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Environmental Education on Soil: Practices in High Schools in Japan and Cambodia

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Abstract

This article reports a study about the knowledge on soil for high school students. The main purposes of the study are: (1) to identify high school students knowledge on soil properties, (2) to discover high school students' knowledge on soil components, (3) to compare Japanese and Cambodian high school students' knowledge on soil components and its properties, and (4) to examine whether the contents on soil are included in high school curriculum of Japan and Cambodia or not, and how it has been treated. The results indicate that majority of students of both countries has misconception on soil properties and its components. They come to science class with their own theories and notions on soil that is not in harmony with the scientific points of view. The misconception on soil of Japanese students is easier to change than that of Cambodian students after the lecture on soil.

Key words: soil properties, soil components, soil adsorption, and high school curricula on soil

1. Introduction

One of the main purposes of science education in school is to educate students to realize the importance of environment and to solve the environmental issues in the belief that environmental education would improve the sustainable development and reduce the public concerns about the environment. Many articles, however, reported that many citizens of the world are still lack of basic knowledge about the environment and environmental issues (NEETF, 2005). People still continue throwing out mixed wastes in water because they do not see these are carried to other places and could be converted into toxic forms. The low level of the basic knowledge on environment and the impact of environmental issues are also shown in situations that many people in the world are dying from diarrhea (Tan, 2004). The Asian Environmental Outlook Report (ADB, 2001) underscored that people health, the survival of species and ecosystem service that are the basis for long term economic development are at risk due to environmental damage. It mentions that Asia will find difficulties to achieve long terms sustainable economic growth unless the countries in the region pay attention to solve the enormous environmental problems. These situations reflect that environmental education in schools has not provided students with concrete fundamental knowledge of environment or another word, environmental education in school has been taken less consideration.

A number of studies have been investigated students' knowledge and understanding on environmental phenomena, events, and issues. Those are included students' understanding on energy, acid rain, greenhouse effect (Gambro, & Switzky, 1996), tropical rainforests, clear cutting (Carderio, & Sayler, 1994), and ozone depletion (Boyes, & Stanisstreet, 1998). The present article reports a study about the knowledge on soil of high school students in two countries, Cambodia and Japan. The main purposes of the study are: (1) to identify high school students' knowledge on soil properties, (2) to discover high school students' knowledge on soil components, (3) to compare Japanese and Cambodian high school students knowledge on soil components and its properties, and (4) to examine whether soil contents are included in high school curriculum of Japan and Cambodia or not, and how it has been treated.

2. Materials and methods

To achieve the purposes of the study, practical work on soil properties was developed after finding out alternative materials and methods. Various tests were conducted to look for appropriate ways of doing experiments. When proper materials and methods were found, worksheet and lesson plan on how to teach the practical works in science classes were developed. Table I is the lesson plan of the practical work.

Table I

Lesson Plan on the Topic of Why Underground Water Is Clean

Objectives	Activities
i) To look for the purification mechanism of underground water. ii) To compare adsorption capacities between charcoal and soil components.	i) Self introduction and give clear objectives of the lesson on soil (10 minutes). Ask some students to show their opinions on reason why underground water is clean. ii) Divide students into 10 groups and explain experimental procedures (10 minutes). - Group 1 and 6 do experiments on adsorption capacities of kaolinite and soil. - Group 2 and 7 do experiments on adsorption capacities of montmorillonite and soil. - Group 3 and 8 do experiments on adsorption capacities of humic acid and soil. - Group 4 and 9 do experiments on adsorption capacities of sand and soil. - Group 5 and 10 do experiments on adsorption capacities of active charcoal and soil. iii) Students do experiments 25 minutes. iv) Making a table and a graph by each group (5 minutes). v) Sharing experimental results (5 minutes). Each group writes their results in a flip chart on the blackboard and all students note other groups' results. vi) Data analysis and preparation of group presentation (10 minutes). vii) Student's presentation (15 minutes). viii) Summary by teacher (10 minutes).

