition (familiarity), and subjective knowledge of nuclear power generation [29]. Each item was rated on a 5-point scale (1 point: strongly disagree–5 points: strongly agree). Objective knowledge was measured by five items regarding the features of nu-

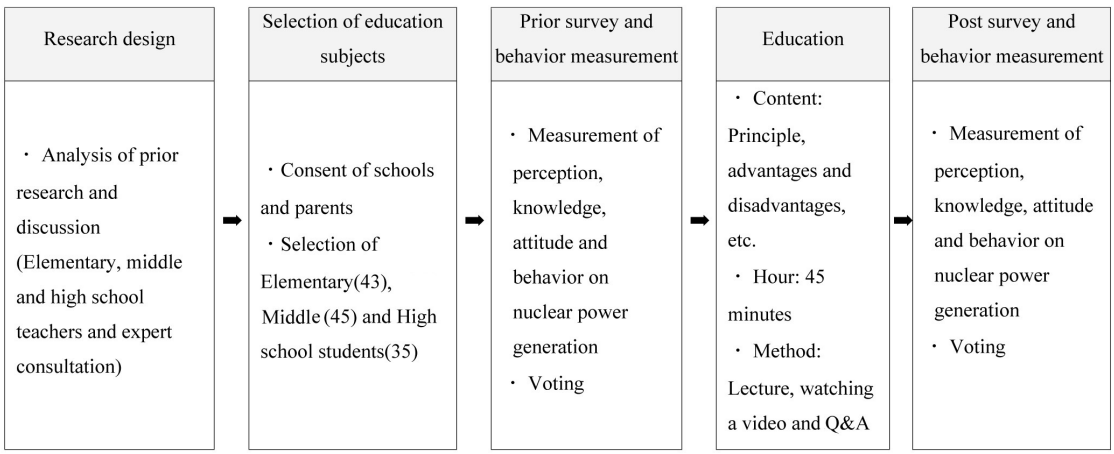

Fig. 1. Research Procedure

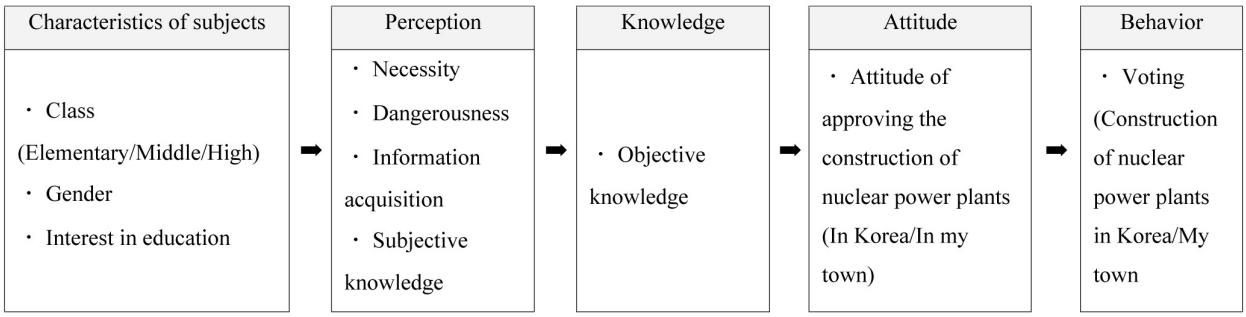

Fig. 2. Questionnaire Content

clear power plants, the actual operational state of domestic and foreign nuclear power plants, radiation exposure around nuclear power generation, and the notion of natural radiation. Higher objective knowledge levels were determined by the increased number of correct answers. The level of behavioral change was considered higher, as the number of students approving nuclear power plant construction increased. The right to vote was only given to the students who chose to participate in the vote on nuclear power plant construction.

Cronbach's α value prior to education was high for perception(including necessity, safety, information acquisition, and subjective knowledge) of 0.840, objective knowledge of 0.771, and attitude of 0.669.Cronbach′s α value after education was also high for perception of 0.870, objective knowledge of 0.737, and attitude of 0.610.

2.2 Analytical Methods

SPSS/WIN 15.0 was used for checking the frequency, percentage, mean, and standard deviation, simple correlation analysis (Pearson's Correlation Analysis), t-test, one-way ANOVA, and multiple regression analysis. For a posteriori testing, the Scheffe method was used. In order to determine scale credibility, Cronbach's α was used.

3. RESULTS

3.1 Characteristics of Subjects before and after the Education

Students who showed a high level of interest in nuclear power education before and after the educational intervention were 70.7% (87students) and 80.5% (99 students), respectively. Additionally, the students who chose to participate in the vote on Korean nuclear power plant construction before and after the education were 79.7% and 86.2%, respectively. The rates were relatively high.

However, the students were less interested in voting on nuclear power plant construction in their residential areas (69.1% and 77.9%, before and after the education, respectively). Before the education, the foremost reason for disapproving of nuclear power plant construction not only in Korea in general but also in their residential areas, was because of nuclear power plants. The approval rate for national nuclear power plant construction was 79.4% before the education, and increased to 94.2% after the education. The approval rate for construction in their own residential area was 34.1% before the education, increasing to 47.4% after the education as shown in Table 1.

