A Study on the Development of Supplementary Nuclear Energy Teaching Materials for Teachers Based on the Analysis of the National Curriculum and Textbooks

Seungah Yang*, Jinmyeong Shin
Nuclear Training and Education Center, Korea Atomic Energy Research Institute
Corresponding author: seungah@kaeri.re.kr

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1. Introduction

Despite the critical role of school education in helping students understand the characteristics and societal role of nuclear power in a balanced manner, the current elementary and secondary school curricula only address nuclear power in a limited and fragmented manner, focusing on keywords within select units.

Consequently, students find it difficult to systematically understand nuclear power and face limitations in forming a balanced perception. While teachers design lessons based on the curriculum and textbooks, the current content alone is insufficient to comprehensively convey the principles, safety, and societal significance of nuclear power. Thus, supplementary teaching and learning materials are urgently needed. Therefore, this study aims to analyze the national curriculum and textbooks to assess the current state of nuclear energy education. Based on this analysis, it seeks to supplement the fragmented nature of the current curriculum's achievement standards and develop a supplementary nuclear energy resource for teachers. This resource will systematically cover the fundamental principles of nuclear energy, its safety aspects, and its role in a carbon-neutral society. This aims to reduce teachers' instructional design burdens while establishing an educational foundation enabling students to understand nuclear energy in a balanced manner within the integrated context of energy, resources, and the environment, and to form their own judgments on related social issues.

2. Foundational Analysis for Supplementary Materials Development

2.1 Status of Nuclear-Related Keywords in Achievement Standards

Achievement standards are core indicators that serve as benchmarks for classroom activities, combining the knowledge and skills students must acquire through each subject, and form the basis for textbook development. Therefore, only when relevant content is explicitly stated in the achievement standards do students gain opportunities to systematically learn that content in the school setting. However, analysis of the achievement standards in the 2015 and 2022 revised curricula revealed that nuclear-related content remains at a very limited level. In middle school, only fragmented keywords like ‘nuclear power generation’ are presented, while high school curricula focus on isolated terms like ‘nuclear fusion’ or ‘nuclear energy’. There is no structural framework established to treat nuclear energy as an independent and systematic energy source. Particularly concerning is the elementary school curriculum, where no achievement standards related to nuclear energy are presented at all. This inevitably limits the scope and level of content reflection right from the curriculum design stage.

2.2 Analysis of Textbooks for the 2015 and 2022 Revised Curricula

This study analyzed textbook content based on the 2015 and 2022 revised curricula. As shown in Table 1, textbooks based on the 2022 revised curriculum are being implemented in stages by grade level from 2024 to 2027. Therefore, at the time this study was conducted, textbooks for all elementary and secondary grades had not yet been released. Accordingly, this study focused on identifying the presentation methods for nuclear energy-related content primarily in the 2015 revised textbooks, which are currently widely used in educational settings, and the 2022 revised textbooks published up to the time of the study.

Regarding the 2015 revised curriculum, prior research [1] indicates that among a total of 294 textbooks analyzed, only 21 textbooks (approximately 7.1%) included nuclear energy–related content, demonstrating an extremely limited presence. Specifically, such content was mentioned only incidentally within selected units, including “Energy Conversion and Conservation” (middle school, Grade 3) and “Power Generation and Renewable Energy” (Integrated Science) in science subjects; “Resources and Environmental Issues” (middle school, Grades 1–2) and “Spaces of Production and Consumption” (high school Korean Geography) in social studies; and “Transportation Technology and Renewable Energy” (middle school Technology and Home Economics).

The reasons why descriptions of nuclear power in textbooks lack systematic coherence and merely provide fragmented information can be found in the following structural limitations. First, compared to fossil fuels or renewable energy, the amount of content dedicated to nuclear power is significantly smaller. It provides only fragmented information, lacking conceptualization or technical explanations of nuclear power's core principles. Second, in social studies textbooks, while the distribution and consumption of energy resources are covered with detailed descriptions of oil, natural gas, and coal, explanations of uranium resources—a major energy source—are entirely absent. This makes it difficult for students to understand nuclear power as a comprehensive energy source. Third, textbook narratives tend to emphasize negative aspects, such as accident cases, while providing limited discussion of safety management systems. Finally, recent technological developments, including small modular reactors (SMRs) and next-generation nuclear systems, are not reflected at all, which limits students' ability to recognize nuclear energy as a future-oriented industry.

This pattern was similarly confirmed in the analysis of textbooks for the 2022 revised curriculum. A comprehensive review of 34 elementary school textbooks across science, social studies, and experimental observation subjects revealed no content related to nuclear energy or radiation.