The worksheet and lesson plan were used to teach forty students of a high school (a Super Science High School) in Japan and sixty students of a high school in Cambodia. The lecture was conducted in English for Japanese students and in Khmer for Cambodian ones. The worksheet of the topic was delivered one week in advance to Japanese students and at the time of teaching to Cambodian ones. Students were divided into ten groups. The lecture ended within ninety minutes. The topic is about why underground water is clean. This lecture was conducted in June 21, 2007 in Japan and July 5, 2008 in Cambodia. In that lecture, students were required to do experiments on adsorption capacities of kaolinite, montmorillonite, humic acid, and sand, which they are the components of soil, active charcoal, and soil collected by each group. Pre- and post- tests which

contain the same questions were delivered to students before and after lessons, respectively. There are three opened questions in the pre- and post- tests: (1) why is underground water clean?, (2) imagine that you put some soil into a PET bottle and pour some water, draw a scheme of soil in the PET battle after shaking it?, and (3) draw the structure of soil and write its components names in the drawing?. A questionnaire was also delivered after a completion of the lecture. The answers of pre- and post- tests were group based on the same answer places in the same group, and then compared and analyzed to identify the improvement of their basic knowledge and conceptions on soil before and after the lesson for both Cambodian and Japanese high school students. The answers of the questionnaire were analyzed in the discussion of this article. Moreover, chemistry curriculum of Cambodia as indicated in Table II and the one treated in Japan as in Table III were compared on how the topic was displayed in high school curriculum of both countries and then find out the strong and critical points of it.

Table II

Chemistry Curriculum of Cambodian High School

Grade 10
Chapter 1 Chemical elements
1.1 Chemical elements
1.2 Atomic structure
1.3 Electronic structure and elements' classification
1.4 Ions and molecules
1.5 Molar volume and chemical reaction
Chapter 2 Soil and agriculture
2.1 Earth science
2.2 Plants and fertilizer
2.3 Ammonium nitrate fertilizer
Chapter 3 Petroleum and natural gas
3.1 Carbon in nature
3.2 Alkane and alkene
3.3 Petroleum and natural gas
3.4 Alkane combustion
3.5 Addition reaction of alkene
3.6 Plastic matter preparation
3.7 Petroleum and environmental problems
Grade 11
Chapter 1 Oxidation reduction reaction
1.1 Reaction between metal(M) and metallic ion(M^{n+})
1.2 Reaction of acidic solutions with metals
1.3 Potential redox
1.4 Oxidation number
1.5 Flashlight and battery
1.6 Electrolysis
Chapter 2 Chemical reaction and heat energy
2.1 Energy production : Heat of reactions
2.2 Heat of reactions and heat energy

Chapter 3 Dissolution of ionic compounds in water
3.1 Dissolution of ionic compounds in water
3.2. Solubility of molecular compounds in water
Chapter 4 Oxidation and Pollution
Chapter 5 Oxygen in organic chemistry
Grade 12
Chapter 1 Chemical kinetic
1.1 Study the experiment of kinetic reaction
1.2 Kinetic factors
1.3 Study the experiment on Catalysts
Chapter 2 Acids and bases
2.1 Definition and pH measurement
2.2 Reactions between strong acid and strong base
2.3 Notation of acid-base couple
2.4 The strength of acid and base
2.5 Titration of weak acid
Chapter 3 Stereochemistry
3.1 Geometry of simple molecules
3.2 Kinetic factors
3.3 Shape and structure of molecules
Chapter 4 Perfume and soap
4.1 Synthesis of ester used in perfumery
4.2 Soap and Saponification reaction
4.3 Study the experiment of catalysts
Chapter 5 Medicine : Aspirin
5.1 Synthesis of medicine: Aspirin
5.2 Components and titration of Aspirin