3. 2 Perception, Knowledge, Attitude, and Behavior Level on Nuclear Power Generation before and after the Education

The levels of interest, perception (necessity, safety, information acquisition, and subjective knowledge), objective knowledge, attitude, and behavior toward nuclear power generation were all higher after the education. The level of perception on the necessity of nuclear power generation was highest both before (4.09±0.87 points) and after (4.27±0.78 points) the education. The attitude level of approval of nuclear power plant construction in their own residential area was the lowest both before (2.56±1.35 points) and after (3.33±1.34) the education. Frewer et al. (1998) reported that technological preferences are affected by the perception of the dangers and benefits, and perceived danger might change as perception of benefits changes [30].

Presumably, the reason why the perception level of nuclear power generation necessity is the highest and attitude level of approval of nuclear power plant construction in residential areas is lowest is the influence of the perceived danger. This is supported by the relatively low level (3.99±0.96 points) of safety perception even after the education as shown in Table 2.

3.3 Change in Perception, Knowledge, Attitude, and Behavior before and after the Education Per Academic Level

The levels of perception including the interest in education ($p<0.001$), necessity ($p<0.017$), safety ($p<0.000$), information acquisition ($p<0.000$), and subjective knowledge ($p<0.000$) were statistically significantly higher after the education than before the education for all elementary,

Table 1. General Characteristics of the Subjects before and after the Education

Item		Section	Before education	After education
			n(%)	n(%)
Interest in education		Low	9(7.3)	8(6.5)
		Moderate	27(22.0)	16(13.0)
		High	87(70.7)	99(80.5)
		Total	123(100.0)	123(100.0)
Intention to vote	Construction of nuclear power plants in Korea	Yes	98(79.7)	106(86.2)
		No	25(20.3)	17(13.8)
		Total	123(100.0)	123(100.0)
	Construction of nuclear power plants in my residential area	Yes	85(69.1)	95(77.9)
		No	38(30.9)	27(22.1)
		Total	123(100.0)	122(100.0)
Vote result	Construction of nuclear power plants in Korea	Approve	76(78.4)	98(94.2)
		Disapprove	21(21.6)	6(5.8)
		Total	97(100.0)	104(100.0)
	Reason for objection	Because it is dangerous	18(81.8)	4(66.7)
		Because it is inadequate	2(9.1)	1(16.7)
		Because it is useless	0(0.0)	0(0.0)
		Hate it for no reason	1(4.5)	1(16.7)
		Others	2(9.1)	0(0.0)
		Total	23(104.5)	6(100.0)
	Construction of nuclear power plants in my residential area	Approve	29(34.1)	45(47.4)
		Disapprove	56(65.9)	50(52.6)
		Total	85(100.0)	95(100.0)
	Reason for objection	Because it is dangerous	43(79.6)	26(47.3)
		Because it is inadequate	10(18.5)	10(18.2)
		Because it is useless	5(9.3)	2(3.6)
		Hate it for no reason	5(9.3)	8(14.5)
		Others	5(9.3)	9(16.4)
		Total	68(125.9)	55(100.0)

* In terms of multiple responses, for the frequency of the reasons for objecting to the construction of nuclear power plants, only the frequency of the students objecting to the construction of nuclear power plants was measured. There are some missing values.

middle, and high school students. Only elementary school students showed no statistically significant difference after the education in interest or voting on nuclear power generation approval. In particular, middle school students displayed the highest level (1.59±0.56 points) in terms of the behavior of voting on nuclear power plant approval ($p<0.000$). Additionally, middle school students displayed the highest level of interest in nuclear power education, perception, and attitude, but not objective knowledge as shown in Table 3. Although the high school students displayed the highest level of objective knowledge, their approval of nuclear power plant construction was

Table 2. The Levels of Perception, Knowledge, Attitude and Behavior regarding the Nuclear Power Plants before and after the Education

Item		Before education	After education
		Mean± SD	Mean± SD
Interest in education		3.98±1.03	4.18±1.00
Perception	Necessity	4.09±0.87	4.27±0.78
	Safety	3.41±1.08	3.99±0.96
	Information acquisition	3.29±1.20	4.23±0.74
	Subjective knowledge	3.30±1.09	4.00±0.83
Objective knowledge		3.06±1.64	4.05±1.32
Attitude	Approving the construction of nuclear power plants in Korea	3.65±1.13	4.15±0.88
	Disapproving the construction of nuclear power plants in my residential area	2.56±1.35	3.33±1.34
Behavior		1.13±0.78	1.42±0.62

* The interest in education, perception (necessity, safety, information acquisition and subjective knowledge), objective knowledge, and attitude regarding the nuclear power generation were measured bya 5-point scale (minimum 1 point, maximum 5 points) and the behavior was measured using a minimum rating of 0 points and a maximum rating of 2 points.

* Higher points refer to higher positive levels on each area.

