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Promotion of Student's Abilities in Proper Judgment on the Topic of Bio-energy: Development of Lesson Model in Chemical Education

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Abstract

A lesson model in chemical education of high school on the topic of bio-energy was developed through this research. Results of the evaluation to the trial showed the lesson model realized the promotion of student's abilities in proper judgment of social problems related to energy supply by knowledge of science.

Introduction

Recently, renewable energy resources have been rapidly developing in the world in place of fossil fuels. Bio-energy produced from biomass is one of a candidate of them, and it is paid to attention as a carbon neutral energy resource. However, students do not entirely understand things about bio-energy with satisfaction, and they are lacking in ability to judge social problems related to energy by knowledge in Japanese science education.

The Berlin's Model developed by Bolte, C. and Kirschenmann, B.[1][2] is one of the excellent lesson model developed to promote student's scientific literacy and to enhance popularity and relevance of science teaching and learning[3]. In the context of modules in the lesson model, popularity refers to students linking the science lessons and wishing to study the subject in school, and relevance means that students recognize the modules being worthy of study.

A lesson model in Japan related to bio-energy is proposed herein through this research, which is aimed at promoting student's ability in judgment through an improved model of the Berlin analogue. A trial and evaluation are conducted in chemical education in Japanese high school.

Development of the lesson model

The aim of making a lesson model is to promote the student's ability to judge social problems related to energy supply by knowledge of science. Contents of the lesson are composed of the following items. Normally, a period is fifty minutes long in Japan. Frequency of classes is indicated in parentheses.

- 1. Lecture: "Energy situation and development of bio-energy in the world and Japan" (1 hour)
- 2. Lecture and Experiment: "Acquisition of the energy from solid of wood" (4 hours)
- 3. Lecture and Experiment: "Acquisition of the energy from liquid of bio-diesel" (4 hours)
- 4. Lecture and Experiment: "Acquisition of the energy from gas of biogas" (2 hours)
- 5. Study Tour: "The bio-energy plant" (1 day)
- 6. Activity: "Evaluation of things concerned about bio-energy" (3 hours)

Materials for the lecture, a manual and work-sheets for the experiments and evaluation-sheets for students' activities were made and exploited. These were things modified from the original of the Berlin model. Contents of Japanese school textbook were incorporated into materials and the manual as a supplement in order for Japanese student to be able to use it. Work-sheets and evaluation-sheets were followed completely as the same of the Berlin model.

Trial of the lesson model

A lesson model was carried out for 25 students of the 11^{th} grade and 3 students of the 10^{th} grade of The High School attached to Hiroshima University during four days from 28^{th} through 31^{st} in July of 2008.

The first day; contents 1 and 2 in the lesson were carried out. In the content 1, the lecture on the energy consumption of the world and Japan, amounts of the CO_2 exhaust, prices of crude oil, and the lately trend of development of renewable energy in the world was given to students. In the content 2, the lecture on compositions of various woods, process of their combustion, and calorific values of combustion of them was done. Then, the experiments by the students with measurements of calorific values of paraffin and wood pellets, and the detection of the gas generated by the combustion of wood pellets were carried out.

The second day; contents 3 and 4 were conducted. In the content 3, the lecture on materials of oils, fats, and fatty acids and the generation of bio-diesel by transesterification of colza oil with methanol were given to students. Then, they experimented on the generation of bio-diesel and measurement of calorific values, viscosities, and flash points among colza oil, bio-diesel, and diesel (light oil). In the content 4, the lecture on methane fermentation, the composition of biogas, and calorific values of biogas was given. Then, the experiments on combustion and generation of methane from the horseshit were practiced.

The third day; the content 5 was implemented. Some sites of manufacturing in the model area as a biomass town were visited, and the use of wood pellets and bio-diesel regenerated from used cooking oil were inspected.

The final fourth day; the content 6 was carried out. The comparison of wood pellets and kerosene and that of bio-diesel and diesel were practiced and evaluated as a fuel from the standpoint of energy. Moreover, students played each role of agriculture and forestry engaging person, manager of enterprise, consumer, scientist, and administrative person at the section concerned about bio-energy, and they discussed about its merits and demerits (or weak points) for the promotion of bio-energy as joint owners themselves.

