DEVELOPMENT OF NUCLEAR ENERGY AND RADIATION TEXTBOOKS FOR ELEMENTARY, MIDDLE, AND HIGH SCHOOL STUDENTS

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Received June 18, 2015 / 1st Revised August 7, 2015 / Accepted for Publication August 13, 2015

To develop tailored elementary, middle, and high school textbooks suitable for understanding the nuclear energy and radiation, quantitative and qualitative research was carried out in parallel, which included nine steps to ensure the validity of content and structure. The elementary, middle, and high school students wanted to acquire information used in their daily lives, including the definition of nuclear energy and radiation, principles and status of nuclear power generation, and information about irradiated food, medical radiation, and radiation in life. In the evaluation of the effects of textbook contents according to the educational requirements of each school level, high suitability frequencies (>80%) were shown for the human character, education goals, curriculum goals, evaluation method, and education time. At some levels, the high suitability frequencies (>70%) were shown for the education grade, education type, and textbook type.

Keywords: Nuclear energy, Radiation, Textbook, School student, Education, Perception

1. INTRODUCTION

For the fluid diversity of use of radiation in the nuclear power generation, which is a major source of energy and improvements in health and welfare in South Korea, the knowledge and trust of the citizens is required [1, 2]. However, because average individuals do not have enough science and technology knowledge, they rely on emotional perceptions based on their experiences rather than rational judgments [3]. The perception of risk has characteristics of cognitive anchoring induced by strong and negative images, such as the Chernobyl and Fukushima nuclear power plant accidents and the consequences thereof. Thus, perception of risk in nuclear energy, related technologies, and nuclear facilities are affected greatly [4, 5]. After the Fukushima nuclear power plant accident, the negative information about direct and indirect effects, such as the radiation contamination of marine products, radioactive concentration in atmosphere, and safe food for future generations, were often reported by the news media [6]; consequently, the negative perception of nuclear power generation and radiation has increased [7-11]. Furthermore, although the need for raising the ability to judge the media critically is increasing, no one can escape the influence of media in our information-based society [13]. It is very difficult for the average individual to make proper value judgments in a social environment where incorrect or hardly understandable information about nuclear power and radiation is disseminated through the media. For this reason, there are many issues surrounding the use of radiation and nuclear power in South Korea [12].

To address the gap existing between average citizens and experts, even though it is not due to a simple difference in knowledge, high quality information and ed-

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ucation are key components [14]. Education cannot be isolated from media in our information-based society, but can bring social changes [15]. Therefore, relevant education must be provided to ensure social acceptance and appropriate judgments of the values and risks of nuclear energy and radiation, which are important for future generations. In South Korea, students learn about nuclear power generation as well as radiation through minimal information in science textbooks; most students acquire concepts through teaching-learning activities between teachers and students. Therefore, if a science teacher has an inaccurate perception about nuclear energy and radiation, this may have an improper influence on students. Textbooks are not only the most common source of knowledge for students but also the most important teaching-learning materials, and essential tools for teachers. In school education, the influence of textbooks is absolute. The basic function of textbooks is to present knowledge to students in a manner and order that the students can comprehend and accept. Therefore, textbooks have a function in determining and controlling the direction and scope of teaching and learning [16]. However, at present, although there is serious social confusion about nuclear energy and radiation, no school subjects or teaching materials have been developed.

The most important and difficult task in developing curriculum is selecting the educational content [17]. The content must be that which is required by most students and most urgently needed. It must be able not only to attract the attention and interest of students but also to raise and satisfy their curiosity [18]. The contents must include the information necessary to solve problems and achieve students' goals. In the construction of curriculum, the psychological development of students, in addition to their demands and needs, must be taken into consideration; when there is a strong focus on students, the efficiency of education is increased [19]. However, fragmentary information provided by relevant organizations about nuclear energy and radiation does not provide the basis for informed value judgments by average individuals or students; instead, it provides knowledge from the perspective of experts. As a result, the social acceptance of nuclear energy and radiation use has not been adequately facilitated. Tyler et al. (1949) emphasized that various circumstances must be considered in selecting and organizing educational curriculum and activities [20]. Therefore, taking the circumstances of the present time and the situation of information receivers, this study aimed to develop textbooks about nuclear energy and radiation targeting elementary, middle, and high school students, the leaders of the next generation.

2. METHODS

In this study, to develop tailored elementary, middle, and high school textbooks suitable for understanding the nuclear energy and radiation, qualitative and quantitative research was carried out in parallel, which included nine steps to ensure the validity of content and structure.

2.1 Step 1

A discussion session regarding the status and educational direction of nuclear energy and radiation understanding was held with twelve people representing science teachers of each grade and experts of nuclear energy and radiation. At this meeting, it was determined that standardized nuclear energy and radiation education is necessary, and the methods of regular class and creative experience learning were selected as the appropriate educational formats. There were various opinions regarding the education medium and contents, and common opinions were reflected in the survey questionnaire.

2.2 Step 2

The format and contents of education on nuclear energy and radiation for students in South Korea and overseas were collected. Information was currently provided on a variety of methods, including the dispatching of instructors, information sharing on a websites, Questions and Answers, textbook publication, field study, and mentoring programs at various organizations (Korea Hydro & Nuclear Power, Korea Nuclear Energy Foundation, Korea Institute of Nuclear Safety, Korea Atomic Energy Research Institute, Korea Academy of Nuclear Safety, Korean Association for Radiation Application, and Women in Nuclear Korea). The concepts, principles, and use of nuclear energy and radiation accounted for the largest proportion of the contents of the materials, and other information, such as effects on humans and safe management methods, were provided.

2.3 Step 3

Student discussion sessions were held to construct the educational requirement draft that included the information that elementary, middle, and high school students wanted to know about nuclear energy and radiation. Approximately eight students were recommended by science teachers from the sixth grade of elementary school, third year of middle school, and third year of high school (the final year of each school level) and a discussion session was held separately for each level. Through the discussion sessions, objective and varied information on nuclear energy and radiation was provided; this was followed by an open discussion on the themes and contents that held interest for the students. After the discussion, students were asked to compose the themes and content for 13 class lessons to be learned in one semester, and the high frequency themes and contents themes were included on the previously mentioned survey questionnaire. Using the questionnaire, preliminary surveys were carried out at each school level to ensure the validity of content in the questionnaire.