Table 3. Change in Perception, Knowledge, Attitude and Behavior before and after the Education per Academic Level

Item		Education	Elementary		Middle		High		Overall	
			Mean± SD	t(p)	Mean± SD	t(p)	Mean± SD	t(p)	Mean± SD	t(p)
Interest in education		Before	4.14±0.77	-1.071 (.290)	4.47±0.73	-2.432 (.019)	3.14±1.14	-2.606 (.013)	3.98±1.03	-3.524 (.001)
		After	4.23±0.75		4.64±0.61		3.51±1.29		4.18±1.00	
Perception	Necessity	Before	4.07±0.80	-1.523 (.135)	4.22±0.88	-3.317 (.002)	3.94±0.94	.339 (.737)	4.09±0.87	-2.419 (.017)
		After	4.21±0.67		4.62±0.58		3.89±0.93		4.27±0.78	
	Safety	Before	3.62±0.82	-2.635 (.012)	3.71±1.20	-5.075 (.000)	2.77±0.94	-3.353 (.002)	3.41±1.08	-6.463 (.000)
		After	3.98±0.90		4.51±0.76		3.34±0.91		3.99±0.97	
	Information acquisition	Before	3.26±1.00	-4.723 (.000)	3.62±1.32	-5.265 (.000)	2.91±1.17	-4.694 (.000)	3.29±1.20	-8.502 (.000)
		After	4.02±0.71		4.67±0.52		3.91±0.78		4.23±0.74	
	Subjective knowledge	Before	3.07±0.94	-3.270 (.002)	3.71±1.22	-5.361 (.000)	3.06±0.97	-4.914 (.000)	3.30±1.09	-7.634 (.000)
		After	3.63±0.82		4.53±0.63		3.77±0.73		4.00±0.83	
Objective knowledge		Before	2.37±1.80	-4.475 (.000)	3.38±1.51	-5.429 (.000)	3.49±1.34	-4.970 (.000)	3.06±1.64	-8.619 (.000)
		After	3.26±1.72		4.47±0.92		4.51±0.56		4.06±1.33	
Attitude	(In Korea) Approve	Before	3.65±1.07	-2.793 (.008)	3.78±1.28	-4.259 (.000)	3.49±1.01	-2.066 (.047)	3.65±1.13	-5.396 (.000)
		After	4.02±0.91		4.53±0.63		3.80±0.96		4.15±0.88	
	(In my town) Approve	Before	2.93±1.30	-2.710 (.010)	2.76±1.48	-4.661 (.000)	1.86±0.94	-5.767 (.000)	2.56±1.35	-7.020 (.000)
		After	3.49±1.26		3.67±1.46		2.71±1.07		3.33±1.34	
Behavior		Before	1.55±0.67	1.000 (.329)	1.06±0.81	-3.919 (.000)	.69±0.60	-2.782 (.014)	1.13±0.79	-4.213 (.000)
		After	1.50±0.67		1.59±0.56		1.13±0.62		1.46±0.63	

* Although the objective knowledge level on the nuclear power generation after the education was significantly higher in high school students as compared to the other groups, the interest in education, perception (necessity, safety, information acquisition and subjective knowledge), attitude and behavior were all significantly higher in middles school students as compared to others. This indicates that the education effect regarding the change in perception, attitude and behavior through a short-term education is strongest in the group of middle school students.

Table 4. Behavior Change before and after the Education according to the Characteristics of Subjects

Item		Section	Before education					After education				
						Mean± SD	t/F (p)				Mean± SD	t/F (p)
Characteristics of subjects	Gender	Male				1.19±0.73	.859 (.399)				1.38±0.61	-.843 (.40)
		Female				1.03±0.85					1.50±0.63	
	Class	Elementary	a			1.55±0.67	6.486 (.003)	a			1.52±0.64	6.591 (.002)
		Middle		b		1.08±0.82		a			1.60±0.55	
		High		b		0.72±0.58			b		1.08±0.56	
	Interest in education	Low				0.75±0.50	2.491 (.090)				1.20±0.84	.940 (.394)
		Moderate				0.81±0.83					1.22±0.67	
		High				1.24±0.76					1.46±0.60	
Perception	Necessity	Moderate				0.94±0.80	-1.213 (.236)				1.00±0.63	-2.345 (.036)
		High				1.20±0.76					1.47±0.60	
	Safety	Low	a			0.73±0.79	9.374 (.000)	a			0.40±0.55	5.628 (.005)
		Moderate	a			0.84±0.69			b		1.25±0.55	
		High		b		1.50±0.70			b		1.55±0.56	
	Information acquisition	Low	a			0.72±0.75	3.379 (.039)				-	-1.734 (.086)
		Moderate		b		1.26±0.73					1.10±0.74	
		High		b		1.24±0.77					1.46±0.60	
	Subjective knowledge	Low	a			0.62±0.77	4.976 (.009)				-	-1.078 (.284)
		Moderate		b		1.07±0.80					1.32±0.57	
		High		b		1.36±0.68					1.48±0.61	
Attitude	Approval attitude (In Korea)	Low	a			0.15±0.55	18.877 (.000)	a			0.25±0.50	20.662 (.000)
		Moderate		b		1.13±0.72			b		0.80±0.42	
		High		b		1.39±0.64				c	1.57±0.53	
	Approval attitude (In my town)	Low	a			0.66±0.57	37.360 (.000)	a			0.83±0.39	46.059 (.000)
		Moderate		b		1.21±0.70			b		1.15±0.37	
		High			c	1.91±0.42				c	1.83±0.48	

* a, b, c refer to the same group in the post analysis. The highest rate is 2 points.

the lowest. This indicates that high objective knowledge level does not lead to the approval of the construction of nuclear power plants.

