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AN EASY-TO-MAKE GLOBAL WARMING MODEL INSTRUMENT AND ITS APPLICATION IN BASIC ENVIRONMENTAL EDUCATION

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Abstract

Environmental education for schoolchildren is a key to developing a sense of responsibility with regards to environmental problems and can lead to more rational and sustainable modes of energy use. The results of a questionnaire given to the junior high school students suggests that a large number of students agree that something needs to be done about global warming and climate change. This study was undertaken to develop a do-it-yourself model instrument of global warming and estimating its applicability to the education of energy and environment. Three types of self-makable model instruments including two alternatives were successfully designed and assembled. Based on our novel approach, we carried out several model experiments for junior high school students. The applicability of our instrument model was tested further as the teaching materials for environmental education in schools. Here, we demonstrate that our novel model instrument can be used as good teaching material to account for global warming. Finally, the student's attitudes toward environmental issues were classified by factor analysis.

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1. Introduction

Environmental education should be directed to encourage students and adults to be enthusiastic about nature and the environment and to expand their knowledge of the natural world. Environmental education is also considered a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment (Liefländera and Bognera [4]). As a result, individuals can develop a deeper understanding of environmental issues with the acquisition of the skills to make informed and responsible decisions (United States EPA [6]). The final aim of environmental education is to become aware of the relationship between human activities and environmental problems and to change behaviours in an environment-friendly manner.

There is little time and limited scope in the education of current environmental problems (e.g., climate change). There is no doubt of the need to promptly provide greater environmental education in formal curriculums (Cutter-Mackenzie and Edwards [1]). The experiences in the UK over many years have shown that it has become increasingly difficult to carry out environmental education, particularly with respect to global issues, if one relies on traditional educational teaching materials (e.g., text and pictorial) (Hungerford and Volk [2]).

The traditional environmental education has typically focused on ecosystems. Meanwhile, there has not been a clear relationship between the formal curriculum of environmental education in school and its tangible results. This is likely to be viewed by many teachers and probably students as a weakness of environmental study mainly with one's textbooks. Children and adults crave to learn the principles of

environment problems without dealing chemicals in text, while providing concrete case studies to show how their actions may affect the natural world and to learn the relationship between their actions and environmental problems (Stanišić and Maksić [5]). The development of teaching materials (e.g., a small-scaled labs experimental kit) is thus ideal for raising student and adult awareness of many imminent environmental issues.

The aims of this study is to introduce a teaching tool for effective environmental education in schools, to improve understanding of global warming processes by participating in a model experiment, and to finally bring about behavioural changes in students with regards to the environment.

2. Development of Self-Makable Model Instruments for Global Warming

2.1. Preliminary questionnaire result

In order to investigate the environmental awareness of students, we conducted a questionnaire survey of 84 junior high school students in Japan. The question was “how much interest do you have in environmental issues?”. The left side pie chart in Figure 1 summarizes the results of the questionnaire. Interest and very much interest account 59% and 28%, respectively. This suggests that most students take an active interest in environmental issues.

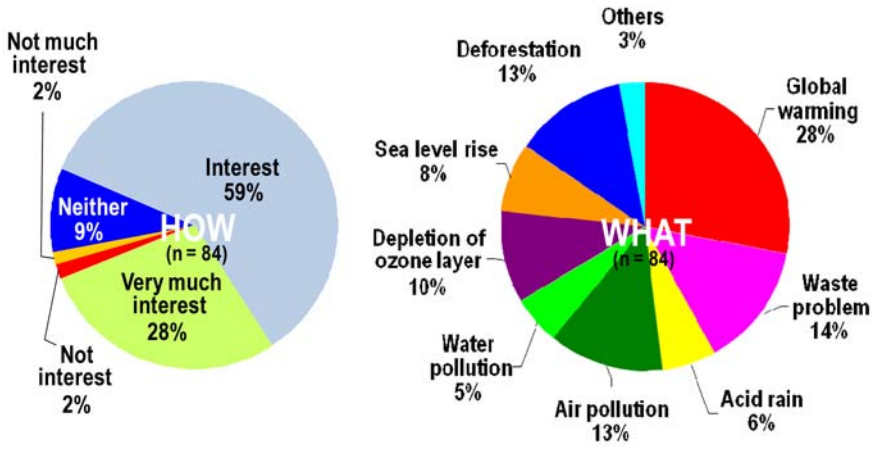

Figure 1. Results of a questionnaire about environmental issues for junior high school students.

