

The developed inquiry-based spiral curriculum to promote the radiation literacy as STS and Sustainability Education

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Abstract

Recent tragic natural disasters such as the Indian Ocean earthquake (Dec. 26th, 2004) or the Great East Japan Earthquake (Mar. 11th, 2011) made us recognize that all human beings are allowed to live on the earth under the unattainable power of the nature. Especially in terms of the education for the sustainability, the nuclear power plant accident at Fukushima threatened our sustainability of current life style. Not much focus on the education of the radiation literacy and energy resource had been paid before the accident, and existing programs were mainly provided to enhance the understanding of scientific concepts, without paying much attention to the literacy and decision-making ability. In the effort of overcoming the tragedy, new orientation of such curriculum is expected to be developed. This study (1) proposes a spiral curriculum, related to radiation literacy, through which learner can get enough basis of understanding and can sharpen their inquiry ability, which leads to decision making as citizen in democratic society, and (2) reports the effect of the curriculum, after conducting a few lessons situated in the curriculum. For elementary level, we proposed inquiry activities of spectrum of sun light using prism and of invisible light (Ultraviolet) using black light and UV beads in grade 3. For junior secondary level, we conducted the self-measurement of “invisible environment” such as carbon dioxide and radiation dose. Students recognized by themselves that their school is safe, and complained that they have been left behind without giving proper information or teaching after the tragedy.

Goals and objectives

Many of the Japanese people who were suffered from the 2011 Great East Japan Earthquake are still on the way of recovering process. Standing on a deep reflection, we as science educators are also trying to contribute to the efforts by developing a new curriculum. This study has two goals: (1) to propose a new spiral curriculum, which relates to existing whole school curriculum, and enhance ability and literacy enough to understand current issues of and to make decision related to radiation in the future as a citizen of democratic society, and (2) to conduct practices out of the part of the curriculum and report its effectiveness.

Theoretical framework

Movement in the Science Education

It is not a recent event that science education started to be argued not to limit its goal only to transfer scientific knowledge and skills to students (Conant, 1947). In the 1980s, Science-Technology-Society became the frag of

the curriculum reform movement in science education (Bybee, 1985; NSTA, 1982; Yager, 1996). And recently, Socioscientific Issues and the Education for Sustainable Development (ESD) have taken the main focus (Zeidler, et al. 2004; Fujioka, 2007), as the Decade of the ESD (2005 - 2014) was adopted by the United Nations in 2002 (UNESCO, 2005). And such aspect in the STEM education is also focused.

STS and ESD education in Japan

The course of study of Japan is revised almost every ten years. One of a senior secondary science textbook, based on the 1998 Course of Study, certainly dealt with the STS issues by adopting the debate. However, not much attention has been paid to the topic in general. Even though the Ministry of Education put “Nature and Human being” on the list of the course of study in grade 6 and 9 to learn, the unit has been almost ignored by most of practitioners in Japan.

The Decade of ESD from 2005 to 2014 of Japanese government proposal was adopted by the General Assembly of the United Nations in 2002 (UNESCO, 2005). Since the 2011 Great East Japan Earthquake occurred during the decade, many educators reflected on their own practice and the decade is closing to the end. It is now expected for a lot of ESD practices to be published in the end of year 2014.

Need for Radiation Education after the Fukushima Daiichi Nuclear Power Plant Accident

Not much attention has been paid to the radiation education in Japan before the accident, and science has lost the trust of citizens as mentioned above. However, it is time to know about radiation in order to survive and save children. The only direction we shall adopt in the curriculum will make learners measure the invisible environment by themselves implementing inquiry activity for critical thinking.

Methodology

Criteria for the developing curriculum

The developed curriculum should be along with students’ cognitive ability and present learning contents of not only science education but also related subjects such as mathematics, social studies, home economics and integrated study. The ultimate goal of the curriculum aims that students acquire the ability of decision-making by themselves through inquiry activities, rather than transferring knowledge and skills.

The criteria for the spiral structure are (1) mechanism, (2) quantity, (3) experiment and (4) reality (Fig.1). (1) As a part of science which explore the hidden rules, mechanism provides how phenomena happen with rational explanation, and students have right to know such mechanism.

However, explanation needs not to be the latest but provided along with their understanding ability, and explanation should not be offered as one way from teachers to students but acquired by themselves or constructed in their mind as it emerges. This understanding is sometimes helped by using a model. (2) It is not enough to understand how phenomena happen. We need to grasp the facing phenomena quantitatively, such as the amount of focusing substance, the concentration, distance or direction, etc. This factor relates to the reality