2.4 Step 4

A partial revision was made to the preliminary survey questionnaire for 13 class lessons through consultation with science teachers and experts. When there were differences in the suggested content, precedence of the contents and themes of the students were taken over those of the teachers and experts.

2.5 Step 5

The educational requirements survey was conducted to select the tailored educational content. In elementary schools, 134 people participated: 57 sixth grade students (42.5%), 32 elementary school science teachers (23.9%), and 45 experts in the fields of nuclear energy and radiation (33.6%). In middle schools, 126 people participated: 52 third-year students (41.3%), 29 middle school teachers (23.0%), and 45 experts in the fields of nuclear energy and radiation (35.7%). In high schools, 131 people participated: 56 third-year students (42.7%), 30 high school science teachers (22.9%), and 45 experts in the fields of nuclear energy and radiation (34.4%). For the selection of themes and contents of thirteen class lessons covering one semester, we attempted to reflect the opinions of students, science teachers, and experts. Using SPSS Windows 15.0, the frequencies and percentages of themes and contents were identified.

2.6 Step 6

The content and structure validity of the educational content result for nuclear energy and radiation understanding, developed in consultation with the nuclear energy and radiation experts, were reviewed; the statistical analysis results were confirmed.

2.7 Step 7

Twelve experts in the pertinent field addressed in each class lesson wrote the contents, which resulted in the preliminary textbooks. The authors were nuclear energy and radiation professors and experts in national regulatory organizations, research institutes, and universities. To match the contents to the grade levels, science teachers of the school levels edited the developed textbook contents.

2.8 Step 8

The textbooks were evaluated in two sets of simulated classes. First, the suitability of textbook contents for each class lesson, such as content and structure suitability, simplicity or difficulty, and amount of preliminary textbooks, was evaluated. The evaluation of the textbooks was held after conducting the first set of simulated classes, using the preliminary textbooks, for sixth grade elementary school students, second-year middle school students, and first-year high school students; these grades were deemed the appropriate place for the curriculum developed in Step 5. There were 95 textbook evaluators: 30 sixth grade elementary students (31.6%), 34 second-year middle school students (35.7%), and 31 first-year high school students (32.6%). Based on the evaluation of content suitability for each lesson in the textbooks, the revision and supplementation process was conducted. Using the finalized textbooks, the second set of simulated classes was conducted for the analysis of educational effect. There were 143 evaluators of educational effect: 37 sixth grade elementary students, 33 second-year middle school students, and 73 first-year high school students. To ensure the objectivity of evaluation, different evaluators took part in the first and second rounds. For the analysis, SPSS Windows 15.0 was used to analyze the averages, standard deviations, frequencies, and percentages.

2.9 Step 9

The final draft of the textbooks was determined through consultation with the experts. Minimize errors of the instructor is required so performed by one expert lecture. This result does not represent the opinion of all elementary, middle, and high school students in Korea. Taba (1962) noted that the first step in educational curriculum development is connecting theory and practice, and it is followed by eight subordinate steps sequentially: diagnosis of requirements; setting a goal; selection of contents; organization of contents; selection of study experiences; organization of study activities; determination of evaluation targets, method, and measures; and verification of balance and sequence [21]. Taba's educational curriculum development steps were used in this study.

3. RESULTS

3.1 Theme Suitability for Elementary School Students

The themes of the 13 lessons had a high suitability frequency (>70%). The lowest rating was 73.7% for "Which jobs are related to nuclear energy and radiation?" (Lesson 11). Theme suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated as 11.18 by elementary school students, 10.10 by elementary school science teachers, and 10.97 by experts. This represents a high average suitability of 10.84. Therefore, the themes were suitable for inclusion in the elementary school textbook (Table 1).

Table 1. Themes of Suitability for Elementary School Students.

Lesson	Theme		Elementary school students	Elementary school teachers	Experts	Total N (%)
1	Definition of nuclear energy and radiation	Suitable	45(78.9)	28(87.5)	43(95.6)	116(86.6)
2	History of nuclear energy and radiation	Suitable	47(82.5)	16(50.0)	39(88.6)	102(76.7)
3	Importance of nuclear energy and radiation	Suitable	54(94.7)	25(78.1)	38(84.4)	117(87.3)
4	Risks of nuclear energy and radiation	Suitable	54(94.7)	31(96.9)	36(80.0)	121(90.3)
5	Coping methods during an incident	Suitable	55(96.5)	30(93.8)	35(77.8)	120(89.6)
6	Utilization of nuclear energy and radiation	Suitable	47(82.5)	29(90.6)	44(97.8)	120(89.6)
7	Nuclear energy generation	Suitable	47(82.5)	17(53.1)	37(82.2)	101(75.4)
8	Irradiation of food	Suitable	46(80.7)	20(62.5)	34(75.6)	100(74.6)
9	Medical radiation	Suitable	50(89.3)	24(75.0)	33(76.7)	107(81.7)
10	Radiation-related products in daily life	Suitable	50(87.7)	23(74.2)	34(75.6)	107(80.5)
11	Nuclear energy and radiation related jobs	Suitable	41(73.2)	25(78.1)	32(71.1)	98(73.7)
12	Energy in the future	Suitable	53(93.0)	29(90.6)	44(97.8)	126(94.0)
13	Concept of Talk-Talk(a study review game)	Suitable	47(82.5)	26(81.3)	40(90.9)	113(85.0)
Theme suitability (average)		Suitable	11.18	10.10	10.95	10.84
		Unsuitable	1.82	2.9	2.05	2.16

* The themes of suitability were scored from 0 to 13 points.

Table 2. Themes of Suitability for Middle School Students.