Table III

Chemistry Curriculum of Japanese High School

Chemistry I
Volume 1: Composition of materials
Chapter 1 Search for materials
Chapter 2 Basic composition of materials
Chapter 3 Amount of materials and chemical equations
Volume 2: Changing of materials
Chapter 1 Chemical reaction and heat of reaction
Chapter 2 Acid and base
Chapter 3 Redox reaction
Volume 3: Inorganic matters
Chapter 1 Periodic table and properties of elements
Chapter 2 Unit and compound of nonmetallic elements
Chapter 3 Unit and compound of metallic elements

Volume 4: Organic compounds
Chapter 1 Properties and structure of organic compounds
Chapter 2 Hydrocarbon
Chapter 3 Organic compounds including oxygen
Chapter 4 Aromatic compounds
Chapter 5 Coexistence of human and the earth
Chemistry II
Volume 1: Structure and chemical equilibrium of materials
Chapter 1 Chemical bonds
Chapter 2 State of materials
Chapter 3 Speed and equilibrium of chemical reaction
Volume 2 : Life and materials *(omission)*
Chapter 1 Plastic chemistry
Chapter 2 Food Chemistry
Chapter 3 Clothes and chemistry
Chapter 4 Chemistry of metals and ceramics
Volume 3: Life and materials
Chapter 1 Chemistry of life
Chapter 2 Chemistry of medicines

3. Results and Discussion

3.1. The conception of high school students on why underground water is clean

Research on student misconceptions and their role in learning science has become one of the main important domains in science education. Many researchers, however, have revealed that students come into science classes with pre-instructional knowledge or beliefs about the phenomena and concepts to be taught that are not in harmony with scientific views (Reinders, 2003). These are coincident with the results found in our study.

As indicated in Table IV, among forty students of a high school of Japan and sixty students of a high school of Cambodia who involved in this study responded to the pretest that underground water is clean due to the following aspects:

i. Soil filtration

73% of Japanese students and 55% of Cambodian ones answered that underground water is clean due to soil filtration. It seems that high school students' knowledge and understanding of both countries on water pollution are caused only by the insoluble matters.

ii. Microbes in soil

15% of Japanese students answered that underground water is clean due to the action of microbes in soil. It means their knowledge and conception on water pollution are caused only by the decomposed organic pollutants. All the pollutants are eaten by microbes in soil as they pass through it. So that, the underground water is clean. Cambodian students don't have this conception.

iii. Soil absorption

Only 2 % of Japanese students gave the answer that underground water is clean mainly due to the soil adsorption. This indicates that only a few Japanese students have knowledge and conception on water pollution caused by both organic and inorganic pollutants which are the main concepts of the lecture. The pollutants are absorbed by soil as they pass through many layers of it before reaching underground. No Cambodian students come up with this idea.

iv. No contact with air

Interestingly, in the pretest, 10 % of Japanese students thought underground water is clean due to the water doesn't contact with air. It means the understanding of those students on water pollution is caused only by the air.

v. Underground water naturally occurs

As indicated in Table IV, 15% of Cambodian students answered the pretest that underground water is clean because it naturally occurs. This means they come into science class with their own concept that is different from the one accepted by scientists.

vi. Soil contains many minerals and no toxic elements

13% of Cambodian students answered that underground water is clean because soil contains many minerals and there are no toxic elements. This result shows that the students have misconception on soil properties. Through this answer, it can also be concluded that the views of Cambodian students maybe base mainly on the commercial PET bottle water that always indicates the amount of minerals in it. Actually, minerals described on the label of the PET bottle are not the same as the one contains in soil.

vii. Water is in the middle between clay and stone

In the pretest, 5% of Cambodian students also gave answers that underground water is clean because it is in the middle between clay and stone, explaining that clay prevents unclean water from entering into the ground water. Therefore, the ground water is clean.

