A study of the researcher's expertise in environmental education for elementary school students

（小学生に対する環境教育に見られた研究者の専門性に関する研究）

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The 2020 Environmental White Paper states that we are now in an era that should be called "climate crisis" rather than "climate change," as weather-related serious disasters frequently occurred around the world and increased the risk of weather disasters caused by global warming. At the Sustainable Development Summit held at the United Nations Headquarters in New York in September 2015, the Sustainable Development Goals (SDGs), consisting of 17 interrelated goals and 169 targets, were adopted as the goals of the action plan for humans, earth, and prosperity, and Japan is actively working on them.

As the above shown in the environmental white paper, environmental problems are becoming more serious, diverse, and interconnected, and the achievement of the SDGs in individual regions is necessary to build a sustainable society in the whole country. Environmental education from childhood will be important to achieve the SDGs in the region. Japanese law defines "environmental education means education and learning about environmental conservation conducted to deepen understanding of environmental conservation" (Article 2, paragraph 3 of the Act on Promotion of Motivation and Environmental Education for Environmental Conservation). The 20th proposal of the Sub-committee relevant to environmental thought and education in Committee of Environment, Science Council of Japan states that the goal of environmental education is "to enrich the 'nature inside' of children, to help them understand the immeasurable

blessings of the environment on humanity and how it works, to conserve the environment, to deepen their awareness of the interaction between humans and the environment, and to help them acquire the so-called 'environmental literacy' actually to improve the environment." While the part about "enriching the nature inside" of children requires a separate discussion, increasing the environmental literacy of children is desirable towards achieving the SDGs in their individual areas.

For environmental education in elementary schools, there is an emphasis on hands-on education using the body and simple tools to look at the environment around us (National Institute for Educational Policy Research Curriculum Research Center, 2014). In order for elementary schools to create opportunities for hands-on environmental education, not only by teachers, but also by requiring the understanding and cooperating of parents and community relevant organizations to prepare for out-of-school activities and instructors (National Institute for Educational Policy Research, 2014). In order to create hands-on environmental education opportunities, elementary schools are required to prepare leaders and places for activities outside the school not only by teachers, but also by parents and other relevant institutions in the community with the understanding and cooperation (National Institute for Educational Policy Research, 2014). Inamori et al. (2009) also pointed out that environmental education in elementary schools requires collaboration with the outside, such as schools and non-profit organizations, companies, and government agencies.

Universities, as centers of learning, have an essential role in searching for truth deeply and in teaching and researching of "specialized arts and sciences" and a public role to play in the knowledge-based society of the future (Ministry of Education, Culture, Sports, Science and Technology, 2005). Universities could be a partner in environmental

education in elementary schools. As a specific example of the collaboration, there is the "Hirameki☆Tokimeki Science" conducted by the Japan Society for the Promotion of Science (JSPS). These are the programs that researchers of universities and research institutes use cutting-edge research results to provide fifth- and sixth-grade students, junior high school students, and high school students with an opportunity to experience the fun of science by seeing, hearing and touching it firsthand. In fiscal year 2018, 278 programs were implemented and 90 were implemented for elementary school students.

In these case studies of collaboration, what do researchers studying natural science, not studying education, in universities pay attention to when they provide elementary school students with science knowledge and experience in their classes? In the "A guide to observations and experiments in elementary school science" (MEXT, 2011), prior learning is considered essential for children to have expectations and hypotheses with their own clarified purpose before observation and experiment. How do university researchers conduct its lessons with an awareness of what is considered necessary in elementary school classes? Such a simple question comes to mind.

This dissertation showed the characteristics, positive points, and sensitive matters of implemented programs in elementary schools when university researchers were involved in environmental education as academic professionals. The target of the study is environmental education programs for upper graders of elementary school developed and implemented by university researchers in Yama no Gakko (2015-2018). Yama no Gakko is an educational activity implemented in collaboration with the Hokkaido University Graduate School of Environ-mental Science, Hokkaido Coca-Cola Bottling Co., Limited, and elementary and senior high schools in Sapporo city.

Chapter 2 focused on an educational material of groundwater developed by university

researchers. This educational material helps children to understand following two things, “Forests are the main groundwater recharge area” and “Groundwater has a longer residence time than surface water.” The educational materials are made of familiar materials to children, such as Lego® blocks and sponges, and its structure consists of three layers, sur-face, shallow and deep layers, and water penetrates underground from the surface in the mostly forested parts on the ground mainly. This material is designed concerning the JMA’s three-storage tank model, with time differences of water outflows from the three layers. As the educational material is placed at an incline downstream and sprinkled on the forest area, the outflows from its downstream part a have higher and earlier peak in the upper levels and a lower and gentler peak in the lower levels. This material quantitatively was confirmed to represent two scientific facts: forests are the main groundwater recharge area, and groundwater has a longer residence time than surface water. This result showed that the material was visualized for a three-storage tank model with groundwater character-istics and supported by scientific knowledge.