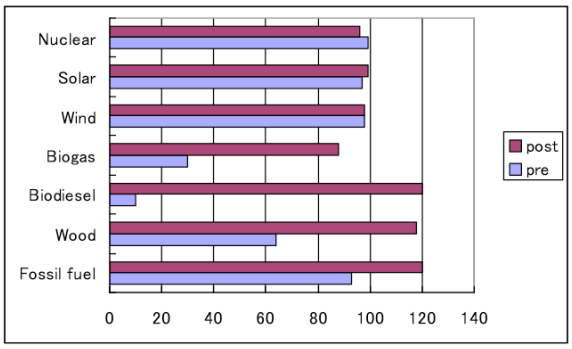

Fig. 1. Number of reasons toward agreement and opposition

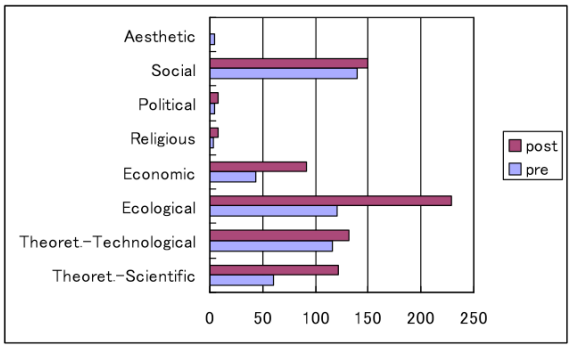

Fig. 2. Number of reasons from the standpoint of the aspect

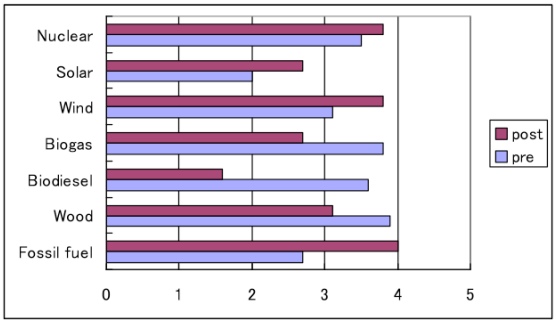

Fig. 3. Grades to facilities of energy supply

Evaluation of the lesson model

Questionnaires were given to the students before and after the lesson.

Reasons for an agreement with or opposition to the construction of facilities of energy supply and use of fossil fuel, wood, bio-diesel, biogas, force of the wind, solar battery, and nuclear power were enumerated. Number of the reasons increased to about 30 pieces per a student after the lesson while the number was about 20 pieces per a student before the lesson (Fig. 1). Especially, the number after the lesson about facilities of energy supply using the bio-energy of wood, bio-diesel, and biogas has increased about seven times many as that

before the lesson.

Aspects of the reasons were various (Fig. 2). Especially, not only the aspect about ecology but those about economy and science (chemistry) increased after the lesson. The sustainability of these aspects also came to appear.

The grade from the viewpoint of student's evaluation to facilities of energy supply was imported on the score from 1 (the highest) to 6 (the lowest). It was worthy of special mention that the grade for bio-diesel had gone up while that of the fossil fuel had come down (Fig. 3).

Another questionnaire was given to the students after the lesson. Since wood pellets *vs.* kerosene and bio-diesel *vs.* diesel were assessed as a fuel, various criteria from the standpoints of the cost, responsible concern for the environment, calorific value, easiness and prospects toward manufacturing, and *etc.* were raised to the surface (Question 1), 3), and 4) in Fig. 4 were conducted to individuals. Question2) was conducted to groups respectively.). An each grade of these materials as a fuel was determined by the rule to score all the standpoints to it. The averages of "Final grade"were 2.4 of wood pellets *vs.* 3.2 of kerosene and 2.4 of bio-diesel *vs.* 3.1 of diesel. Wood pellets and bio-diesel were higher grade.

Moreover, students' interests were clarified and identified each other through the discussion after the stage of a role playing as the evaluation activity about bio-energy. Ultimately, it was concluded that students' participation and cooperation as a citizen were evidently necessary in order to promote the bio-energy resource.

Work sheet

Carry out your own assessment of the two fuels, biodiesel and diesel, in group work.

1) Write down ten criteria which are important for your assessment of both kinds of fuels, i.e. biodiesel and diesel.

2) Choose five of the ten criteria which you want to use for the assessment. Determine the "importance" or the weighting factor of each criterion by allocating all in all 20 points to the chosen criteria.

Criterion	Weighting factor
A	
B	
C	
D	
E	

3) Assessment of the fuel biodiesel:
List your selection of criteria and the respective weighting factors.
Assess biodiesel after each criterion and allocate grades to it [*1 = very good* to *5 = inadequate*].
- Calculate the "weighted grades" by multiplying the grade of the respective criterion with the weighting factor. Then add the single "weighted grades". In order to calculate the fina grade, divide the sum of the "weighted grades" by 20.

Biodiesel			
Criterion	**Weighting factor**	**Grade**	**"weighted grade"**
A			
B			
C			
D			
E			
Sum	**20**		
			: 20
Final grade			

4) Assessment of the fuel diesel:
Use the same principle as with the fuel biodiesel.

Diesel			
Criterion	**Weighting factor**	**Grade**	**"weighted grade"**
A			
B			
C			
D			
E			
Sum	**20**		
			: 20
Final grade			

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Fig. 4. Work-sheet to the assessment of energy resources (bio-diesel *vs.* diesel)

Closing

The lesson model related to bio-energy in chemical education of high school was proposed. The model realized to promote the student's ability to judge social problems of related to energy supply by various knowledge including that of science. Further research would be to discover commonness in diversity by

comparing with practices of this lesson model in other countries.

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