Lesson	Theme		Middle school students	Middle school teachers	Experts	Total N (%)
1	Definition of nuclear energy	Suitable	44(84.6)	27(90.0)	45(100.0)	116(91.3)
2	Nuclear energy technology	Suitable	40(76.9)	20(69.0)	36(80.0)	96(76.2)
3	Current status of nuclear energy utilization	Suitable	39(75.0)	28(93.3)	41(91.1)	108(85.0)
4	Definition of radiation	Suitable	45(86.5)	25(86.2)	42(93.3)	112(88.9)
5	Risks of radiation	Suitable	50(96.2)	27(90.0)	39(86.7)	116(91.3)
6	Use of radiation for food	Suitable	35(67.3)	17(65.4)	40(88.9)	92(74.8)
7	Household products using radiation	Suitable	40(76.9)	24(80.0)	39(88.6)	103(81.7)
8	Radiation in life	Suitable	45(86.5)	29(96.7)	42(95.5)	116(92.1)
9	Nuclear bombs	Suitable	37(71.2)	20(66.7)	30(71.4)	87(70.2)
10	Misunderstandings and truths about radiation	Suitable	46(88.5)	27(90.0)	37(84.1)	110(87.3)
11	Progress in nuclear energy research	Suitable	34(66.7)	22(75.9)	30(68.2)	86(69.4)
12	Pro-con debate about nuclear energy	Suitable	25(49.0)	19(65.5)	34(77.3)	78(62.9)
13	Energy in the future	Suitable	49(94.2)	28(93.3)	44(100.0)	121(96.0)
Theme suitability (average)		Suitable	10.14	10.65	11.29	10.66
		Unsuitable	2.86	2.35	1.71	2.34

* The themes of suitability were scored from 0 to 13 points.

3.2 Theme Suitability for Middle School Students

In 11 lessons out of 13, the theme suitability frequencies were high (>70%). The lowest suitability rating was for “Pros and cons in the debate on nuclear energy” (Lesson 12) (62.9%), but had a relatively high suitability rating by experts (77.3%). “Progress in nuclear energy research” (Lesson 11), the second lowest suitability rating (69.4%), had a rating of 75.9% by teachers. Theme suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated at 10.14 by middle school students, 10.65 by middle school science teachers, and 11.29 by experts. This represents a high average suitability of 10.66. Therefore, although a partial revision is required for Lessons 11 and 12, these themes were suitable for inclusion in the middle school textbook (Table 2).

Table 3. Themes of Suitability for High School Students.

Lesson	Theme		High school students	High school teachers	Experts	Total N (%)
1	History of nuclear energy and radiation	Suitable	39(69.6)	27(90.0)	40(88.9)	106(80.9)
2	Definition of nuclear energy and radiation	Suitable	53(94.6)	30(100.0)	43(95.6)	126(96.2)
3	Misunderstandings and truths about radiation	Suitable	47(85.5)	25(86.2)	40(88.9)	112(86.8)
4	Types of radiation	Suitable	50(89.3)	29(96.7)	45(100.0)	124(94.7)
5	Nuclear power generation	Suitable	44(78.6)	27(90.0)	44(97.8)	115(87.8)
6	Radiation utilization for food	Suitable	41(73.2)	24(80.0)	40(88.9)	105(80.2)
7	Medical radiation	Suitable	47(83.9)	27(90.0)	42(93.3)	116(88.5)
8	Industrial radiation	Suitable	38(67.9)	24(80.0)	42(93.3)	104(79.4)
9	Radiation for research	Suitable	40(71.4)	21(72.4)	40(88.9)	101(77.7)
10	Current domestic and overseas status related to radiation	Suitable	43(76.8)	27(90.0)	39(86.7)	109(83.2)
11	Radiation incidents and contamination	Suitable	51(91.1)	29(96.7)	36(80.0)	116(88.5)
12	Discussion (expert-centric)	Suitable	31(55.4)	28(93.3)	40(88.9)	99(75.6)
13	Discussion (student-centric)	Suitable	30(54.5)	28(96.6)	37(86.0)	95(74.8)
Theme suitability (average)		Suitable	10.00	11.74	11.79	11.00
		Unsuitable	3.00	1.26	1.21	2.00

* The themes of suitability were scored from 0 to 13 points.

Table 4. Textbook Content Suitability for Elementary Students.

Lesson	Education content		Elementary school students	Elementary school teachers	Experts	Total N (%)
1	Concept, type, existence status, characteristics	Suitable	44(81.5)	27(84.4)	42(93.3)	113(86.3)
2	History of technical progress, important historical figures	Suitable	40(71.4)	16(51.6)	38(84.4)	94(71.2)
3	Benefits of nuclear power generation and radiation uses, probable issues when nuclear power and radiation are not used	Suitable	46(82.1)	26(81.3)	36(80.0)	108(81.2)
4	Risk criteria, Fukushima/ Chernobyl incident, radiation exposure and human disorders, damage period	Suitable	51(91.1)	32(100.0)	34(75.6)	117(88.0)
5	Incident types, coping methods of students, safety gear or facilities during incident	Suitable	52(92.9)	31(96.9)	32(71.1)	115(86.5)
6	Principles of utilization, current status of utilization	Suitable	47(83.9)	28(87.5)	42(95.5)	117(88.6)
7	Principles and structure of nuclear power plants	Suitable	44(78.6)	22(68.8)	32(71.1)	98(73.7)
8	Principles, types of utilization, and current status of food irradiation	Suitable	39(69.6)	22(68.8)	31(68.8)	92(69.2)
9	Principles and types of medical radiation diagnosis and treatments	Suitable	48(87.3)	27(84.4)	32(72.7)	107(81.7)
10	Types of radiation irradiated products used at home	Suitable	49(87.5)	27(87.1)	32(71.1)	108(81.8)
11	Occupational clusters related to nuclear energy and radiation, work performed in each occupational cluster	Suitable	41(73.2)	27(84.4)	32(71.1)	100(75.2)
12	Transition process and current utilization status of energy; types, principle, and practicality of future energy	Suitable	49(87.5)	31(96.9)	43(95.6)	123(92.5)
13	Problem solving regarding radiation and nuclear energy, imagination	Suitable	47(83.9)	28(87.5)	40(88.9)	115(86.5)
Learning element suitability (average)		Suitable	10.75	11.00	10.41	10.69
		Unsuitable	2.25	2.00	2.59	2.31

* The themes of suitability were scored from 0 to 13 points.

