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Limitations and Strategies for Improvement of Nuclear Energy Education in School Textbooks: Focused on the 2015 Revised Curriculum

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1. Introduction

Nuclear power is a major source of energy, accounting for approximately 30% of domestic energy production and playing a crucial role in achieving carbon neutrality. Between 2007 and 2011, the Korea Nuclear Energy Foundation (currently the Korea Energy Information Culture Agency) submitted subject-specific proposal papers to include nuclear-related content in the education curriculum based on the 2007 revised curriculum [1].

However, following the Fukushima nuclear accident in 2011, public perception of nuclear power shifted dramatically towards a negative direction, leading to a decline in overall social acceptance of nuclear energy and radiation. Since then, proposal activities related to textbook revisions have not been sustained, and little research has been conducted on how such changes in public perception have been reflected in subsequent curriculum revisions, which are updated every 5 to 7 years.

This study analyzes the narratives on nuclear energy in Science, Technology and Home Economics, Social Studies, Environmental Studies, and Integrated Social Studies textbooks according to the revised curriculum from 2015 [2] to understand how nuclear energy is currently addressed in education. The aim is to draw implications for improving nuclear energy education at elementary, middle, and high school levels. School education is essential for future generations to comprehend nuclear technology and related issues. In particular, textbooks are the learning materials utilized in school education, and the contents related to nuclear energy and radiation are described in textbooks have a great influence on the formation of students' perceptions. Therefore, this study analyzes the current status of nuclear energy-related education and provides basic data for fostering future nuclear manpower and balanced energy education.

2. Methods and Results

2.1 Research Methodology

This study analyzes textbooks for elementary, middle, and high schools according to the revised curriculum in 2015. A total of 294 textbooks were analyzed, including 139 in science, 49 in Practical Course, Technology and Home Economics, and Environmental Studies, and 106 in Social Studies [3]. Among them, 21 textbooks contain nuclear energy-related content. The analysis criteria are as follows:

Table I: Analysis Criteria

Analysis Item	Contents
Scientific Content Analysis	Accuracy of nuclear-related terms
Descriptive Expression Analysis	Balance in the presentation of positive and negative aspects of nuclear power use
Reflection of Nuclear Content Analysis	Appropriate mention of nuclear power as a carbon-neutral energy source for achieving carbon neutrality

2.2 Results of Nuclear Education Content Analysis

2.2.1 Status of Nuclear Descriptions in Textbooks

According to the analysis of the narratives included in each textbook, the overall nuclear energy-related content is limited, and some textbooks only describe the negative aspects of nuclear energy. In particular, elementary school textbooks do not describe nuclear energy and radiation at all, and only one publisher mentions nuclear energy in “Changes in Advanced Industries”. Middle and high school textbooks often lack conceptualization and technical explanations.

As shown in Tables 2 to 4, the analysis of the contents within the textbooks revealed that nuclear energy is mentioned in Science, Social Studies, Technology and Home Economics, and Environmental Studies subjects. In Science, nuclear-related concepts are mentioned in units on energy conversion and conservation (middle school – Science 3) and electrical energy production and transportation (high school – Physics and Integrated Science), while in Social Studies, limited nuclear-related content is included in units on resources and environmental issues (middle school – Social Studies 1 and 2). In Technology and Home Economics and Environmental Studies, nuclear energy concepts and the Fukushima accident are only briefly mentioned in textbooks from a few publishers in units such as transportation technology and energy (middle school – Technology and Home Economics 2) and sustainable society (high school – Environmental Studies).

Table II: Reflection of Content in Science Textbooks

Grade	Subject	Unit	Publisher
Elementary School	Not Mentioned		
Middle School	Science 3	Unit 6: Energy Conversion and Conservation	Type 1
High School	Integrated Science	Unit 4: Environment and Energy	Type 2
		Unit 9: Power Generation and Renewable Energy	Type 1
	Physics 1	Unit 1: Mechanics and Energy	Type 4
		Unit 2: Matter and Electromagnetic Fields	Type 1

Table III: Reflection of Content in Social Studies Textbooks

Grade	Subject	Unit	Publisher
Elementary School	Social Studies 6-1	Unit 6: Economic Development of Korea	Type 1
Middle School	Social Studies 1	Unit 6: Competition and Conflict over Resources	Type 2
	Social Studies 2	Unit 10: Environmental Issues and Sustainable Environment	Type 1
	Social Studies and Environment	Unit 6: Competition and Conflict over Resources	Type 1
High School	Korean geography	Unit 5: Space of Production and Consumption	Type 1

Table IV: Reflection of Content in Technology and Home Economics and Environmental Studies Textbooks

Grade	Subject	Unit	Publisher
Elementary School	Not Mentioned		
Middle School	Technology and Home Economics 1	Unit 5: Manufacturing Technology and Problem Solving	Type 1
		Unit 7: Life-Creating Technology	Type 1
	Technology and Home Economics 2	Unit 4: Transport Technology and Renewable Energy	Type 2
	Environmental Studies	Unit 3: Regional Environment and Global Environment	Type 1
High School	Environmental Studies	Unit 2: Environmental Systems	Type 1
		Unit 3: Environmental Exploration	
		Unit 4: Sustainable Society	

2.2.2 Comparison of Nuclear Content to Other Energy Sources

Compared to other energy sources like thermal power, new renewables, and gas, the proportion of nuclear energy narratives was significantly lower. Most textbooks do not cover nuclear energy at all. While the need for and potential of renewable energy sources were relatively emphasized in the textbooks, nuclear energy tended to be under-explained or presented in a negative perspective, with the exception of some science textbooks. Additionally, definitions and explanations of nuclear terms and concepts often lacked clarity and did not reflect the latest technological trends.