3.4 Comparison of Behavioral Change before and after the Education according to the Characteristics of Subjects

The approval rates of plant construction nationally and in residential areas were compared. The highest rating was 2 points (approving construction both in Korea and individual's residential area) and the lowest rate was 0 points (disapproval of construction both in Korea and individual's residential area). Elementary school students showed high approval behavior rates ($p<0.003$) before the education, but the middle school students showed high approval behavior rates ($p<0.002$) after the education. The students who perceived safety as high both before and after the education ($p<0.000$, $p<0.005$), the students who approved highly of nuclear power plant construction in Korea ($p<0.000$, $p<0.000$), and the students who approved highly of nuclear power plant construction in their own residential areas ($p<0.000$, $p<0.000$) also showed high approval behaviors (i.e., voting) on nuclear power plant construction as shown in Table 4.

In order to create positive behavior change on nuclear power generation, it is necessary to improve the perception of the safety of nuclear power or to encourage the approval of nuclear power generation. That is, offering knowledge alone will only result in limited behavioral change. Yamamura (2012) reported that the perceived danger of nuclear accidents is related to technological disasters [17], and Visschers and Siegrist (2012) showed that perceived benefits significantly influence the acceptance of nuclear power [16]. Ho et al. (2013) reported that the perception of danger in nuclear power has been the major decision factor in nuclear power plant construction since the Fukushima nuclear disaster [31]. As the benefits to nuclear power are perceived as higher, the acceptance of nuclear power is higher [16, 31, and 32]. As found in the present research and prior research, high levels of perception of the necessity and safety of nuclear power generation leads to high levels of approval of nuclear power generation.

3.5 Correlation between Variables before and after the Education

A statistically significant correlation was discovered between interest in education, perception (necessity, safety, information acquisition, and subjective knowledge), attitude, and behavior toward nuclear power plant construction. The students who displayed high information acquisition both before and after the education showed high subject knowledge levels. All behaviors showed positive correlations except for subjective knowledge. That is, the students who had high interest in education and the students who had positive perception levels (including the safety, necessity, information acquisition, and subjective knowledge of nuclear power plants) showed high approval rates of nuclear power plant construction. In particular, the variable with the highest relevance to approval behavior of nuclear power plants construction is the approval of nuclear power plants in residential areas. What is unusual is that the objective knowledge about nuclear power and the approval behavior of nuclear power plant construction had no correlation either before or after the education as shown in Tables 5.

Biel and Dahlstrand (1995) discovered that attitudes toward nuclear power, and trust in the government and experts, substantially affects danger perception, but individual knowledge about nuclear waste does not have any influence [36]. Davidson and Freudenburg (1996) hypothesized that knowledge increase would reduce interest, but this was not supported despite repeated examinations [37]. Stoutenborough et al. (2013) also examined public support after the Fukushima nuclear disaster, but discovered that knowledge of nuclear power did not influence policy support [38]. Traditionally in practical research, only the importance of knowledge was highlighted in the danger perception of scientific technology, but the role of knowledge has not been that significant in the danger perception process; other factors have been playing more important roles [33, 39]. However, this should not be interpreted to mean that offering knowledge has no effect on behavior change in nuclear power generation approval. It is thought that Public attitudes regarding science are presented differently depending on the related knowledge level; and, knowledge accumulation will lead to rational judgment [40]. Thus, attitudes should be positively changed through offering knowledge in order to positively impact behavior. Kuncruther (2001) found that a scarcity of knowledge about nuclear power led to more severe perceptions of danger, and this caused the difference of perspective on danger between the general population and experts [34]. Research describes that in the case of nuclear power, level of related knowledge has a close correlation with perception [35].

In the present research, on the questionnaire regarding objective knowledge, responses to the statement "the residents near nuclear power plants are more exposed to the radiation than the residents in other areas" showed the lowest level of accurate knowledge before and after the education. That is, a majority of the general public think that the residents near the nuclear power plants are more exposed to radiation than the residents in other areas. This corresponds to the finding that the general population perceives scientific technology through emotional experiences, not knowledge. [33]. Thus, in order to create approval behavior toward nuclear power generation, attitudes should be positively changed and knowledge education should be provided together because the attitude is affected by the knowledge. Here, knowledge correlates with perception, and thus the message of increasing positive perceptions should also be included.

3.6 Factors Affecting the Behavior of Approving Nuclear Power Generation before and after the Education

Multiple linear regression analysis was conducted by setting the behavior of nuclear power plant construction approval as the dependent variable and setting the interest in education, perception (necessity, safety, information acquisition, and subjective knowledge), objective knowledge, and attitude (approval of nuclear power plants in Korea and approval of nuclear power plants in residential areas) as the independent variables. The variable with the greatest influence on the approval behavior before and after the education was the approval attitude. This means that when the approval attitude of nuclear power plants in an individual's residential area is high, the behavior of approving actual construction of nuclear power plants could be raised as well. The explanatory power before and after the education was 54.3% and 59.9%, respectively as shown in Table 6.