3.3 Theme Suitability for High School Students

The themes of 13 lessons had high suitability frequency (70%). The lowest observed frequency was 74.8% for “Group discussion about the uses of radiation and nuclear energy” (Lesson 13). Theme suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated as 10.00 by the high school students, 11.74 by the high school science teachers, and 11.79 by the experts. This represents a high average suitability of 11.00. Therefore, these themes were suitable for inclusion in the high school textbook (Table 3).

3.4 Textbook Content Suitability for Elementary School Students

The textbook contents of 12 lessons had high suitability frequencies (70%). The content area “Why is radiation used for food?” (Lesson 8) had a relatively low suitability frequency (69.2%). Content suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated as 10.75 by the elementary school students, 11.00 by the elementary school science teachers, and 10.41 by the experts. This represents a high average suitability of 10.69. Therefore, although some revision is necessary by the textbook content of Lesson 8, the textbook contents were suitable for elementary, middle, and high school students (Table 4).

3.5 Textbook Content Suitability for Middle School Students

The textbook contents of 11 lessons had high suitability frequencies (>70%). “Progress in nuclear energy research” (Lesson 11) had a content suitability rating of 68.9%, but the students’ rating was 73.1%. The “Pro and cons in the debate on nuclear energy and radiation” (Lesson 12) had the lowest overall suitability frequency (60.5%), but the experts’ rating was relatively high (70.5%). Content suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated as 9.69 by the middle school students, 10.42 by the middle school science teachers, and 11.31 by the experts. This represents a high average suitability of 10.42. Therefore, although some revision is necessary for the textbook content of Lessons 11 and 12, the textbook contents were suitable for middle school students (Table 5).

Table 5. Textbook Content Suitability for Middle School Students.

Lesson	Education content		Middle school students	Middle school teachers	Experts	Total N (%)
1	Concept of atoms, concept and principles of nuclear energy, characteristics of nuclear power generation	Suitable	41(78.8)	27(93.1)	44(97.8)	112(88.9)
2	History of technological progress, perception of nuclear energy in each country	Suitable	37(71.2)	20(71.4)	37(82.2)	94(75.2)
3	Changes in energy uses, use of nuclear power plant, medical radiation utilization technology	Suitable	40(76.9)	28(96.6)	42(93.3)	110(87.3)
4	Concept of radiation, characteristics by type of radiation, important historical figures of radiation discovery	Suitable	39(75.0)	18(64.3)	42(95.5)	99(79.8)
5	Incident types, effect on the human body, method of reducing exposure damages, risk levels at home and school	Suitable	44(84.6)	25(86.2)	41(91.1)	110(87.3)
6	Principles, types, and current status of food irradiation; safety of irradiated food	Suitable	35(67.3)	18(66.7)	39(88.6)	92(74.8)
7	Types of household products using the radiation, principle and current status radiation use, safety of household products	Suitable	40(76.9)	24(82.8)	39(90.7)	103(83.1)
8	Types of radiation in life, radiation dosage in life	Suitable	41(78.8)	29(100.0)	42(97.7)	112(90.3)
9	Basic principles, history, risks, damage cases, and ethical values of nuclear bombs	Suitable	35(68.6)	20(69.0)	30(71.4)	85(69.7)
10	Misunderstandings and truths: investigation of urban legends about fish, rain, mutation, etc.	Suitable	40(76.9)	23(79.3)	36(83.7)	99(79.8)
11	Current level of nuclear energy technology, future research direction of nuclear energy, large-scale accelerator	Suitable	38(73.1)	18(66.7)	28(65.1)	84(68.9)
12	Questions regarding nuclear energy and radiation, yes and no poll, persuading other people	Suitable	25(48.1)	19(67.9)	31(70.5)	75(60.5)
13	Energy depletion and sustaining period, earth environment and energy, nuclear fusion research (ITER), space development	Suitable	46(88.5)	29(100.0)	44(100.0)	119(95.2)
Learning element suitability (average)		Suitable	9.69	10.42	11.31	10.42
		Unsuitable	3.31	2.58	1.69	2.58

* The themes of suitability were scored from 0 to 13 points.

Table 6. Textbook Content Suitability for High School Students.

Lesson	Education content		High school students	High school teachers	Experts	Total N (%)
1	First discoveries and scientists, history of incidents, history of development process	Suitable	42(75.0)	26(89.7)	41(91.1)	109(83.8)
2	Definitions of nuclear energy and radiation, understanding of radiation	Suitable	53(94.6)	30(100.0)	42(95.5)	125(96.2)
3	Misunderstandings and truths: investigation of urban legends about fish, rain, mutation, etc.	Suitable	47(85.5)	26(86.7)	39(86.7)	112(86.2)
4	Natural radiation, artificial radiation	Suitable	51(91.1)	30(100.0)	45(100.0)	126(96.2)
5	Principles of nuclear power generation, safety design system, current status and policies, utilization status and alternative energy	Suitable	44(80.0)	25(83.3)	43(95.6)	112(86.2)
6	Principles of irradiation of food, types and utilization status, safety	Suitable	44(78.6)	24(80.0)	40(88.9)	108(82.4)
7	Medical radiation utilization technology, medical radiation exposure amount and allowable standards, factors to consider	Suitable	49(87.5)	27(90.0)	42(93.3)	118(90.1)
8	Non-destructive radiation testing, radiation gauge, neutron use, environment conservation use, radioactive tracer, radiation sterilization	Suitable	42(75.0)	25(83.3)	40(88.9)	107(81.7)
9	Principles of accelerator, research areas	Suitable	42(75.0)	21(72.4)	38(84.4)	101(77.7)
10	Difference in perceptions of nuclear energy and radiation, pro and con cases, utilization status, related occupational clusters	Suitable	45(80.4)	25(83.3)	40(88.9)	110(84.0)
11	Incident cases (Chernobyl, Fukushima), radioactive waste, descendants of atomic bomb victims	Suitable	51(91.1)	28(93.3)	37(82.2)	116(88.5)
12	Listening to expert opinions (food, mutation, alternative energy, radiation exposure)	Suitable	31(55.4)	26(89.7)	40(88.9)	97(74.6)
13	Group discussions, yes / no poll for nuclear power generation and radiation usage, value judgment	Suitable	33(58.9)	27(93.1)	39(90.7)	99(77.3)
Learning element suitability (average)		Suitable	10.20	11.50	11.81	11.03
		Unsuitable	2.8	1.5	1.91	1.97

* The themes of suitability were scored from 0 to 13 points.