The number of textbooks based on the 2015 revised national curriculum that include nuclear energy content is extremely limited. Their descriptions tend to be restrictive and negative. This phenomenon can be interpreted as more than just individual textbook authors' choices, but rather a result of structural and sociocultural factors.

Firstly, major nuclear accidents such as Chernobyl (1986) and Fukushima (2011) significantly weakened public trust in nuclear energy and spread negative perceptions across society. These perceptions likely influenced the content of education, leading to a preference for narratives that raise awareness of the risks associated with nuclear energy.

Secondly, the national curriculum places high importance on social acceptability and educational neutrality. As a result, in the case of socially controversial technologies like nuclear energy, textbook content tends to emphasize risks, safety, and environmental concerns, or avoid in-depth discussion altogether.

Lastly, the expertise of textbook authors is also an important factor. Textbooks are typically written by current teachers and curriculum experts. However, in areas requiring a high level of specialized knowledge, such as nuclear energy and radiation, the lack of participation from professionals in the field or industry may lead to limitations in technical accuracy and up-to-date information. As a result, descriptions of nuclear energy often fail to reflect the broader technical or policy context, remaining superficial or fragmented. This ultimately leads to textbooks lacking a balanced perspective on nuclear energy.

2.2.3 Lack of Integration of Nuclear Technology and Future Industries

Recently, the government designated next-generation nuclear power as one of the 12 national strategic technologies through the National Strategic Technology Development Policy (enacted by a special law on September 22, 2023), and emphasized the importance of small modular reactors (SMRs), advanced nuclear power systems, and radiation technology. In addition, the 10th Basic Plan for Long-term Electricity Supply and Demand emphasizes the active use of nuclear energy as a stable energy source, alongside renewable energy sources [4]. However, in current textbooks, these latest technological trends and industrial applications are not mentioned at all. This results in a limitation that prevents students from being educated about the direction of nuclear technology and its future applications.

In the 2022 revised curriculum, key concepts such as "sustainable development" and "carbon neutrality" are prominently featured. Therefore, it is necessary to examine whether these concepts are appropriately reflected in secondary school textbooks to be implemented starting in the 2025 academic year.

3. Direction for Improvement

3.1 Scientific Content Improvement

It is necessary to clarify the definitions of nuclear-related terms and concepts and strengthen their integration with current nuclear technology. In current textbooks, incorrect terms such as '핵발전소' (nuclear power plant) instead of '원자력발전소' (nuclear power plant), and '핵폐기물' (nuclear waste) instead of '방사성폐기물' (radioactive waste) are used. This requires the terms to be revised in compliance with the official definitions provided by the 'Atomic Energy Safety Act.' Additionally, there is a need for conceptual clarity as nuclear-related terms such as 'radiation', 'radioactivity', and 'radionuclide' are often used interchangeably. For example, instead of using 'radiation exposure risk,' it would be more accurate to use 'risk of radioactive material release.'

Additionally, the fundamental principles of nuclear power, including nuclear fission and radiation concepts, should be explained systematically to enhance learners' understanding. Current textbooks do not sufficiently reflect latest technological trends such as small modular reactors (SMRs), nuclear-based hydrogen production, or nuclear robots and AI. It is necessary to provide in-depth instruction on scientific principles and relate them to real life and future industries. In this way, it will be possible to convey an accurate concept of nuclear energy and clearly recognize its relevance to future energy technologies.

3.2 Descriptive Representation Improvement

The descriptive representations of nuclear power in textbooks tend to emphasize the negative aspects, and it is necessary to provide objective and balanced information. For example, the Environment textbook only provides examples of thermal drainage, the Fukushima accident, and the Chernobyl accident. However, it does not describe the improvements in 50 items that Korea has implemented after the Fukushima accident and the current status of building the best safety system. In Korean Geography textbook, the advantages of nuclear power generation, such as a high plant utilization rate and low power generation cost, are explained along with its disadvantages, such as the difficulty of disposing of radioactive waste. However, safety management measures, including its role as a carbon-free energy source, multiple barrier systems, seismic design, and multiple radiation shielding facilities, are not fully covered.

It is necessary to explain safety efforts and regulatory frameworks and provide objective information so that Korea's nuclear power generation does not simply emphasize the risks. In addition, it is necessary to balance the technical and environmental aspects and present the role of sociological thinking in the context of nuclear energy so that students can develop critical thinking about nuclear energy.