Table IV

The Result of Pretest on the Question of Why Underground Water Is Clean (%)

Countries / Student answers	Percentage of Cambodian students' answers	Percentage of Japanese students' answers
Soil filtration	55%	73%
Microbes in soil	0%	15%
Soil adsorption	0%	2%
No contact with air	0%	20%
Natural occurred water	20%	0%
No toxic elements and contain many minerals	13%	0%
Water is in the middle between clay and stone	5%	0%
No answer	7%	0%

From the pretest answers, high school students of both countries have misconception on soil's properties. This means they are lacking of basic knowledge on soil as well as on environmental education. The conceptions on soil they brought into science classes are not in harmony with scientific views. Their answers based mainly on their own conceptions or understandings in which they encounter every day. These concepts or understandings cannot be accepted by scientists. So, teachers, educators and curriculum developers who are the key persons to design, adapt and implement curricula should take notes these misconceptions in planning curriculum and designing teaching and learning environment.

Table V shows the result of posttest obtained from students of both countries. Majority of Japanese students (68%) answered that underground water is clean due to soil adsorption, meaning that majority of Japanese students can change their misconception on soil function after the experiment. Disappointingly, Cambodian students do not change their own existing knowledge or beliefs. There is an increase in percentage of Cambodian students answering underground water is clean due to soil filtration, meaning that Cambodian high school students existing ideas and beliefs are difficult to change even after the experiment on soil. The reason may be attributed to unfamiliarity of Cambodian students to do experiments in classes like Japanese one due to the lack

of experimental tools, chemicals, and experts in the laboratory in their schools. Therefore, they are not good at observing the phenomena of the experiment like Japanese students.

Table V

The Posttest Result on the Question of Why Underground Water Is Clean (%)

Countries / Students' answers	Percentage of Cambodian students' answers	Percentage of Japanese students' answers
Soil filtration	88%	25%
Microbe in soil	0%	7%
Soil adsorption	0%	68%
No toxic elements and contain many minerals	10%	0%
No answer	2%	0%

However, it is advisable that the topic on soil adsorption should be introduced in high school curriculum of both countries. The reason is that the topics are common, familiar with students living, and crucial for future sustainability. Moreover, the topics are consistent with the level of student understandings if it is well prepared and the lesson is well planned. Answering to the questionnaire delivered at the end of the lectures as shown in Table VI many Japanese and Cambodian students answered that they understand the reason why underground water is clean and the adsorption capacity of soil, respectively after the lecture conclusion.

Table VI

Percentage of Student Answers on the Question of "Do You Come up with the Reason Why Underground Water Is Clean" and "Do You Understand the Adsorption Capacity of Soil"

Questions	Japanese students		Cambodian students	
	Yes (%)	Not sure (%)	Yes (%)	Not sure (%)
Do you come up with the reason why underground water is clean?	63	37	100	0
Do you understand the adsorption capacity of soil?	53	47	100	0

3.2. The conception of high school students on soil structure and its component names in a PET bottle

In pre- and post- tests, students of both countries who participated in the study were also asked to draw a structure of soil and write the soil component names in their drawing as a PET bottle is put some soil and some water is poured in it and then the PET bottle is shaken. The main purpose of this question is to discover how high school students of both countries depict the structure and give the components' names of soil. The answers of the pretest on this question were grouped into six categories as shown in Table VII. Some examples of their drawings are illustrated in Figs. I and II for both Japanese and Cambodian students, respectively.

From Table VII, 64% Cambodian students and 3% Japanese one who participated in the study could not draw the structure and give the components' names of soil, meaning that most

Cambodian high school students and few Japanese ones do not know the soil structure and what soil is composed of even they live on it every day.