3.6 Textbook Content Suitability for High School Students

The textbook contents of the 13 lessons had high suitability frequencies (>70%). Content suitability was measured by assigning one point to each suitable lesson; the overall suitability was rated as 10.20 by the high school students, 11.50 by the high school science teachers, and 11.03 by the experts. This represents a high average suitability of 11.03. Therefore, the textbook contents were suitable for high school students (Table 6).

3.7 Evaluation of Textbook Contents for Elementary School Students

With respect to the contents of the 13 lessons developed in total for the elementary school textbook, the clarity of the contents had the highest score (3.95±0.58), and the interest factor had the lowest score (2.97±0.69). Due to the characteristics of nuclear energy and radiation textbook, since clear content is more important than interest, we believe the full contents were acceptable. Nevertheless, cartoons, photographs, and images should be added to improve interest and understandability for elementary school students (Table 7).

3.8 Evaluation of Textbook Contents for Middle School Students

With respect to the contents of the 13 lessons developed for the middle school textbook, the clarity of the contents had the highest score (4.07±0.56), and the easiness of the contents had the lowest score (2.88±0.64). Due to the characteristics of nuclear energy and radiation textbook, since clear content is more important than easy content, we believe the full contents were acceptable. Nevertheless, cartoons, photographs, and images should be added to provide easily accessible information and improve understandability for middle school students (Table 8).

3.9 Evaluation of Textbook Contents for High School Students

With respect to the contents of the 13 lessons developed for the high school textbook, the clarity of the contents had the highest score (3.76±0.46), and the easiness of the contents had the lowest score

Table 7. Evaluation of Textbook Contents for Elementary School Students.

Classification	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10	Lesson 11	Lesson 12	Lesson 13	Total (Mean±SD)		
														Lowest	Highest	Average
1. The contents are helpful.	4.00 (0.38)	3.87 (0.82)	3.87 (0.63)	4.10 (0.88)	3.90 (0.61)	3.93 (0.64)	3.90 (0.71)	4.10 (0.61)	4.13 (0.73)	3.93 (0.74)	3.80 (0.89)	3.80 (0.76)	3.87 (0.63)	2.92	5.00	3.93 (0.43)
2. The contents are easy.	2.87 (0.94)	3.00 (1.05)	3.13 (0.90)	3.03 (0.89)	2.77 (1.07)	2.70 (0.84)	2.70 (0.92)	3.37 (0.93)	3.30 (1.12)	3.23 (0.90)	3.13 (0.90)	3.17 (0.99)	3.70 (0.92)	2.00	4.54	3.08 (0.60)
3. There are too much information.	3.03 (1.03)	2.67 (0.96)	3.33 (0.92)	3.20 (1.06)	3.30 (0.92)	2.93 (0.91)	2.97 (0.89)	3.10 (0.92)	2.87 (1.07)	2.87 (1.04)	2.87 (0.82)	2.87 (0.82)	2.63 (0.96)	1.31	3.77	2.97 (0.56)
4. It is better to learn in class than in an experiment	3.20 (1.35)	3.13 (1.17)	3.30 (1.06)	3.33 (1.15)	3.17 (1.26)	3.23 (1.10)	3.73 (1.01)	3.43 (1.36)	3.33 (1.03)	3.33 (1.15)	3.30 (0.99)	3.50 (1.07)	3.57 (0.97)	1.00	4.85	3.35 (0.80)
5. The contents are clear.	3.97 (0.72)	3.73 (0.74)	4.10 (0.71)	4.03 (0.76)	3.73 (0.83)	4.03 (0.81)	4.00 (0.77)	3.97 (0.89)	4.03 (0.76)	3.93 (0.69)	3.97 (0.93)	3.87 (0.86)	3.77 (0.77)	2.92	5.00	3.95 (0.58)
6. The contents are interesting.	2.60 (1.07)	2.93 (0.83)	2.93 (0.98)	2.93 (0.94)	2.67 (0.99)	2.63 (1.00)	2.90 (0.99)	3.13 (0.78)	3.37 (1.13)	3.27 (1.01)	2.87 (0.97)	2.87 (1.04)	3.50 (1.01)	1.85	5.00	2.97 (0.69)
7. The contents induce interest.	3.17 (0.95)	3.27 (1.11)	3.03 (1.19)	3.17 (1.15)	2.90 (0.96)	2.97 (1.16)	2.93 (1.20)	3.37 (1.19)	3.13 (1.14)	3.43 (1.04)	3.20 (1.22)	3.17 (1.09)	3.40 (0.97)	1.38	5.00	3.16 (0.83)
8. More cartoons are necessary.	3.80 (1.19)	4.20 (1.06)	3.83 (1.12)	3.77 (1.19)	3.93 (1.05)	3.63 (1.27)	3.80 (1.00)	3.17 (1.12)	3.13 (1.25)	3.17 (1.32)	3.25 (1.40)	3.37 (1.22)	2.80 (1.32)	1.31	5.00	3.54 (0.89)
9. More photographs or images are necessary.	3.77 (1.10)	4.13 (0.94)	4.33 (0.84)	4.43 (0.86)	4.13 (1.04)	4.03 (0.93)	4.13 (1.01)	3.23 (1.48)	3.27 (1.14)	3.17 (1.37)	3.33 (1.32)	3.27 (1.23)	3.27 (1.28)	2.23	5.00	3.73 (0.59)
10. The contents are suitable overall.	4.07 (0.87)	3.73 (0.78)	3.57 (0.86)	3.70 (0.84)	3.87 (0.90)	3.87 (0.86)	3.93 (0.87)	3.80 (1.00)	4.07 (0.87)	4.00 (0.64)	3.80 (1.00)	3.90 (0.92)	4.20 (0.76)	3.00	4.92	3.88 (0.60)

*All scores are mean (SD).