Chapter 3 revealed the characteristics and challenges of environmental education programs in the elementary school developed by a university researcher as academic professionals by recording activities and interviewing stakeholders. These have the following three characteristics.

As the first characteristic, the structure in these programs was according to a common organizational structure called the IMRaD: Introduction, Methods, Results, and Discussion. Based on this structure, the programs provided time for children to predict the results as their working hypotheses before their experiments and to discuss their results after their experiments. The program structure, allowing children to have a perspective on the results of the experiments and to draw their own conclusions, was consistent with the

subject objectives of elementary school science, “The goal is to develop the qualities and abilities necessary for students to scientifically solve problems related to natural things and phenomena through familiarity with nature, application of scientific views and ideas, and observation and experimentation with a clear perspective.” (MEXT, 2017). However, he did not have enough time for children to be interested in the program and develop methods for observation and experimentation beforehand, as it is done in the prior learning that is important in elementary school observational and experimental education (MEXT, 2011). Because the programs covered quite a lot of content in 90 minutes, elementary teachers must conduct prior learning that is not currently done. Therefore, communication about the program’s content and the information necessary for prior learning should be conveyed to elementary school teachers by university researchers in advance.

As the second characteristic, scientific explanations were provided using handcrafted educational materials made with familiar materials. Of course, the educational materials represent scientific knowledge, as mentioned in Chapter 2. Universal teachers thought that even elementary school teacher would be able to easily create and use by themselves be-cause they were made of familiar materials. However, since explaining using these educa-tional materials requires specialized knowledge, many elementary school teachers com-mented that if they actually use the materials, they would ask for experts, such as universi-ty researchers, to be dispatched. For using these educational materials in elementary schools, university researchers are required to go to the classroom, or elementary school teachers are required to learn expertise and teaching techniques from university research-ers in advance. This is similar to the challenges faced by the Trunk Kit, a learning re-source developed by museum curators or other experts. The interviews with the elemen-tary school teachers suggested that the explanations using the

educational materials were not always easy for the children to understand because the materials were not made of nat-ural materials. The order of the program should be kept in mind: first the actual experience of tree planting activities, and then the explanation of phenomena that cannot be actually seen with the eyes using this material.

As the thirdly characteristic, the two resources of the university researcher, his research network and creative mind, are utilized. There were new requests for the program from elementary schools, the students in the graduate school participating changed every year, and no more students participated. Under these changes in circumstances, a university re-searcher found the collaborators from his own research network and developed new pro-grams with their help. Even without these changes in circumstances, the interview survey confirmed that the researcher used creativity to change the program and conduct new pro-gram every time. In environmental education activities in which university researchers participate, it is essential to understand enough about the creativity of the researchers and manage the entire activity.

In addition, for better environmental education with the participation of university re-searchers, this study suggests the following, not only for Yama no Gakko.

Many university researchers provide environmental education for elementary school stu-dents, which succeeded to some extent because of its program structure according to the IMRaD structure, the ability to develop materials based on scientific knowledge, human networks, and creativity. However, it became clear that the program's challenges to be understood if university researchers' programs are going to be better. For example, the IMRaD structure is similar but different from the prior learning emphasized on observa-tions and experiments in elementary school science. The creativity of university research-ers comes into play in developing educational materials made of familiar

materials. While anyone can make educational materials because they are made of familiar materials, any-one cannot interpret and explain natural phenomena with them, which requires specialized knowledge and skills. To overcome that weakness, university researchers and elementary school teachers must inform each other, such as what they value in each other.

University researchers and Elementary school teachers should share their needs and information required to better implement the programs; for example, the former trying to develop creative new programs, the latter needing to implement prior learning to motivate children and desiring to have a program well connected to the content taught in the class, as well as each other's motivations, merits, and demerits for implementation. If such an exchange of information is implemented, then we can provide programs that allow children to learn more deeply.

One feature of the "Yama no Gakko" not discussed in this study is the participation of graduate students in developing and implementing the program. In the activities of the "Yama no Gakko" until 2016, graduate students had the leading role in developing the programs and implementation under the supervision of the university researcher, who was the main person in developing the program. When graduate students have the leading role, the disadvantage is that the contents and level of the programs provided are highly dependent on their expertise and communication skills. However, the supervisor commented that it was a valuable learning experience for the students. The elementary school teachers commented that the children enjoyed learning as graduate students who were more famil-iar to them and international graduate students with whom they rarely interacted, which are advantages of teaching by graduate students.

This doctoral dissertation provides an example of how groundwater can be studied

from the perspective of the water cycle. The educational materials and educational programs clarified in this study can be used to study the water cycle in elementary school classes as an approach to the SDGs (especially Goal 6 and Goal 15).