The change in the general public's attitude to nuclear power may vary depending on the country [14, 41], and in the present research, it could also be inferred that the attitude of approving nuclear power generation in the

residential area was most closely related. This confirms research that the attitude of ordinary citizens on nuclear power might reveal extreme worries, concerns, interest, etc., when a group is more directly affected in their daily lives [42]. Only objective knowledge has no correlation. The high correlation of attitude and behavior corroborates research that individual danger perception of scientific technology is created by emotional judgment, not rational judgment [43, 44, 45, and 46].

Table 5. Correlation of the Interest in Education, Perception, Knowledge, Attitude and Behavior before and after the Education

Section	Item	Interest in education	Necessity	Safety	Information acquisition	Subjective knowledge	(In Korea) Approval attitude	(In my town) Approval attitude	Objective knowledge	Behavior
Before education	Interest in education	1								
	Necessity	.553**	1							
	Safety	.607**	.583**	1						
	Information acquisition	.365**	.518**	.532**	1					
	Subjective knowledge	.327**	.472**	.532**	.701**	1				
	Approval attitude (In Korea)	.317**	.449**	.513**	.354**	.351**	1			
	(In my town) Approval attitude	.341**	.251**	.523**	.333**	.268**	.511**	1		
	Objective knowledge	.045	.336**	.246**	.262**	.324**	.254**	.030	1	
	Behavior	.337**	.335**	.441**	.300**	.345**	.591**	.681**	**.101**	1
After education	Interest in education	1								
	Necessity	.653**	1							
	Safety	.640**	.658**	1						
	Information acquisition	.649**	.600**	.517**	1					
	Subjective knowledge	.425**	.494**	.452**	.756**	1				
	Approval attitude (In Korea)	.480**	.501**	.599**	.410**	.480**	1			
	Approval attitude (In my town)	.334**	.345**	.561**	.301**	.309**	.477**	1		
	Objective knowledge	.165	.247**	.065	.443**	.372**	.147	-.006	1	
	Behavior	.252*	.335**	.537**	.209*	.286**	.620**	.706**	**-.033**	1

* The case that denotes the attitude level of approving the construction of nuclear power plants in my town indicates that the behavior of voting for the approval of the construction of nuclear power plants is also high.

* High objective knowledge does not necessarily mean high behavior level to construct nuclear power plant.

* $p < 0.005$, ** $p < 0.001$

Table 6. Factors Affecting the Behavior of Approving the Nuclear Power Generation before and after the Education

Section	Item	Non-standard coefficient		Standard coefficient	t	p
		B	Standard error	β		
Before education	(Constant)	-.714	.350		-2.041	.045
	Interest in education	.022	.083	.028	.266	.791
	Necessity	.092	.119	.099	.772	.443
	Safety	-.047	.093	-.065	-.509	.613
	Information acquisition	-.084	.082	-.127	-1.022	.310
	Subjective knowledge	.106	.080	.153	1.317	.192
	Objective knowledge	.012	.047	.023	.260	.796
	Approval attitude (In Korea)	.168	.074	.247	2.257	.027
	Approval attitude (In my town)	.291	.060	.539	4.857	.000
	F	10.268(.000)				
	R^2	0.543				
After education	(Constant)	-.397	.309		-1.284	.203
	Interest in education	-.127	.075	-.200	-1.698	.093
	Necessity	.033	.101	.042	.330	.743
	Safety	.055	.090	.083	.604	.547
	Information acquisition	.042	.115	.052	.365	.716
	Subjective knowledge	-.032	.093	-.042	-.346	.730
	Objective knowledge	.005	.038	.011	.146	.884
	Approval attitude (In Korea)	.267	.075	.388	3.566	.001
	Approval attitude (In my town)	.228	.040	.498	5.675	.000
	F	15.115(.000)				
	R^2	0.599				

4. DISCUSSION

As a result of conducting a 45 minute-long education on the principles, state of use, advantages, and disadvantages of nuclear power generation for Korean elementary, middle, and high school students, the levels of perception including the necessity ($p<0.017$), safety ($p<0.000$), information acquisition ($p<0.000$), and subjective knowledge ($p<0.000$), objective knowledge ($p<0.000$), attitude ($p<0.000$), and behavior ($p<0.000$) were all significantly higher. This indicates that if education for enhancing social acceptance in Korea argued nuclear power should be constantly used, an educational effect could be anticipated. When offering the education, a few strategies are necessary as follows.

First, because the behavior of approving nuclear power generation did not correlate with objective knowledge and showed highest relevance with attitude, education focused on forming desirable attitudes, not education focused on offering information, should be provided. The research of Shower (1995) comparing the knowledge and attitude of high school students on nuclear energy also reported that persuasion is effective in changing attitude [47].

Second, in many cases, education for attitude change should be designed under the assumption that the perceptions of the general population toward scientific technology are based on emotional experiences [33]. In Finucane et al.'s (2000) research, emotion played a critical role in the judgment of the danger and benefits [48]. In the present research as well, the reason why the perception level of nuclear power convenience is high while the approval be-

havior level on nuclear power generation is low seems to be related to the relatively low perception of safety level even after education. Educational content focused on convenience and safety should be based on emotion in order to be most effective.