3.3 Improving the reflection of nuclear-related content

Current textbooks do not reflect nuclear energy-related content, especially in Social Studies, which deals with the distribution and consumption of energy resources, and include only oil, natural gas, and coal, but there is no description of uranium resources. In addition, Technology and Home Economics textbooks introduce careers such as renewable energy specialists and robotics researchers, but do not include nuclear and radiation-related careers. Nuclear and radiation technologies are utilized in various industries, and their role is becoming more important with the development of SMRs, nuclear robots, AI, and radiation utilization technologies. Therefore, it is necessary to introduce nuclear energy-related careers in textbooks to provide students with more diverse career options.

Compared to renewable energy, nuclear energy is described in a relatively negative way, and the amount of explanation is very limited. Nuclear energy is a key source of energy for enhancing energy security and realizing carbon neutrality, and basic nuclear knowledge should be fostered from elementary school. Current textbooks tend to treat nuclear energy in terms of environmental issues, and it is necessary to provide accurate, balanced, and systematic education on nuclear energy from basic concepts to in-depth content as part of energy education.

3.4 Procedures for revising and updating textbook content

Expanding and improving the content related to nuclear energy within textbooks cannot be solely dependent on their editorial direction. Therefore, it is essential that these changes are reflected during the curriculum revision process, which typically occurs every 5-7 years. Currently, textbooks for elementary, middle, and high schools in Korea are developed based on the national curriculum announced by the Ministry of Education. This curriculum consists of a general framework (“general guidelines”) and subject-specific details (“subject-specific guidelines”). Among these, the “achievement standards” outlined in the subject-specific guidelines serve as the core basis for textbook writing. As long as these standards remain unchanged, substantial changes to textbook content are inherently limited.

Curriculum revisions are generally led by the Ministry of Education or the National Education Commission. The draft curriculum is first developed and then undergoes expert consultations, public forums, and trial implementation. The revised curriculum is then publicly announced and reviewed before its official adoption. Throughout this process, various groups such as teachers, academics, professionals from related industries, and members of civil society participate actively. Once it is officially announced, private publishers develop textbooks accordingly, with the content structured by the authors based on the achievement standards.

Therefore, to include nuclear energy content in textbooks, it is essential to ensure that such topics are explicitly stated in the curriculum, particularly within the achievement standards. This requires mid- to long-term efforts, such as continuous input from experts and policy-level discussions, rather than short-term revision demands.

Furthermore, even textbooks that have already been published may be eligible for partial revisions and updates through the process shown in Figure 1.

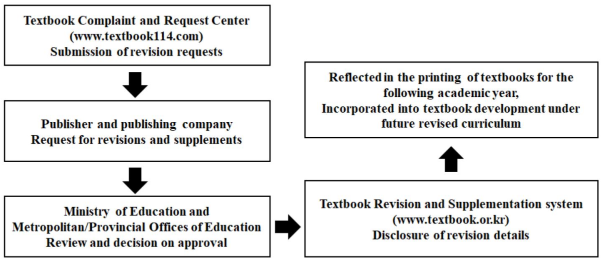

Fig. 1. Procedures for revising and updating textbook content

4. Conclusions

The current education curriculum in elementary, middle, and high schools includes limited nuclear-related content, with some textbooks highlighting the potential risks associated with nuclear power. This could lead to difficulties for students in forming a balanced perspective on nuclear energy.

Furthermore, despite recent government initiatives emphasizing advanced nuclear technologies such as small modular reactors (SMRs), cutting-edge reactor systems, and radiation technology through the enactment of the National Strategic Technology Development Act (2023.09.22 special law), these topics are not adequately covered within the current curriculum. Moreover, there is a growing focus on the multipurpose applications of next-generation nuclear reactors and their integration with AI, hydrogen production, and supercomputer technologies; however, students have limited opportunities to engage with such content. In light of this situation, it is imperative to revise and supplement the curriculum to enhance education in nuclear technology and related future industries.

The teaching of nuclear energy and radiation should evolve into an interdisciplinary approach that links science not only to other scientific subjects but also to Social Studies and Environment textbooks. To foster a comprehensive understanding of nuclear energy's importance and limitations, students need opportunities to explore these concepts in the context of broader issues such as climate change and environmental concerns.

This study aims to analyze the current state of nuclear education content and suggest improvements from both scientific and pedagogical perspectives. The analysis indicates that elementary school children require basic education on natural radiation and fundamental radiation experiments. For middle and high schools, it is essential to progressively enhance nuclear and radiation education in a manner tailored to each age group. By doing so, students will develop a correct understanding of nuclear energy beyond viewing it as mere technology, gaining profound insights into future energy and environmental policies.

To improve the quality of nuclear education, sustained mid- to long-term efforts are required to improve textbook content. Developing teacher training programs, creating supplementary materials, and designing hands-on teaching tools is also essential. These efforts can help establish a more systematic educational environment and contribute to nurturing skilled professionals who will lead the development of future nuclear industries

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