Furthermore, we carried out another survey of the question, "what environmental issues interest you most?". The right side pie chart in Figure 1 shows the results. Global warming received 28%, followed by waste problem (14%), air pollution and deforestation (each 13%), depletion of ozone layer (10%), sea level rise (8%), acid rain (6%), and water pollution (5%). This result indicates that many agreed that climate change is one of the greatest threats facing the planet. In the other words, a large number of students agree that something needs to be done about global warming and climate change.

2.2. Description of self-makable model instrument

Our model instrument is designed with the school student in mind. Although the school student is the target of model experiment, the appropriate age is older than 10 years. Our model instrument is also intended for adults, for example, local villager. It consists of two transparent hemispherical bowls (polystyrene) with a diameter of 20cm, an infrared lamp with 100W, a digital thermometer with the sensitivity of 0.1 degree, two rubber bungs, and a globe with a diameter of 10cm.

The procedure of set up of model instrument is as follows: Fix the globe on the bottom hemispherical bowl (1) - Make a hole at top of the upper hemispherical bowl (2) - Set the infrared lamp to the center of upper hemispherical bowl (3, 4) - Combine the upper and bottom hemispherical bowl (5) - Insert two rubber bungs into both sides of upper hemispherical bowl and insert a digital thermometer into one side of one rubber bung (6). An illustrated explanation for the procedures of the model instrument is shown in Figure 2.

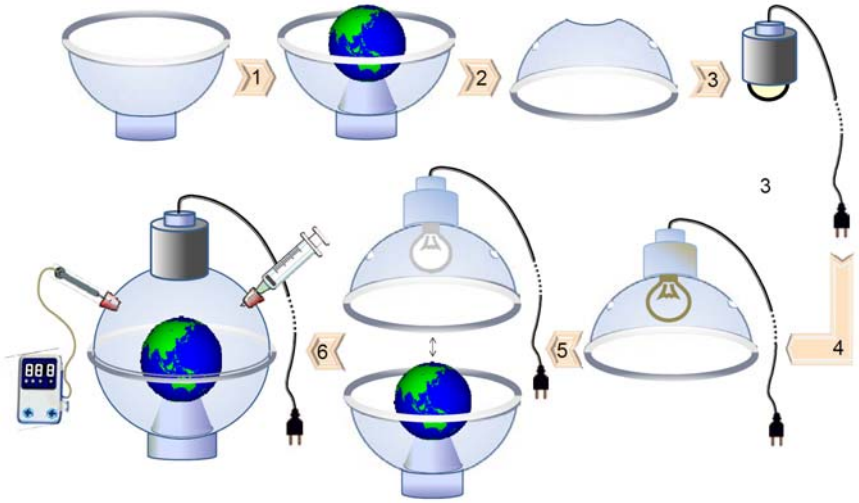

Figure 2. Making procedures of model instrument for the experiment of global warming.

Following this flow, our model experimental tool comes easily assembled. And most parts are available by purchasable materials at modest expense. Our small scaled (20cm diameter, 25cm height) model instrument typically costs below US $ 70. Photo 1 shows a view of the completed model instrument.