Third, in developing educational content focused on the convenience and safety, a focus on positive information would increase its effectiveness. That is because when positive information on scientific technology is given, consumer purchase motivation on related products is raised, whereas when negative information is given, negative messages operate more strongly [49]. Peters and Slovic (1996) discovered that the perception and acceptance of danger (particularly of nuclear power) are determined through two types of psychological systems (cognition and emotion) and the interaction of unitive influences within the constituents of such psychological systems [50]. This indicates that positive and negative messages on the necessity and safety of nuclear power generation should be offered at the same time while focusing on the positive message.

Fourth, in terms of educational content, it is necessary to prove that the information focused on the perception change of the convenience and safety of nuclear power is appropriate to the state of Korea. The perception of a given danger is calculated by the multiplication of danger probability and danger severity, but individual danger perception is not necessarily related to actual danger severity. It is reported that various factors such as emotion, experience, socio-cultural environment, and values play more important roles in human judgment [39, 51, and 52].

Finally, in order to change attitudes (which has the greatest influence on behavior), perception and objective knowledge level (which are related to the attitude) should be raised as well. Although objective knowledge does not have any direct influence on behavior change, it is an important variable for attitude change, and thus information on objective knowledge should be offered as well. Here, the contents preferred by the education subjects should also be considered. The effect of the message is enhanced when various formats of information are offered [53]. According to So et al. (2011), danger perception may actually differ even with the same content depending on the genre of the TV program [54].

5. CONCLUSIONS

In order to induce behavior change toward positive judgments on nuclear power generation, it is necessary to focus on attitude improvement while providing the information in all areas related to perception, knowledge, attitude, and behavior. Here, the positive message on the convenience and the safety of nuclear power generation should be highlighted. Choi et al. (2011) described scientific requirements that global citizens require in order to solve current socio-scientific issues (SSI) by classifying them into five dimensions. These include content knowledge integrating science, the cognitive habit of scientific thinking, character and values, understanding the nature of science (science as human endeavor), and meta cognition and self-direction [55]. In the present research, students who had high interest in education, students who positively perceived necessity and safety, and students who had positive attitude levels showed high approval behavior toward nuclear power, and thus this indicates that an educational design in various dimensions is necessary. This confirms Zeidler et al.'s (2005) highlighting not only scientific technology understanding of SSI, but also the moral and ethical development of the students. Teaching strategies that can develop moral and ethical sensitivity and the acceptance of various perspectives and understanding (such as sympathetic consideration) toward SSI are necessary [5]. Considering that present research corroborates previous research, it would be desirable to provide ongoing education in perception, knowledge, attitude, and behavior regarding the necessity and safety of nuclear power generation in order to enhance its social acceptance in Korea. The present research has been performed as one experiments and not enough sample of elementary, middle, and high school students in Korea. Therefore it would be necessary to derive more objective educational strategies by conducting the education with a larger group.

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REFERENCES

[1] National Research Council, "Conceptual Framework for New Science Education Standards" Retrieved from http://www7.nationalacademies.org, (2011).

[2] D. A. Roberts, "Scientific literacy" In S. K. Abelland N.G. Lederman (eds.), *Handbook of Research on Science Education*, pp. 729-780 (2007).

[3] T. D. Sadler, "Informal Reasoning Regarding Socio-scientific Issues: A Critical Review of the Research" *Journal of Research in Science Teaching*, vol. 41, pp. 513-536 (2004).

[4] D. L. Zeidler and M. Keefer, "The Role of Moral Reasoning and the Status of Socio-scientific Issues in Science Education" In D. L. Ziedler (ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education*, Kluwer Academic Press, The Netherlands, pp. 7-38 (2003).

[5] D. L. Zeidler, T. D. Sadler, M. L. Simmons, and E. V. Howes, "Beyond STS: A Research-based Framework for Socio-scientific Issues Education" *Science Education*, vol. 89, pp. 357-377 (2005).

[6] J. Y. Jang, J. Y. Mun, H. S. Ryu, K. H. Choi, K. Joseph, and S. W. Kim, "Korean Middle School Students' Perceptions as Global Citizens of Socio-scientific Issues" *Journal of the Korean Association for Science Education*, vol. 32, pp. 1124-1138 (2012).