†All questions were scored on a 5-point scale; a higher score is associated with a positive result for questions 1, 5, 6, 7, and 10, and a median score is associated with positive results for questions 2 and 3. Questions 4, 8, and 9 were on subjects required a more complex analysis to bring about high/low scores. (For question 4, the students were required to participate in both an experiment and class. For questions 8 and 9, cartoons, photographs, and an image oriented textbook was desired, but due to difficulties in developing images for the textbook, the evaluation was conducted as if the images had been developed.)

Table 8. Evaluation of Textbook Contents for Middle School Students.

Classification	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10	Lesson 11	Lesson 12	Lesson 13	Total (Mean±SD)		
														Lowest	Highest	Average
1. The contents are helpful.	3.71 (0.87)	3.59 (0.86)	3.59 (0.99)	3.97 (0.94)	3.94 (0.95)	3.85 (0.96)	3.91 (1.03)	3.59 (1.13)	3.82 (1.03)	3.94 (0.92)	3.44 (1.11)	3.82 (1.14)	3.79 (0.95)	1.00	4.77	3.77 (0.80)
2. The contents are easy.	2.68 (0.77)	2.32 (0.84)	2.24 (0.82)	2.88 (0.98)	2.76 (0.97)	3.29 (0.97)	3.06 (1.07)	3.09 (1.11)	2.88 (1.04)	3.38 (1.04)	2.35 (0.92)	3.44 (1.11)	2.97 (1.17)	1.00	3.92	2.88 (0.64)
3. There are too much information.	3.38 (0.92)	3.56 (1.21)	4.32 (0.68)	3.09 (1.01)	3.56 (1.05)	3.15 (1.13)	2.88 (1.04)	2.38 (1.26)	3.47 (1.08)	2.47 (1.16)	3.21 (1.01)	2.79 (1.12)	3.15 (1.08)	1.85	5.00	3.16 (0.63)
4. It is better to learn in class than in an experiment	3.06 (1.18)	3.09 (1.00)	2.94 (1.15)	3.32 (1.12)	3.24 (1.05)	2.97 (1.07)	2.88 (1.09)	3.09 (1.11)	2.97 (1.22)	3.47 (1.16)	3.15 (1.16)	3.18 (1.19)	3.71 (0.94)	1.00	4.15	3.16 (0.61)
5. The contents are clear.	4.24 (0.74)	4.15 (0.70)	4.21 (0.73)	4.24 (0.61)	4.00 (0.85)	4.12 (0.64)	4.06 (0.69)	3.91 (0.79)	3.97 (0.87)	4.03 (0.90)	3.91 (0.90)	4.06 (0.55)	4.06 (0.74)	2.85	5.00	4.07 (0.56)
6. The contents are interesting.	2.88 (1.04)	2.82 (1.11)	2.91 (1.24)	3.35 (1.07)	2.97 (1.24)	3.41 (1.18)	3.56 (1.05)	3.15 (0.93)	3.21 (1.17)	3.24 (1.21)	2.59 (1.05)	3.50 (1.19)	3.29 (1.19)	1.08	4.62	3.14 (0.72)
7. The contents induce interest.	2.91 (0.97)	3.00 (1.10)	2.76 (1.18)	3.12 (1.09)	3.32 (1.30)	3.47 (1.11)	3.41 (1.18)	3.18 (1.17)	3.12 (1.19)	3.26 (1.26)	2.47 (0.96)	3.39 (1.25)	3.24 (1.08)	1.08	4.31	3.12 (0.74)
8. More cartoons are necessary.	3.53 (1.02)	3.74 (1.05)	3.44 (1.21)	2.88 (1.19)	3.50 (1.13)	3.18 (1.24)	2.82 (1.09)	3.03 (1.09)	3.62 (1.18)	3.33 (1.19)	3.71 (1.22)	2.71 (1.19)	3.29 (1.12)	1.69	4.54	3.37 (0.65)
9. More photographs or images are necessary.	3.21 (0.95)	4.12 (0.95)	3.82 (1.04)	2.94 (1.28)	3.82 (1.14)	2.76 (1.02)	3.09 (1.08)	3.24 (1.05)	3.65 (1.15)	3.94 (1.10)	3.97 (1.06)	3.03 (1.36)	3.56 (1.24)	2.15	4.85	3.45 (0.58)
10. The contents are suitable overall.	3.74 (0.71)	3.82 (0.80)	3.71 (0.84)	3.97 (0.80)	3.71 (1.00)	4.03 (0.80)	4.15 (0.82)	3.94 (0.98)	3.85 (0.82)	4.00 (0.74)	3.53 (0.96)	4.06 (0.98)	4.06 (0.74)	2.77	5.00	3.89 (0.60)

[*]All scores are mean (SD).

[†]All questions were scored on a 5-point scale; a higher score is associated with a positive result for questions 1, 5, 6, 7, and 10, and a middle score is associated with positive results for questions 2 and 3. Questions 4, 8, and 9 were on subjects required a more complex analysis to bring about high/low scores. (For question 4, the students were required to participate in both an experiment and class. For questions 8 and 9, cartoons, photographs, and an image oriented textbook was desired but, due to difficulties in developing images for the textbook, the evaluation was conducted as if the images had been developed.)

Table 9. Evaluation of Textbook Contents for High School Students.

