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Analysis of the Domestic and International Industry and Policy Environment for Nuclear Power and Radiation Education in Elementary, Middle, and High Schools

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1. Introduction

Nuclear power is a major source of energy that supplies about 30% of Korea's electric power, and it is a key technology for realizing carbon neutrality. However, following the Fukushima nuclear accident in 2011, public perception of nuclear power has shifted negatively, affecting social acceptability of both nuclear power and radiation use. Therefore, it is necessary to provide accurate information and education on nuclear power and radiation awareness, including the implementation of Korea's nuclear safety system after the Fukushima accident. This is an important factor in building a sustainable energy future and promoting safety and innovation in the nuclear industry.

The purpose of this study is to analyze Korea's industrial and policy environment for nuclear and radiation education. It also aims to explore improvement directions by comparing international guidelines from the IAEA with current educational practices at elementary, middle, school level in the United States, France, and Japan. It is necessary to provide systematic nuclear and radiation education in the elementary, middle, and high school curriculum because it helps future generations develop skills for safely and efficiently utilizing technology.

2. Analysis of the Industry and Policy Environment of Nuclear Power and Radiation Education in Korea and Other Countries

2.1 Domestic Environment

Recently, domestic energy policy has shifted toward the strategic promotion of the nuclear power industry, rediscovering the importance of nuclear power amid global energy supply and demand instability and the challenge of achieving carbon neutrality. Consequently, there is a growing need for systematic education at the elementary, middle, and high school levels to maintain the sustainability and competitiveness of the nuclear and radiation industries.

Currently, nuclear and radiation education in Korea is insufficiently developed to meet the objectives outlined by relevant policies. As the industrial and policy environment evolves, education on the fundamental principles of nuclear energy, safety, and environmental impacts is necessary. However, content related to nuclear energy and radiation remains limited within the current curriculum. Therefore, it is necessary to strengthen education for future human resources and promote the development of scientific thinking skills.

Ultimately, domestic nuclear power and radiation education must be developed systematically and practically to meet changes in energy policy, requiring essential policy support and educational innovation.

2.2 International Environment

Globally, nuclear power is gaining attention as an important future energy source. In particular, countries like China, India, and the United Arab Emirates (UAE) are increasing their energy independence through the construction of new nuclear reactors, and the status of nuclear power in these countries is rising. Additionally, these countries are strengthening foundational education on nuclear topics at elementary, middle, and high school levels to develop the next generation of professionals for the continuous development of future energy industries.

The International Atomic Energy Agency (IAEA) provides standardized guidelines [1] and promotes information sharing among member states regarding radiation safety education [2, 3]. The IAEA is also increasing its support to ensure that nuclear energy and radiation-related education is consistent and systematic on a global scale. In the future, international cooperation among countries will lead to a more active cultivation of global human resources.

2.3 IAEA Guidelines for Nuclear Power and Radiation Education in Elementary, Middle, and High Schools

The IAEA offers guidelines for nuclear power and radiation education aimed at improving understanding of nuclear energy and radiation in a safe and scientific manner. These guidelines emphasize scientific accuracy, safety, and social responsibility. The IAEA also provides a range of resources and support for the systematic implementation of scientifically accurate and safe nuclear education in each country. The educational guidelines emphasize scientific accuracy, safety, and social responsibility, as shown in Table 1. Additionally, the IAEA provides various materials and support to ensure that scientifically accurate and safe nuclear education is systematically implemented in each country.

Table I: IAEA Guidelines overview

Category	Key content
Understanding Basic Concepts and Scientific Principles	Nuclear and radiation fundamentals, Types and effects of radiation, Natural vs. artificial radiation
Practical Applications of Nuclear Power and Radiation	Learning about the use of radiation and nuclear energy in medical, industrial, and energy sectors
Safety Education on Nuclear Power and Radiation	Radiation protection principles (ALARA), Safety management regulations, Safety guidelines for experiments and practical training
Environmental, Social, and Ethical Considerations	Environmental impact of radiation, Nuclear ethics and social discussions, Response measures for nuclear accidents
Guidelines for Educational Methods and Tools	Use of experiments, simulations, audiovisual materials, Participatory education, Teacher training and professional development

2.4 International Analysis of Nuclear and Radiation Education

2.4.1 United States

In the United States, STEM programs in elementary, middle, and high schools aim to integrate nuclear energy and radiation education into science classes such as physics, chemistry, and biology, with the goal of teaching practical scientific thinking and skills. As the grade level increases, educational depth gradually intensifies. It covers a wide range of topics from basic concepts and principles to nuclear physics, biological impacts of radiation, and the technical and ethical aspects of nuclear power generation. Additionally, education focuses not only on scientific understanding but also on ethical and social issues, with an emphasis on helping future generations develop the right values and become responsible members of society.

In elementary school, the education focuses on teaching basic concepts that will capture students' interest. For example, it covers various forms of energy and fundamental atomic concepts in a way that explains radiation in everyday life through engaging stories. In middle school, students learn fundamental concepts and applications such as atoms, radioactive decay, the use, and hazards of radiation. In high school, students engage in advanced education on the fundamental principles of nuclear physics, radioactive isotopes, and the dangers and safety management of radiation. Specifically, high school curriculum also discuss social and ethical issues surrounding applied radiation and nuclear power generation.