[7] M. J. Bebeau, J. R. Rest, and D. Narvaez, "Beyond the Promise: A Perspective on Research in Moral Education" *Educational Researcher,* vol. 28, pp. 18-26 (1999).
[8] H. Clarkeburn, "A Test for Ethical Sensitivity in Science" *Journal of Moral Education*, vol. 31, pp. 439-453 (2002).
[9] T. D. Sadler, "Moral Sensitivity and Its Contribution to the Resolution of Socio-scientific Issues" *Journal of Moral Education*, vol. 33, pp. 339-358 (2004).
[10] S. R. Fowler, D. L. Zeidler, and T. D. Sadler, "Moral Sensitivity in the Context of Socio-scientific Issues in High School Science Students" *International Journal of Science Education*, vol. 31, pp. 279-296 (2009).
[11] M. Greenberg, K. Lowrie, J. Burger, C. Powers, M. Gochfeld, and H. Myer, "The Ultimate LULU? Public Reaction to New Nuclear Activities at Major Weapons Sites" *Journal of American Planning Association*, vol. 73, pp, 346–351 (2007).
[12] H. J. Lee and S. T. Park, "Comparison of Perception Differences About Nuclear Energy in 4 East Asian Country Students: Aiming at 10th Grade Students who Participated in Scientific Camps, from Four East Asian Countries: Korea, Japan, Taiwan, and Singapore" *Journal of the Korean Association for Research in Science Education*, vol. 32, pp. 775-788 (2012).
[13] H. J. Seo, "Fukushima Nuclear Accident and Negative Perceptions" *Journal of Governmental Studies*, vol. 19, pp. 321-361 (2013).
[14] G. Pratiand B. Zani, "The Effect of the Fukushima Nuclear Accident on Risk Perception, Antinuclear Behavioral Intentions, Attitude, Trust, Environmental Beliefs, and Values" *Environment and Behavior*, vol. 45, pp. 782-798 (2012).
[15] M. Siegristand V. H. M. Visschers, "Acceptance of Nuclear Power: The Fukushima Effect" *Energy Policy*, vol. 59, pp. 112-119 (2013).
[16] V. H. M. Visschersand M. Siegrist, "Fair Play in Energy Policy Decisions: Procedural Fairness, Outcome Fairness and Acceptance of the Decision to Rebuild Nuclear Power Plants" *Energy Policy*, vol. 46, pp. 292-300 (2012).
[17] E. Yamamura, "Experience of Technological and Natural Disaster and their Impact on the Perceived Risk of Nuclear Accidents After the Fukushima Nuclear Disaster in Japan 2011: A Cross-country Analysis" *The Journal of Socio-Economics*, vol. 41, pp. 360-363 (2012).
[18] D. K. Bird, K. Haynes, R. V. D. Honert, J. McAneney, and W. Poortinga, "Nuclear Power in Australia: A Comparative Analysis of Public Opinion Regarding Climate Change and the Fukushima Disaster" *Energy Policy*, vol. 65, pp. 644-653 (2014).
[19] P. M. Figueroa, "Risk Communication Surrounding the Fukushima Nuclear Disaster: An Anthropological Approach" *Asia Europe Journal*, vol. 11, pp. 53-64 (2013).
[20] P. Pongsoiand S. Wongwises, "A Review on Nuclear Power Plant Scenario in Thailand" Renewable and Sustainable *Energy Reviews*, vol. 24, pp. 586-592 (2013).
[21] K. Y. Cho and J. H. Moon, "Investigation of Perception of Nuclear Power by the Local Residents Adjacent to Nuclear Installations" *Journal of the Nuclear Fuel Cycle and Waste Technology*, vol. 9, pp.181-189 (2011).
[22] S. Y. Yu, "A Public Relations Policy Study on Recovered Confidence of the People for a Nuclear Plant" *The Journal of Digital Policy and Management*, vol. 11, pp. 287-294 (2013).
[23] K. S. Park, "Reexamination of Nuclear Safety Legislation" *Administrative Law Journal*, vol. 33, pp.169-190 (2012).
[24] T. H. Kim "Sicherheitsgewahrleistung Durch Atomrechtssystem" *Administrative Law Journal*, vol. 30, pp. 39-65 (2011).
[25] The Asahi Shinmun, 2011. 6. 9. http://ajw.asahi.com/article/0311disaster/fukushima/AJ201106090571
[26] M. Hayashi and L. Hughes, "The Fukushima Nuclear Accident and its Effect on Global Energy Security" *Energy Policy*, vol. 59, pp. 102-111 (2013).
[27] Nuclear Safety and Security Commission, Korea Institute of Nuclear Safety, Korea Institute of Nuclear Nonproliferation and Control, "2012 Nuclear Safety Yearbook" *2012 Nuclear Safety Yearbook*. pp. 1-518 (2013).
[28] Y. H. Kim, M. K. Kim, and W. J. Kim, "Effect of the Fukushima Nuclear Disaster on Global Public Acceptance of Nuclear Energy" *Energy Policy*, vol. 61, pp. 822-828 (2013).
[29] E. O. Han and Y. S. Choi, "Development of a Tool to Measure Knowledge, Attitude and Behavior towards Irradiated Food" *Journal of the Academia-Industrial Cooperation Society*, vol. 14, pp. 3096-3101, (2013).
[30] L. J Frewer, C. Howard, and R. Shepherd, "Understanding Public Attitudes to Technology" *Journal of Risk Research*, vol. 1, pp. 221-235 (1998).
[31] J. C. Ho, S. F. Kao, J. D. Wang, C. T. Su, C. T. Lee, R. Y. Chen, H. L. Chang, M. C. Ieong, and P. W. Chang, "Risk Perception, Trust, and Factors Related to a Planned New Nuclear Power Plant in Taiwan after the 2011 Fukushima Disaster" *Journal of Radiological Protection*, vol. 33, pp. 773-789 (2013).
[32] J. I. deGroot, L. Steg, and W. Poortinga, "Values, Perceived Risks and Benefits, and Acceptability of Nuclear Energy" *Risk Analysis*, vol. 33, pp. 307-317 (2013).
[33] S. Krimsky, "The Role of Theory in Risk Studies" In S. Krimsky and D. Golding (eds.), *Social Theories of Risk*, Praeger, Westport, CT, pp. 3-22 (1992).
[34] H. Kunreuther, "Risk Analysis and Risk Management in an Uncertain World" *Risk Analysis*, vol. 22, pp. 655-664 (2002).
[35] L. Sjbergand B. Drottz-Sjberg, "Knowledge and Risk Perception among Nuclear Power Plant Employees" *Risk Analysis*, vol. 11, pp. 607–618 (1991).
[36] A. Biel and U. Dahlstrand, "Risk Perception and the Location of a Repository for Spent Nuclear Fuel" *Scandinavian Journal of Psychology*, vol. 36, pp. 25-36 (1995).
[37] D. J. Davidson and W. R. Freudenburg, "Gender and Environmental Risk Concerns: A Review and Analysis of Available Research" *Environment and Behavior*, vol. 28, pp. 302-339 (1996).
[38] J. W. Stoutenborough, S. G. Sturgess, and A. Vedlitz, "Knowledge, Risk, and Policy Support: Public Perceptions of Nuclear Power" *Energy Policy*, vol. 62, pp. 176-184 (2013).
[39] P. Honkanen and B. Verplanken, "Understanding Attitudes towards Genetically Modified Food: The Role of Values and Attitude Strength" *Journal of Consumer Policy*, vol. 27, pp. 401-420 (2004).
[40] D. A. Scheufele and B. Lewenstein, "The Public and Nanotechnology: How Citizens Make Sense of Emerging Technologies" *Journal of Nanoparticle Research*, vol. 7, pp. 659-667 (2005).