Table VII

Student Conception on Soil Components in Their Drawing in the Pretest

Countries / Students' answers	Percentage of Japanese students' answers	Percentage of Cambodian students' answers
No answer and drawing	3%	64%
Clear water and soil	28%	21%
Turbidity water and sedimentary	0%	12%
Turbidity water	0%	1%
Turbidity water, transparency water, and soil mixture	30%	2%
Only drawing picture	39%	0%

From Table VII, it also shows that although many Japanese (97%) and Cambodian high school students (36 %) could draw the structure of soil and give soil components/ names but they just drew a PET bottle and listed components' names in which those are not scientific points of view. In their drawings, they just indicated that if some soil is put into a PET bottle and some water is poured in it and then it is shaken, after shaking, the soil in the PET bottle is divided into two layers: clear water located in the upper part and turbidity water located in the bottom. This means that no one could describe the proper name of soil components, such as sand, clay or humic acid, and no one could draw the proper structure of soil.

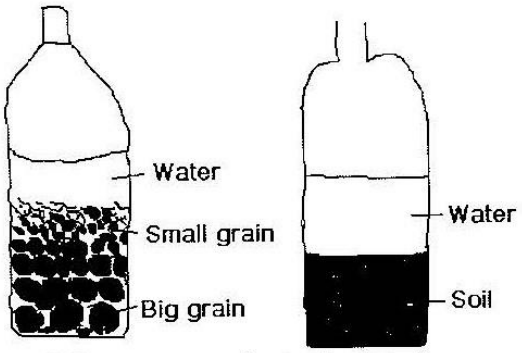

Figure I. Japanese students depicted the structure and gave the component names of soil in a PET bottle in the pretest.

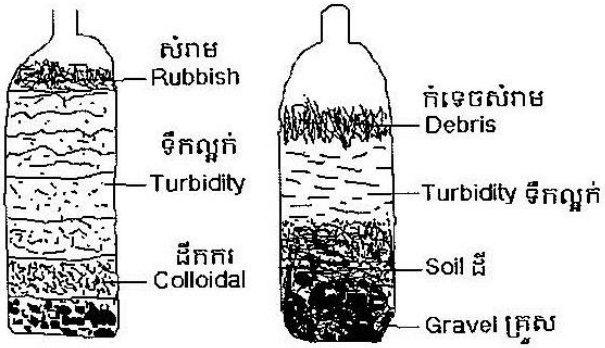

Figure II. Cambodian students depicted the structure and gave the component names of soil in a PET bottle in the pretest.

These results indicate that high school students of both countries have misconception on soil structure and soil components. They bring their own alternative conceptions into science classes. These conceptions are different from those accepted by the scientists.

In the posttest, however, as indicated in Fig. III, many Japanese students are able to describe about the components of soil. Although, the percentage of the correct answers is not much desirable but comparing to the result of the pretest, it shows a big progress (42.5%). The percentage of students who gave incorrect answers is also high (42.5%). This result doesn't mean that the content of the topic is too difficult for them. It might cause by their English ability as illustrated in

Fig. IV. Students wrote the answers to the questions only in Japanese even if they were required to write in English.

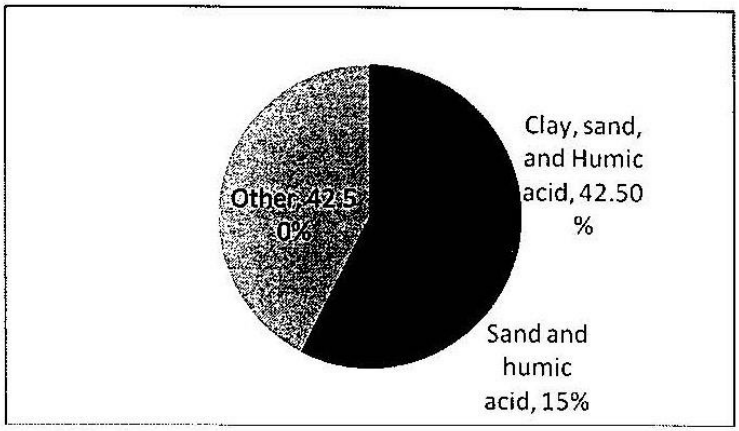

Figure III. The result of posttest on the question of drawing the structure of soil and writing the names of its respective components.