Classification	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10	Lesson 11	Lesson 12	Lesson 13	Total (Mean±SD)		
														Lowest	Highest	Average
1. The contents are helpful.	3.42 (0.99)	3.68 (0.65)	3.77 (0.96)	3.55 (0.93)	3.71 (0.82)	3.65 (0.88)	3.74 (0.89)	3.55 (0.89)	3.29 (0.94)	3.65 (0.91)	3.55 (0.96)	3.81 (0.79)	3.61 (0.99)	2.23	4.54	3.61 (0.57)
2. The contents are easy.	2.81 (1.01)	3.03 (0.84)	3.68 (0.79)	2.52 (0.85)	2.77 (0.96)	3.55 (0.89)	2.87 (0.96)	2.97 (0.95)	2.48 (0.81)	3.13 (1.02)	2.97 (0.98)	3.48 (1.03)	3.84 (0.86)	1.46	4.00	3.08 (0.57)
3. There are too much information.	3.77 (0.92)	2.19 (0.83)	2.74 (0.82)	3.71 (1.04)	3.16 (0.64)	3.32 (0.83)	3.16 (0.82)	3.13 (0.81)	3.03 (1.08)	3.32 (0.87)	3.16 (1.04)	2.65 (1.05)	2.32 (1.14)	2.31	4.15	3.05 (0.46)
4. It is better to learn in class than in an experiment	3.10 (0.91)	3.06 (1.09)	3.13 (1.06)	3.13 (1.02)	3.10 (1.11)	3.26 (1.03)	3.23 (1.12)	3.16 (1.10)	3.23 (1.09)	3.35 (1.08)	3.52 (0.89)	3.35 (1.08)	3.35 (1.17)	1.31	4.92	3.23 (0.77)
5. The contents are clear.	3.77 (0.72)	3.97 (0.55)	3.94 (0.85)	3.65 (0.88)	3.71 (0.78)	3.45 (0.81)	3.68 (0.75)	4.00 (0.68)	3.65 (0.84)	3.77 (0.84)	3.94 (0.89)	3.68 (0.75)	3.68 (0.87)	2.62	4.77	3.76 (0.46)
6. The contents are interesting.	2.81 (1.11)	2.84 (0.93)	3.81 (0.91)	2.65 (1.05)	3.03 (1.08)	3.55 (0.93)	3.13 (1.12)	3.06 (1.09)	3.00 (1.18)	3.06 (1.06)	3.16 (1.29)	3.35 (0.98)	3.55 (0.85)	1.46	5.00	3.15 (0.71)
7. The contents induce interest.	2.84 (1.21)	2.84 (1.07)	3.94 (0.85)	2.84 (1.21)	3.06 (1.06)	3.52 (1.00)	3.19 (0.95)	3.19 (1.11)	3.00 (1.16)	3.29 (1.04)	3.06 (1.41)	3.45 (1.06)	3.52 (1.00)	1.62	5.00	3.21 (0.70)
8. More cartoons are necessary.	3.45 (1.12)	3.06 (1.06)	3.68 (1.25)	3.19 (1.08)	3.19 (1.11)	3.23 (1.23)	3.45 (1.12)	3.23 (1.31)	3.32 (1.17)	3.16 (1.32)	3.68 (1.01)	3.23 (1.31)	2.87 (1.28)	1.46	5.00	3.29 (0.92)
9. More photographs or images are necessary.	3.77 (0.99)	3.45 (0.93)	4.10 (0.79)	3.32 (1.01)	3.35 (1.14)	3.45 (0.96)	3.65 (0.91)	3.23 (1.26)	3.48 (1.03)	3.45 (0.93)	4.06 (0.85)	2.97 (1.22)	3.00 (1.32)	2.46	5.00	3.48 (0.64)
10. The contents are suitable overall.	3.63 (0.93)	3.71 (0.78)	3.84 (0.78)	3.39 (0.92)	3.65 (0.88)	3.68 (0.83)	3.58 (0.92)	3.74 (0.89)	3.45 (0.99)	3.77 (0.76)	3.71 (1.01)	3.81 (0.91)	3.81 (1.05)	2.15	4.92	3.66 (0.63)

*All scores are mean (SD).

†All questions were scored on a 5-point scale; a higher score is associated with a positive result for questions 1, 5, 6, 7, and 10, and a middle score is associated with positive results for questions 2 and 3. Questions 4, 8, and 9 were on subjects required a more complex analysis to bring about high/low scores. (For question 4, the students were required to participate in both an experiment and class. For questions 8 and 9, cartoons, photographs, and an image oriented textbook was desired but, due to difficulties in developing images for the textbook, the evaluation was conducted as if the images had been developed.)

(3.08±0.57). Due to the characteristics of nuclear energy and radiation textbook, since clear content is more important than easy content, we believe the full contents were acceptable. Nevertheless, cartoons, photographs, and images should be added to provide easily accessible information and improve understand ability for high school students (Table 9).

3.10 Evaluation of Educational Effects for Textbook by School Level

In the evaluation of the effects of textbook contents according to the educational requirements of each school level, high suitability frequencies (>80%) were shown for "the human character," education goals, curriculum goals, evaluation method, and education time. At some levels, the high suitability frequencies (>70%) were shown for the education grade, education type, and textbook type (Table 10). According to the research in understanding nuclear energy and radiation curriculum development conducted by Han et al (2014), "the human character" proposed for elementary and middle school students is "a person who knows and understands nuclear energy and radiation correctly" and for high school students is "a person who can make rational judgment and action for the nuclear energy and radiation" [22].

Table 10. Evaluation of Educational Effects for the Textbooks by School Level.

Classification	Elementary school students (N=37)	Middle school students (N=33)	High school students (N=74)
	Suitable	Suitable	Suitable
	N (%)	N (%)	N (%)
Subject title	34(91.9)	33(100.0)	55(74.3)
Pursued human character	37(100.0)	33(100.0)	68(91.9)
Goal of education	36(97.3)	33(100.0)	71(95.9)
Goal of education process	36(97.3)	33(100.0)	68(91.9)
Goal of curriculum	32(86.5)	33(100.0)	68(91.9)
Teaching/learning method (lecture, experiment, field trip, discussion)	35(94.6)	33(100.0)	72(97.3)
Student evaluation method (presentation, discussion, report submission, etc.)	32(86.5)	28(84.8)	62(83.8)
Application of student evaluation(not reflecting grades)	35(94.6)	25(75.8)	70(94.6)
Education time(1 hour/week)	31(83.8)	28(84.8)	61(82.4)
Textbook type(thin textbook with many images)	35(94.6)	29(87.9)	73(98.6)
Applicable school grades(elementary: 6th grade, middle school: 2nd year, high school: 1st year)	28(75.7)	25(75.8)	71(95.9)
Education type(creative experience learning)	29(78.4)	32(97.0)	66(89.2)

Table 11. Verification of Educational Effects by School Level.