[41] M. V. Ramana, "Nuclear Policy Response to Fukushima: Exit, Voice, and Loyalty" *Bulletin of the Atomic Scientists*, vol. 69, pp. 66-76 (2013).
[42] B. M. Drottz-Sjöbergand L. Sjöberg, "Risk Perception and Worries after the Chernobyl Accident" *Journal of Environmental Psychology*, vol. 10, pp. 135-149 (1990).
[43] H. J. Lee and Y. A. Lee, "Affect Heuristic in Risk and Benefit Perception of Scientific Technologies" *Korean Journal of Cognitive Science*, vol. 8, pp. 305-324 (2007).
[44] P. Slovic, M. L. Finucane, E, Peters, and D. G. MacGregor, "The Affect Heuristic" *European Journal of Operational Research*, vol. 177, pp. 1333-1352 (2007).
[45] Y. A. Lee and N. K. Lee, "Psychological Dimensions of Risk Perception" *Korean Journal of Cognitive Science*, vol. 6, pp. 199-211 (2005).
[46] P. Fleming, E. Townsend, J. A. van Hilten, A. Spence, and E. Ferguson, "Expert Relevance and the Use of Context-Driven Heuristic Processes in Risk Perception" *Journal of Risk Research*, vol. 15, pp. 857-873 (2012).
[47] D. E. Showers and R. L. Shrigley, "Effect of Knowledge and Persuasion on High School Students' Attitudes toward Nuclear Power Plants" *Journal of Research in Science Teaching*, vol. 32, pp. 29-43 (1995).
[48] M. L. Finucane, A. Alhakami, P. Slovic, and S. M. Johnson, "The Affect Heuristic in Judgments of Risks and Benefits" *Journal of Behavioral Decision Making*, vol. 13, pp. 1-17 (2000).
[49] J. A. Fox, D. J. Hayes, and J. F. Shogren, "Consumer Preferences for Food Irradiation: How Favorable and Unfavorable Descriptions Affect Preferences for Irradiated Pork in Experimental Auctions" *Journal of Risk and Uncertainty*, vol. 24, pp. 75-95 (2002).
[50] E. Peter and P. Slovic, "The Role of Affect and Worldviews as Orienting Dispositions in the Perception and Acceptance of Nuclear Power" *Journal of Applied Social Psychology*, vol. 26, pp. 1427-1453 (1996).
[51] D. Bem, "The Concept of Risk in the Study of Human Behavior" In J. Dowie and P. Lefrere II, (eds.), *Risk and Chance: Selected Readings*, The Open University Press, Milton Keynes, England, pp. 1-15 (1980).
[52] N. Weinstein, "Unrealistic Optimism about Future Life Events" *Journal of Personality and Social Psychology*, vol. 39, pp. 806-820 (1980).
[53] S. K. Reed, "*Cognition: Theories and Application* (8th ed.)" Wadsworth Cengage Learning, Belmont, CA (2010).
[54] S. J. So, H. Y. Cho, and J. R. Lee, "Genre-Specific Media and Perceptions of Personal and Social Risk of Smoking among South Korean College Students." *Journal of Health Communication: International Perspectives*, vol. 16, pp. 533-549 (2011).
[55] K. H. Choi, H. J. Lee, N. S. Shin, S. W. Kim, and J. Krajcik, "Re-conceptualization of Scientific Literacy in South Korea for the 21st Century" *Journal of Research in Science Teaching*, vol. 48, pp. 670-697 (2011).