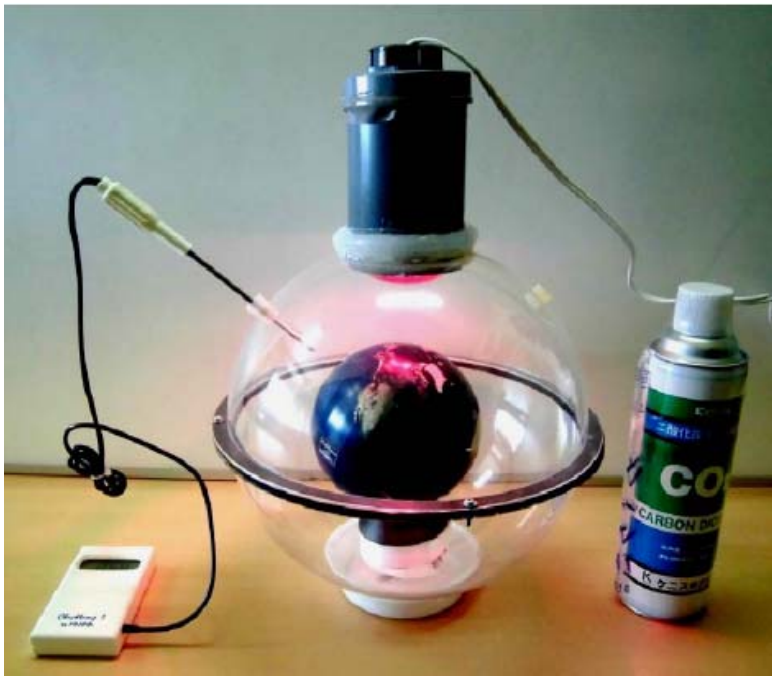

Photo 1. Real view of the model instrument for experiment of global warming.

A more simple model instrument (Alternative type 1) is alternatively suggested (Photo 2). The components of this alternative experimental tool are quite similar to upper one. However, since making a hole at bowl is unnecessary, this alternative model tool allows children ages 10 and up to easily make and assemble their own model instrument.

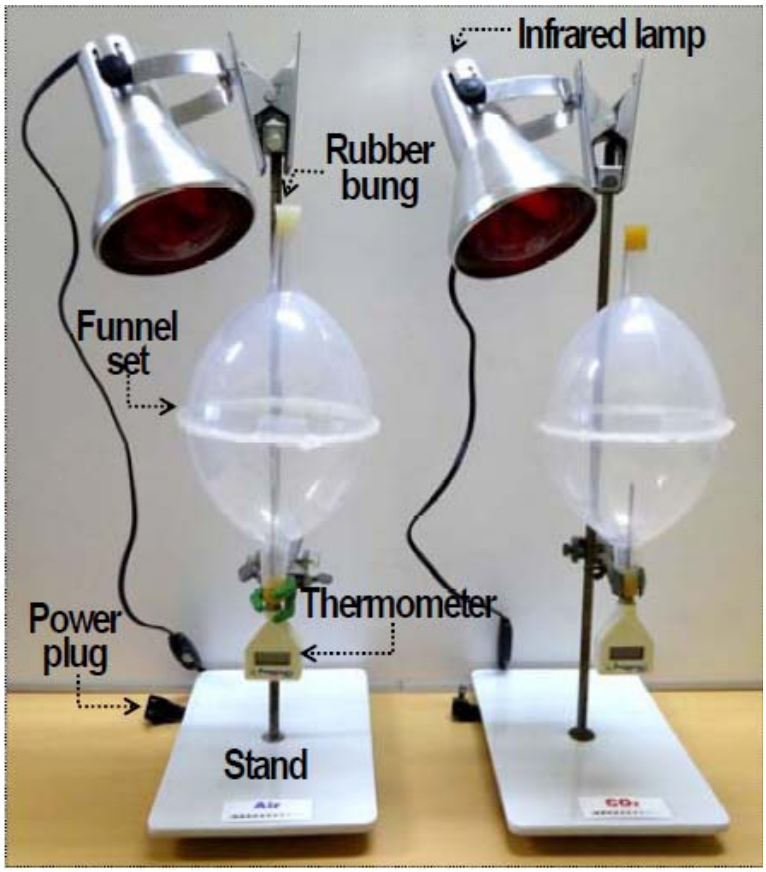

Photo 2. An alternative model instrument that can be readily assembled (Alternative type 1).

Furthermore, Photo 3 shows another alternative model instrument combining an automatic data drawer of temperature (Alternative type 2). As compared to the upper ones, the major difference is the automatic drawing of temperature variation by installing the temperature data transmission to note-PC. A cardboard box was employed instead of a transparent hemispherical bowl.