Similarly, an analysis of 48 textbooks across six subjects in middle school revealed that only 7 textbooks in Technology, Home Economics, and Environment mentioned keywords like 'nuclear power generation'. Comprehensive coverage of nuclear power principles or safety remained insufficient. Analysis of 81 high school textbooks revealed nuclear keywords appeared in one Integrated Science 2 textbook and ten elective textbooks. Specifically, detailed descriptions of nuclear fusion and fission were only found in the elective subjects Advanced Physics and General Engineering. This highlights a structural limitation: the vast majority of students who do not take these electives find it difficult to encounter related content in depth. Overall, the findings indicate that existing textbooks present significant limitations in enabling students to develop a comprehensive and objective understanding of nuclear energy as an energy source.

Table I: Years of Implementation for the 2022 Revised Curriculum

Grade	2024	2025	2026	2027
Elementary School	1st-2nd Grade	3rd -4th Grade	5th -6th Grade	
Middle School		1st Grade	2nd Grade	3rd Grade
High School		1st Grade	2nd Grade	3rd Grade

3. Content Structure of the Supplementary Nuclear Energy Materials for Teachers

3.1 Criteria for the Development of the Supplementary Materials

In this study, curriculum alignment and usability for teachers were established as the core criteria for developing the supplementary nuclear energy materials for teachers.

First, with regard to curriculum alignment, the scope of the content was defined to faithfully reflect the intent of the 2015 and 2022 revised national curricula while effectively supplementing the limited nuclear-related content presented in existing textbooks. In particular, considering the scarcity of nuclear-related keywords explicitly stated in the current curriculum achievement standards, as identified in the preceding analysis, key terms such as "nuclear power" in the middle school curriculum and "nuclear energy" and "nuclear fusion" in the high school curriculum were included as foundational learning elements. However, the development of the supplementary materials was not confined to the restricted scope of these achievement standards. Instead, the materials were designed to systematically organize essential information necessary for students to understand nuclear energy, including its fundamental principles, safety aspects, and societal roles.

Next, in terms of usability for teachers, the primary criterion was whether the materials could be immediately incorporated into existing lesson design and classroom instruction without requiring additional restructuring. Given that textbooks typically provide only limited coverage of nuclear energy, teachers often face a substantial burden in developing supplementary teaching and learning resources on their own. To address this issue, the proposed materials include not only explanatory narratives but also concrete activity components that can be directly applied in classroom settings. Through this approach, the supplementary materials aim to reduce teachers' lesson preparation burden and to serve as a practical instructional tool for comprehensively conveying the principles, safety, and societal significance of nuclear energy in actual teaching contexts.

3.2 Supplementary Materials Development Procedure

The supplementary nuclear energy materials for teachers were developed following a phased development procedure to ensure curriculum alignment and practical field applicability.

In the first phase, core nuclear energy keywords were derived based on prior curriculum achievement standards and textbook analysis results. This formed the basis for defining the scope of content to be included in the supplementary materials and establishing its interdisciplinary curriculum linkage direction. During this process, uranium resources and the latest technological trends (such as SMRs), which were entirely absent from textbook explanations, were selected as essential supplementary elements, laying the groundwork for development.

In the second stage, a draft supplementary material was compiled based on the curriculum alignment and usability for teachers criteria established in Section 3.1. Particular emphasis was placed on clearly presenting comparative data not only on the advantages and disadvantages of nuclear power but also against other energy sources to ensure balanced information.

The third stage involved a double-review process to enhance the reliability and practicality of the developed draft. First, internal experts in the nuclear field reviewed it to verify scientific accuracy and the inclusion of the latest technological trends. Subsequently, field teachers from elementary and secondary schools reviewed it to assess the appropriateness of the narrative style and its practical applicability in actual classes. In response to feedback indicating that certain explanations were somewhat rigid, the expressions and organizational structure were refined to better align with students' cognitive levels. Through this iterative refinement process, the final version of the supplementary nuclear energy materials for teachers was completed.

3.3 Content Structure of the Supplementary Nuclear Energy Materials for Teachers

The supplementary nuclear energy materials for teachers developed in this study consist of three major units to supplement the limited content of textbooks and provide practical support for teachers' lesson planning. Figure 1 shows the cover of the developed supplementary material, and Figure 2 presents the overall table of contents.

Chapter I, "The Past, Present, and Future of Nuclear Energy," covers the origins and development of nuclear energy, global technological evolution, and the history and current role of nuclear energy in South Korea. This section enables teachers to understand how nuclear power has contributed to electricity production and scientific and technological development, grasp its history, and connect it to discussions on the advantages and limitations of nuclear power and the energy transition toward carbon neutrality goals.

Chapter II, "Understanding Nuclear Power Generation," systematically organizes core concepts related to nuclear power generation. This includes what nuclear fission is, the difference between nuclear power and atomic bombs, the process of electricity production through nuclear power generation, uranium resources and the nuclear fuel cycle, the safety of nuclear power plants, and radioactive waste management. This content is structured to be utilized in conjunction with the energy concepts in the science curriculum and the resources and environment units in the social studies curriculum.