The U.S. educational system emphasizes experiment-based learning, allowing students to gain hands-on experience in actual nuclear power plants or radiation laboratories. Various non-profit and government organizations provide nuclear and radiation-related materials and programs, as well as teacher training programs to enhance their expertise [4]. Additionally, many universities also offer undergraduate and graduate courses in nuclear engineering and radiation-related fields, providing in-depth education in areas such as radiation safety, nuclear power generation, and radiation medicine.

2.4.2 France

France is one of the most nuclear-dependent countries in the world, and its elementary, middle and high school curriculum systematically educate students on the safe use of radiation, its principles and applications, including basic knowledge of nuclear energy. Given that nuclear power plays a significant role in France's energy supply, the country prioritizes nuclear safety education. To achieve this effectively, various programs are implemented. The French Ministry of Education collaborates with CEA (French Alternative Energies and Atomic Energy Commission) and EDF (Electricité de France) to provide educational materials. These organizations conduct joint educational programs, materials, and hands-on experiences with schools to raise public awareness about nuclear energy. Like the United States, they emphasize experimental learning, such as radiation detection activities.

2.4.3 Japan

In Japan, nuclear and radiation education is systematically implemented in the curriculum of elementary, middle, and high schools, with content structured according to grade level. Especially after the 2011 Fukushima accident, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) has significantly strengthened nuclear power and radiation education, focusing on improving scientific understanding and safety awareness [5]. Schools located in regions directly affected by the disaster have expanded practical training programs focused on improving radiation safety and emergency response capabilities. This allows students to gain a proper understanding of the risks associated with radiation and prepare effectively for emergency.

The Japan Nuclear Society's Education Committee has continuously reviewed nuclear and radiation-related content included in textbooks since 1995 [6]. It has published 17 reports investigating accuracy in reflecting current data, using appropriate terms and units, and submitted these to MEXT and textbook publishers to request ongoing improvements.

After the Fukushima accident, additional supplementary materials have been actively utilized. These materials focus on conveying fundamental concepts, various application cases, safety management, and health impacts of radiation through a scientific and critical perspective. In their recent revised editions, they incorporate innovative educational methods such as digital content and QR codes to enhance learning effectiveness for students.

3. How to Improve Nuclear Power and Radiation Education

The analysis of nuclear and radiation education systems in domestic and international emphasizes the importance of experimental approaches and field experiences. It is essential to provide opportunities to experience the practical applications of nuclear energy and radiation through experiments, practical exercises, and field visits, in addition to theoretical education. Furthermore, educational programs are necessary to address vague concerns about nuclear energy and radiation by providing clear, scientifically accurate information about their benefits and safety.

In Korea, there is a need to further develop nuclear and radiation education in a more systematic way and create educational programs targeting various age groups and social classes to improve public awareness.

Currently, the Korea Atomic Energy Research Institute (KAERI) has analyzed 2015 revised elementary, middle, and high school textbooks to review the status of incorporating nuclear-related content [7]. The textbooks analyzed included 139 science textbooks, 49 textbooks from subjects such as Technology and Home Economics and environmental studies, and 106 social textbooks, amounting to 294 books. Among them, only 21 textbooks contained content related to nuclear energy. The results of the analysis showed that renewable energy-related content was included in a significant amount, but nuclear energy-related content was rarely covered. To include nuclear and radiation-related content in textbooks, the achievement standards must reflect the content, which requires systematic efforts.

Therefore, as in the case of the Atomic Society of Japan, it is necessary to establish a specialized education committee to develop a systematic strategy to develop nuclear and radiation education content step by step and incorporate it into the curriculum. It is important to support students to acquire scientifically correct nuclear and radiation knowledge in school curriculum.

4. Conclusions

This study introduces the domestic and international industrial and policy environments of nuclear and radiation education at the elementary, middle, and high school levels, and presents recommendations for improving the Korean education system.

By examining the educational systems in the United States, France, and Japan, it became evident that each country has developed a systematic education framework tailored to its own industrial and policy context. The United States prioritizes experimental and field-based education, ensuring balanced foundational and advanced learning. France systematically organizes education related to nuclear safety and technological advancements, reflecting the country's high reliance on nuclear energy. Following the Fukushima nuclear accident, Japan strengthened radiation safety education, improved textbooks, and provided policy support to enhance students' scientific understanding and awareness of safety.

Based on these analyses, we propose the following directions for the policy development of nuclear and radiation education in Korea:

First, it is necessary to establish a systematic curriculum linked to national energy policies, referencing IAEA guidelines. Second, experimental and hands-on education should be developed and expanded to provide students with opportunities to experience the practical applications of nuclear energy and radiation. Third, training programs and the development and support of educational materials to enhance teachers' capabilities are essential. Fourth, an educational system must be developed to adapt to changes in industry and policy, reflecting the latest developments in nuclear energy, radiation technologies, and policies.

In conclusion, this study provides directions for Korea's nuclear and radiation education to develop into a balanced system that includes not only scientific understanding but also policy and industrial perspectives. In the future, continuous research and policy support will be necessary to ensure that students acquire scientifically accurate information and develop a balanced understanding of nuclear power and radiation.

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