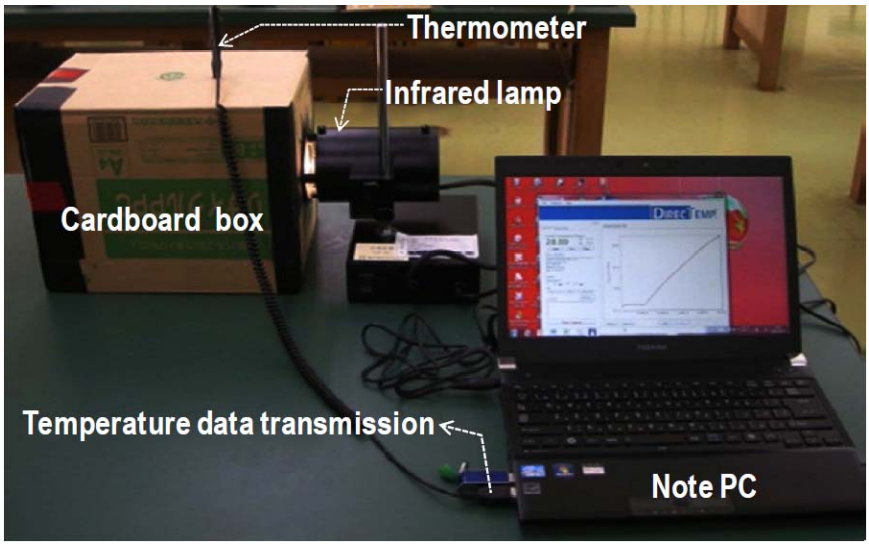

Photo 3. An alternative model instrument combining an automatic data drawer of temperature (Alternative type 2).

Kawamura [3] introduced an apparatus for the demonstration of global warming. Although the component of his apparatus is similar to ours, it is difficult to make and assemble his apparatus for the lower grade students because it was designed to periodically rotate the light source using a motor. Meanwhile, our model instrument suggested here can be easily assembled by students (in the case of Alternative type 1, about 10 years old) using the parts readily available.

3. Model Experiment and Result

3.1. Procedures of a model experiment

The procedures adopted in this study for the experiment of global warming were as follows:

(1) Prepare three model experiment sets for the comparative model experiments between air and greenhouse gases (e.g., carbon dioxide and methane).

(2) Switch on a digital thermometer.

(3) Using a syringe, inject 100mL of carbon dioxide and methane into two model instruments, respectively. In this case, the concentration of carbon dioxide gas with 95% assay can be calculated as 25,900ppm by an equation of $100\text{cm}^3 \cdot [4 \cdot 3^{-1} \cdot \pi \cdot [(10\text{cm})^1\text{-}(5\text{cm})^3]]^{-1}(95 \cdot 100^{-1}) \cdot 10^6$. If one wants to adjust the carbon dioxide concentration to that of real ambient level (360ppm), the amount of injected carbon dioxide should be 1.39mL. No gas was fed into the control instrument (i.e., air).

(4) Record the initial temperature of each model instrument after a steady temperature.

(5) Switch on infrared lamps at the same time.

(6) Read and record the temperature of each experimental set every minute until the temperature rises to 40 degrees Celsius.

3.2. Result of model experiment

Temperature variation drawn during the period of model experiment is illustrated in Figure 3. As might be expected, the temperature was dissimilarly varied as the functions of the type of gas and elapse time. The time required reach to 40 degrees Celsius is 6 minutes 30 seconds, 13 minutes 30 seconds, and 18 minutes 30 seconds for methane, carbon dioxide, and air, respectively. As a result, it allows students to visually demonstrate how temperature varies according to each type of gas. When 100mL of greenhouse gas was injected into our model instrument, the time required for an entire model experiment is about 25 minutes.

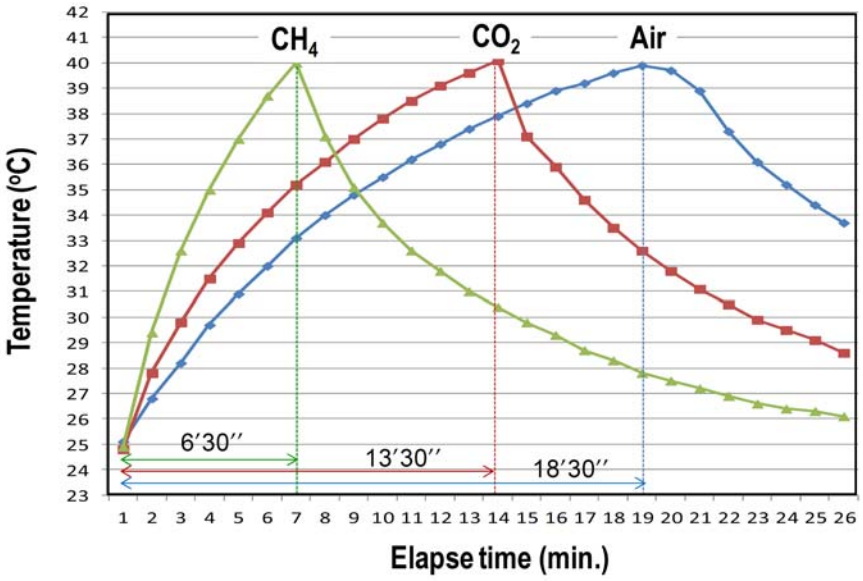

Figure 3. Temperature variation as the functions of gas kind and elapse time drawn by a model experiment.