Classification		Elementary school		Middle school		High school	
		Before education	After education	Before education	After education	Before education	After education
		N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Nuclear power plant	Yes	28(75.7)	31(83.8)	21(63.6)	30(90.9)	26(35.1)	62(83.8)
	No	9(24.3)	6(16.2)	12(36.4)	3(9.1)	48(64.9)	12(16.2)
Medical radiation	Yes	35(94.6)	37(100.0)	30(90.9)	33(100.0)	67(90.5)	73(98.6)
	No	2(5.4)	0(0.0)	3(9.1)	0(0.0)	7(9.5)	1(1.4)
Irradiated food	Yes	32(86.5)	34(91.9)	13(39.4)	30(90.9)	31(41.9)	66(89.2)
	No	5(13.5)	3(8.1)	20(60.6)	3(9.1)	43(58.1)	8(10.8)
Entire nuclear power generation and radiation by various fields	Yes	36(97.3)	35(94.6)	24(72.7)	32(97.0)	56(75.7)	71(95.9)
	No	1(2.7)	2(5.4)	9(27.3)	1(3.0)	18(24.3)	3(4.1)
Total		37(100.0)	37(100.0)	33(100.0)	33(100.0)	74(100.0)	74(100.0)

3.11 Verification of Educational Effects at Each School Level

By conducting simulated classes with the textbooks, which were constructed according to the requirements of students, science teachers, and experts, the educational effects were verified by voluntary behavior changes based on value judgments. A dichotomous yes/no vote about the continued use of radiation, such as nuclear power plants, medical radiation, food irradiation, and overall usage field, yielded high frequencies of change from before to after education. In the case of elementary school students, the changes to "yes" frequencies were high after the simulated classes (Table 11). To date, the large proportion of education courses have explained the methods of teaching themes. However, reaching the goal is the objective, not the standardization of methods for reaching the goal [23]. Behavioral decision-making theory defines decision making as a psychological process of selecting an alternative with large value or an alternative with valid reason and abandoning the other alternatives by comparatively evaluating their pros and cons [24, 25]. Ajzen (1985), in the theory of reasoned action, asserts that humans act by considering the advantages and disadvantages resulting from the action through the maximum use of information gained before performing the action [26]. The information acquired from the textbooks allowed students to change their value judgments. Unlike the conventional methods of providing knowledge, the receiver-oriented information themes and content led to behavior changes.

3.12 Table of Contents in the Finalized Textbooks

The elementary, middle, and high school students wanted to acquire information used in their daily lives, including the definition of nuclear energy and radiation, principles and status of nuclear power generation, and information about irradiated food, medical radiation, and radiation in life. The "Radiation and Life" textbook for elementary school students consists of the following chapters: 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 accident occurs, Chapter 6. How are nuclear energy and radiation used?, Chapter 7. What is 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 (a study review game).

Table 12. 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 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 nuclear 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

The “Nuclear Energy and Radiation” textbook for middle school students consists of the following chapters: 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. Misunderstanding and truths about radiation, Chapter 11. Progress in nuclear energy research, Chapter 12. Pros-cons discussion for uses of nuclear energy and radiation, Chapter 13. Energy in the future.

The “Nuclear Energy and Radiation” textbook for high school students consists of the following chapters: 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 accidents and radiation contamination, Chapter 12. Expert opinions on the uses of nuclear energy and radiation (Table 12).

4. CONCLUSION

The textbooks for elementary, middle, and high school students were developed to help future generations make value judgments based on appropriate information about nuclear energy and radiation. The themes and educational contents of the 13 lessons, to be delivered in one semester at each school level, were selected by the educational requirements of students, science teachers, and experts. The elementary school students were interested in basic concept-oriented studying; the middle school students desired information that could be viewed from various perspectives, such as atomic bombs; and the high school students requested problem solving-oriented information.

The general trend in recent educational curriculum development suppresses national education course organizations and authorities and expands the autonomy and authority of regions and schools [27]. The derived textbook contents are expected to be helpful as first textbooks for the autonomous selection of education about nuclear energy and radiation for use in creative experiences developed at the school level. The education courses do not have significance only by being well planned; they have significance when they are executed in classes [28, 29]. The present textbooks can be used in creative experience studying. The curriculum of creative experience studying consists of four areas: autonomous activities, club activities, voluntary activities, and career activities. Specific activities of each area can be flexibly selected by a school to satisfy the characteristics of students, class, grade, school, and regional society [30].

At present, the social acceptance of nuclear energy and radiation in South Korea is a concern, and the application of educational curriculum is urgently needed to provide correct information about nuclear energy and radiation and its relationship to various areas, such as future energy, welfare, and health problems. As an example of curriculum development, the USA developed the alphabet curriculums (the PSSC and BSSC) after experiencing the so-called “Sputnik shock” caused by the USA lagging behind the Soviet Union in space development in the late 1950s. The science curriculum reformation executed gradually from 1980s led to development of national science education standard based on scientific knowledge [31]. Science education reform led to full educational curriculum reform; this demonstrates the core role of science education process in science education reform [32].

We found that the proposed textbooks were lacking sufficient cartoons, illustrations, and visual images, and the addition of these visual materials is required in the future. Because illustrations in the textbooks will be visually encoded before the text [33], these will play a very important role in the learning concept [34]. According to Girondi (1983) and Eiser et al. (1998), because the social, political, and technical factors are complex and entangled in the goals of solving energy problems, the social and political support of citizens may provide important alternative solutions [35, 36]. Before the failure of securing social acceptance due to ignorance about nuclear energy and radiation leads to biased political effects, the correct information should be provided in schools to allow future generations to develop educated value judgments. The present textbooks were developed as a part of such effort.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Science, ICT and Future Planning.

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