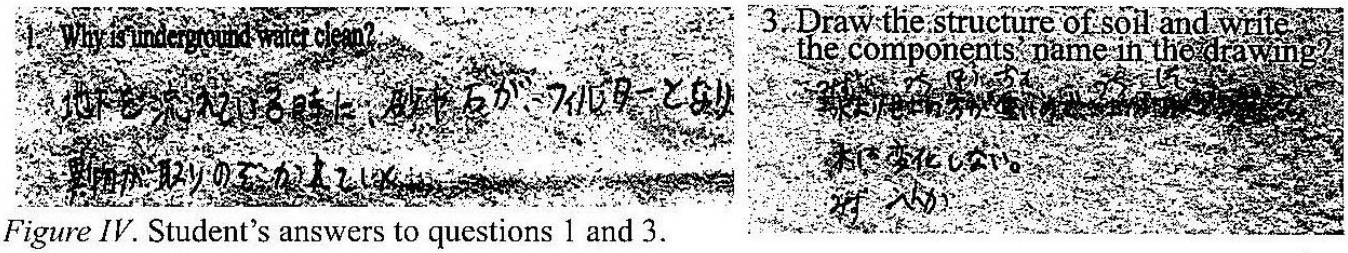

Figure IV. Student's answers to questions 1 and 3.

Disappointingly, Cambodian students still resist changing their conceptions and beliefs on soil structure and components because no one could give the correct answer in the posttest. They viewed the structure and components of soil differentiate from the ones accepted by scientists. Their viewing was shown in Fig. V.

Figure V. Students diagram of the structure and components of soil in PET bottle in the posttest.

3.3. Comparison between chemistry curriculum in high school of Japan and that of Cambodia

As viewed by many researchers, curriculum is one of the most important factors to improve the quality and the efficiency of education. It can bring the national goals of education directly to school if it is prepared by focusing on learning fundamental concepts and skills that are relevant to the daily lives.

Disappointingly, the concept of soil and soil's properties are not included in chemistry high school curriculum of Japan. For Cambodian curriculum, the topic is appeared in grade 10. However, it does not involve the knowledge of soil's adsorption. Its contents are prepared with fewer showing

advantages of the knowledge in the world society and there is no connection between theory and daily application. For the detail of these sub contents is shown in Table III and IV. This means that the fundamental knowledge on soil and soil properties are less considered in upper secondary education of both countries. So, it is recommended that the contents should be included in the future curriculum innovation. The reason is that the concepts are very important for building up a concrete knowledge of environmental education in which much concerned by many educators because of its contribution to sustainable development in the future.

4. Conclusion

The study on environmental education on soil has revealed that the conceptions on soil and soil properties have not been well understood by high school students of both Japan and Cambodia. The students have misconception on soil's properties and could not draw the structure of soil. They did not know the components of soil, meaning that they are lacking of basic knowledge on soil as well as on environmental education. The conceptions on soil they brought into science class are different from those accepted by scientists. Their answers based mainly on their own conceptions, experiences or understandings in which they encounter every day. So that, to promote students to enhance their problem solving on environment or to promote students to become environmental literates that have been long considered one of the most important goals of science education, students should be equipped with strong fundamental knowledge because building a wonderful house requires firstly starting from the concrete setting, educating students to become science literates, engineers or scientists require starting from teaching them fundamental knowledge. A house cannot be strong enough if the concrete is not built in good condition. In the same way, a student cannot be science literates, engineers or scientists if the background knowledge of science is not solid. In chemistry education at the upper secondary school level, learners should be educated a certain established way of thinking in science, commonly referred to as scientific thinking. Therefore, it is advisable that the topic on soil and soil's properties especially on soil adsorption should be introduced in high school curriculum of both countries. The reason is that the topics are common, familiar with students living, and crucial for future sustainability. Moreover, the topics are consistent with the level of student understandings if it is well prepared and the lesson is well planned.

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