Chapter III, "Understanding Carbon Neutrality 2050 and the Future Role of Nuclear Power," focuses on the climate crisis, carbon neutrality, energy security, and power mix discussions, addressing the societal role nuclear power can fulfill. It is structured around social issues that students are likely to be genuinely curious about, enabling expansion into discussion and inquiry activities.

Each unit is designed following the flow of 'Concept Understanding → Additional Information Expanding the Concept → Group Research Learning Task', allowing teachers to directly use it as reference material in existing subject lessons. This structure is significant as it complements the curriculum achievement standards and textbook content while also serving as a reference resource for teachers during lesson planning.

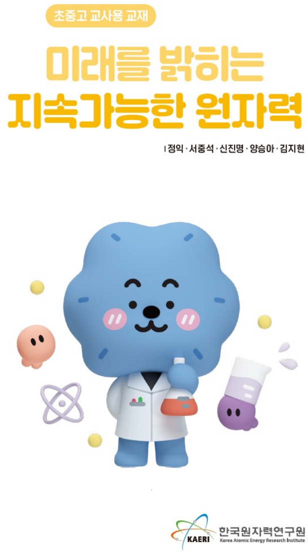

Figure 1: Cover of the Supplementary Nuclear Energy Materials for Teachers

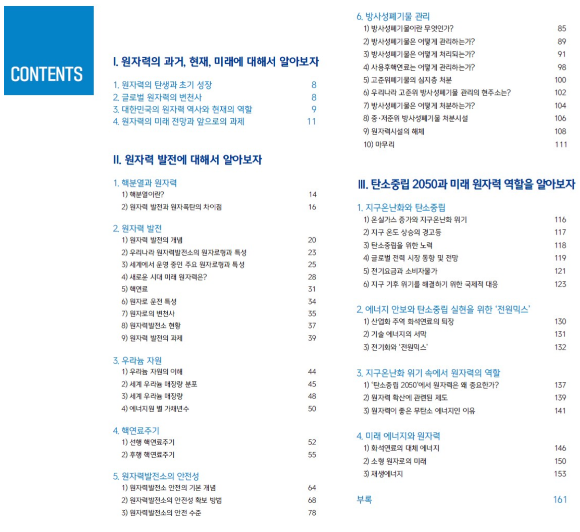
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Figure 2: Table of Contents of the Supplementary Nuclear Energy Materials for Teachers

4. Discussion

The supplementary nuclear energy materials for teachers developed in this study are significant in that they provide ‘alternative educational resources’ enabling teachers to systematically teach nuclear energy as one pillar of energy sources, complementing the fragmented, keyword-focused descriptions of the current curriculum's achievement standards. Particularly considering the challenges of treating nuclear energy as an independent subject in schools, the ‘modular’ structure allows immediate citation of only the necessary parts within the context of existing subject lessons, maximizing convenience and practicality for teachers' lesson planning. This composition fills gaps in textbooks while possessing educational value in helping students recognize nuclear energy not merely as a technical subject but as a comprehensive topic requiring social judgment.

5. Conclusion and Recommendations

This study developed supplementary teaching materials on nuclear energy for elementary and secondary education based on analyses of the 2015 and 2022 revised curricula and textbooks, presenting their organizational principles and development process. Analysis confirmed that nuclear energy content is presented extremely limited in curricula and textbooks, revealing structural limitations for systematic classroom coverage. Therefore, this study completed supplementary materials that teachers can immediately utilize when designing lessons. These materials reflect the keywords of the achievement standards while supplementing the core concepts and background knowledge necessary for understanding nuclear energy as a key component of the energy mix.

The developed supplementary materials systematically cover the history of nuclear power, its development principles and safety, and its connection to carbon neutrality. They will serve as a practical tool to complement the limitations of textbooks and support teachers in designing effective lessons. Based on this research, the following recommendations are proposed to enhance the substance of future nuclear education:

First, to maximize the effectiveness of nuclear and radiation education, developing hands-on teaching aids and experimental tools that enable student participation is essential. Current educational settings lack dedicated tools sufficient to support related theories, limiting their ability to spark learner interest and foster practical understanding. Therefore, developing age-appropriate tools—ranging from basic radiation experiment kits for elementary students to experiential kits for middle and high school students—and linking them with supplementary materials could create a vivid educational environment that goes beyond mere knowledge transfer.

Second, as the 2022 revised curriculum textbooks are phased in through 2027, the status of nuclear content inclusion in newly released textbooks must be continuously monitored. This will ensure supplementary materials are continually updated with the latest information and expanded to align with evolving curricula.

Third, beyond distributing supplementary materials and teaching aids, teacher training programs must be developed to enhance educators' expertise. Establishing a systematic support framework is essential to enable interdisciplinary approaches integrating nuclear education with subjects like science, social studies, and environmental studies.

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