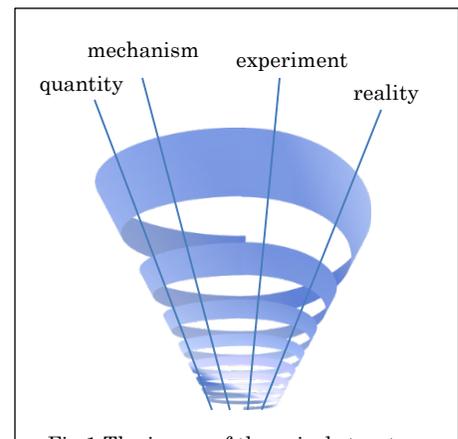


Fig.1 The image of the spiral structure of the developing curriculum

too. (3) It is not good just to believe what is taught or learned. We need to have an attitude of skepticism once. When any of new explanation or idea is introduced, learners had better check by themselves if it is true or not. This claim is related to discuss the importance of teaching and learning the Nature of Science (NOS) in science education. (4) The contents should be checked to see how much they are connected to students' daily life, other's occupation, sometimes in terms of their carrier design, affect the self, family, next generation, or workers. The criteria mentioned above are important to cultivate critical thinking or decision making ability. The contents or units should be organized properly for the latter advanced content.

Trial at the attached school and local school

The practical trials have been conducted. Here, we report two latest practices of elementary and junior secondary level. The prior one was implemented to grade 3 students who had just finished learning the properties of light. The following lesson continues to focus the sun light using prism where students could discover that light can be divided or sun light is a mixture of colored lights, that prism has the function to separate the color lights, and that there is the order of the appeared colors. Taking the result, the last lesson challenges to the invisible light (Infrared and ultraviolet) using remote control equipment, the black light and UV beads. Students are expected to remember the experience of spectrum when they study it in senior secondary physics.

For the junior secondary level, the self-measurement of the radiation (equivalent dose) was conducted using dosimeter.

Results and discussion

Proposed Curriculum

Inserting contents with inquiry-based activities, we revised previous leaning to come alive in the latter learning. This table is still being constructed with careful deliberation. Some of the significant items are described below.

In the table, the recommended month to be practiced by the teacher's guide of each subject is also shown, which help us run the curriculum more feasible.

Usually people run out of building in normal disaster drill, however, recent living condition provides it the opposite direction. Historically, the photochemical smog became the social issues in 1960s in Tokyo and students were prohibited to play outside. Recently, the particulate matter (PM2.5) from the mainland is focused. Mainly in the spring time, they can be trained to shelter indoors to avoid the PM2.5. In June of rainy season and summer (from July to September), we are sometimes hit by heavy rain or typhoon, and we have dry season in winter in the pacific coast side of Japan. As the related science units are located in the curriculum properly to the seasonal change, school disaster rills are inserted as well.

After learning 'kilo meters' in mathematics in grade 3, we propose a lesson just before the disaster drill. We need to prepare against the unpredicted earthquake even when students walk on the way to school or home. In this lesson, students are asked to determine where they continue walking or turn around for safer or closer place.

In the unit of climate of grade 4 science, they usually learn the daily change of temperature. However, without typical data which shows the rising temperature in the night or decreasing in daytime, students start to think the reason to explain unexpected data. It is easy for them to hit upon the existence of warm/cold air mass or the wind

direction, which can be the key to survive when we face nuclear accident.

When they learn the line chart in grade 4 mathematics, we can introduce the half-life chart, without mentioning its relation to the radiation.

Spectrum for Grade 3

As predicted, grade 3 students expressed that prism makes a rainbow. We thought it is important experience which leads to understanding of electromagnetic waves in secondary level. Additionally, because students have just started learning science in that grade, I emphasized them to record what they observed, if every colored dots are same and there is also determined in order of color. Based on the reflection sheet, the content was seemed to be aligned with their cognitive level.

Self-measurement of radiation dose

For the practical trial for upper graders, 32 of Grade 7-9 students who belong to the Attached Junior Secondary School of the College of Education, Ibaraki University, Japan, participated in the special lesson in October 2012. This lesson was a little challenging to start with first general talk on radiation and that lesson enabled them to measure it by themselves. In order to relieve the discomfort, the theme was announced as "to measure the invisible environment", and radiation dose were measured as well as carbon dioxide. The content of the beginning brief instruction is shown in Table 2. After 40 minutes brief instruction, eight groups of 4-5 students measured all around the school yard, holding digital CO₂ detector and radiation meter in 30 minutes. After collecting the data on a map, students discussed the result.

The data of CO₂ concentration were distributed around 450 [ppm] as average and the radiation dose were from 0.04 to 0.40 [μ Sv/h]. Some of the students' impressions were as follows: "I am happy I could discover that our school is safe to live." "Now I can understand what is broadcasted in the news show." "We have not provided proper lesson after the tragic accident."

Conclusions and significance of the study

The spiral curriculum is still being developed. The units and items are designed for students to understand contemporary issues so that they would not be left behind in such important issues and discussions.

Interestingly, in the preparing UV lesson for grade3, students would use the UV beads as first experience of using an indicator which shows something insensible in science curriculum. Teachers should be careful when they introduce such equipment to students.

Though living in the society which is filled with stagnation and blockage, our wish of education for the next generation seems to be supported by students' comments. Additionally they have been left behind without being given proper information. Rapid curriculum development, which aims not at simple understanding of scientific conceptions but at enhancing ability and literacy, is strongly expected.

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