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Development of Nuclear Energy and Radiation Textbooks for Middle School Students

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1. Introduction

After the Fukushima nuclear power plant incident, 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 [1]; consequently, the negative perception of nuclear power generation and radiation has increased. 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. It is very difficult for the average individual to make proper value judgments in a social environment where incorrect or difficult to understand 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. 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.

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 middle school students - the leaders of the next generation.

2. Methods and Results

In this study, to develop tailored middle 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 educational requirements survey was conducted to select the tailored educational content. 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%). 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. Taba's educational curriculum development steps were used in this study. 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 [2].

2.1 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 1>

2.2 Evaluation of Educational Effects for Textbook

In the evaluation of the effects of textbook contents according to the educational requirements of middle school, 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. According to the research in understanding nuclear energy and radiation curriculum development conducted by Han et al (2014), "the human character" proposed for middle school students is "a person who knows and understands nuclear energy and radiation correctly" [3]<Table 2>.

3. Conclusions

The textbooks for middle 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 middle school, were selected by the educational requirements of students, science teachers, and experts. The middle school students desired information that could be viewed from various perspectives, such as atomic bombs. 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. 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 middle school.

<Table 1> Theme Suitability for Middle School Students

Lesson	Theme		Students	Teachers	Experts	Total
1	Definition of nuclear energy	Suitable	44(84.6)	27(90.0)	45(100.0)	116(91.3)
		Unsuitable	8(15.4)	3(10.0)	0(.0)	11(8.7)
2	Nuclear energy technology	Suitable	40(76.9)	20(69.0)	36(80.0)	96(76.2)
		Unsuitable	12(23.1)	9(31.0)	9(20.0)	30(23.8)
3	Current status of nuclear energy utilization	Suitable	39(75.0)	28(93.3)	41(91.1)	108(85.0)
		Unsuitable	13(25.0)	2(6.7)	4(8.9)	19(15.0)
4	Definition of radiation	Suitable	45(86.5)	25(86.2)	42(93.3)	112(88.9)
		Unsuitable	7(13.5)	4(13.8)	3(6.7)	14(11.1)
5	Risks of radiation	Suitable	50(96.2)	27(90.0)	39(86.7)	116(91.3)
		Unsuitable	2(3.8)	3(10.0)	6(13.3)	11(8.7)
6	Use of radiation in food	Suitable	35(67.3)	17(65.4)	40(88.9)	92(74.8)
		Unsuitable	17(32.7)	9(34.6)	5(11.1)	31(25.2)
7	Household products using radiation	Suitable	40(76.9)	24(80.0)	39(88.6)	103(81.7)
		Unsuitable	12(23.1)	6(20.0)	5(11.4)	23(18.3)
8	Radiation in life	Suitable	45(86.5)	29(96.7)	42(95.5)	116(92.1)
		Unsuitable	7(13.5)	1(3.3)	2(4.5)	10(7.9)
9	Nuclear bombs	Suitable	37(71.2)	20(66.7)	30(71.4)	87(70.2)
		Unsuitable	15(28.8)	10(33.3)	12(28.6)	37(29.8)
10	Misunderstandings and truths about radiation	Suitable	46(88.5)	27(90.0)	37(84.1)	110(87.3)
		Unsuitable	6(11.5)	3(10.0)	7(15.9)	16(12.7)
11	Progress in nuclear energy research	Suitable	34(66.7)	22(75.9)	30(68.2)	86(69.4)
		Unsuitable	17(33.3)	7(24.1)	14(31.8)	38(30.6)
12	Pro-con debate about nuclear energy	Suitable	25(49.0)	19(65.5)	34(77.3)	78(62.9)
		Unsuitable	26(51.0)	10(34.5)	10(22.7)	46(37.1)
13	Energy in the future	Suitable	49(94.2)	28(93.3)	44(100.0)	121(96.0)
		Unsuitable	3(5.8)	2(6.7)	0(.0)	5(4.0)
Theme suitability (average)		Suitable	10.14	10.65	11.29	10.66
		Unsuitable	2.86	2.35	1.71	2.34

The theme suitability score ranged from 0 to 13 points.

<Table 2> Evaluation of Educational Effects for the Textbooks

Classification	Suitable *n* (%)	Unsuitable *n* (%)
Subject name	33(100.0)	0(0.0)
Pursued human character	33(100.0)	0(0.0)
Goal of education	33(100.0)	0(0.0)
Goal of education process	33(100.0)	0(0.0)
Goal of curriculum	33(100.0)	0(0.0)
Teaching/learning method (lecture, experiment, field trip, discussion)	33(100.0)	0(0.0)
Student evaluation method (presentation, discussion, report submission, etc.)	28(84.8)	5(15.2)
Application of student evaluation (not reflecting grades)	25(75.8)	8(24.2)
Education time (1 hour/week)	28(84.8)	5(15.2)
Applicable school grades(elementary: 6^{th} grade, middle school: 2^{nd} year, high school: 1^{st} year)	25(75.8)	8(24.2)
Education type (creative experience learning)	32(97.0)	1(3.0)

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[3] E. O. Ha, S. K. Lee, and Y. S. Choi, “Curriculum Development for Nuclear Power and Radiation Education in Elementary, Middle, and High Schools,” *Journal of Radiation Protection*, vol. 39, pp. 159-170 (2014).