It is well known that methane is over 20 times more effective than carbon dioxide in trapping heat in the atmosphere. In our model experiment (Figure 3), methane reached 40 degrees Celsius more rapidly than carbon dioxide. The reason for this is in the molecular geometry. Carbon dioxide and other triatomic gases can absorb infrared radiation because of intramolecular motion (vibration, rotation, and bending). Methane is a more effective greenhouse gas than carbon dioxide because methane can rotate more (it has four bonds rather than just two double bonds).

4. Availability Estimation for Model Experiment

In order to evaluate the availability of our model experiment for students' understanding of the principle of global warming, the questionnaire asking "do you understand the principle of global warming?" were conducted before and after the model experiment. Figure

4 shows the variation of degree of understanding for the principle of global warming before and after the model experiment.

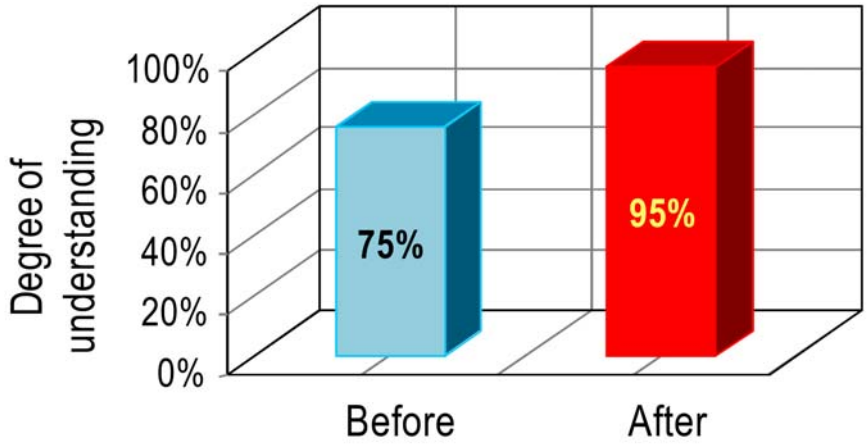

Figure 4. Variation of degree of understanding for the principle of global warming between before and after model experiment.

Before the experiment, 75% replied positively. On the other hand, 95% of the students gave an affirmative answer after the experiment. This result suggests that our experiential model experiment was readily intelligible to almost the all of students who joined in our participative model experiment. As a result, environmental education through the practical model experiment cloud improves students' capacity to understand the fundamentals of environmental problems. In the other words, the effect of the environmental lesson can be enhanced when an explanation is accompanied by concrete educational tools.

5. Analysis of Determination Factors for the Student's Environmental Awareness

In order to come up with an effective plan for environmental education, investigation into determination factors for student environmental awareness is essential. In this study, the following 22 variables were selected for factor analysis: listening to environmental

issues on daily life (Lis), experience in education of environmental issues in school (Exp), interest in environmental issues (Int.e), interest in global warming (Int.g), interest in model experiment of global warming (Int.ex), understanding the global warming model experiment (Und.e), interest in environmental issues after the model experiment (Int.af), liking science (Like), number of education experiences for environmental issues (Num.e), environmental action volunteers in school (Act.e), number of environmental action volunteers in school (Num.a), understanding global warming (Und.g), necessity for education on environmental issues in school (Edu), joining a seminar on environmental issues in school (Join), pets and plants in home (Pet), environment-friendly action in the home (Act), communication with family to become environment-friendly (Com), watching TV programs on environmental issues (Env), contacting the media (e.g., newspaper and TV news) (Med), recycling at home (Rec), duplex generation (Dup), and leaving food (Lea). We carried out a survey targeting junior high school students who joined in our participative model experiment and then factor analysis was practiced.

The result of factor analysis intended for junior high school students is summarized in Table 1.

Table 1. Result of factor analysis for junior high school students

	Factors					
	1	2	3	4	5	6
Com	0.626	278	0.211	-0.064	0.361	-0.236
Med	0.679					
Rec	0.827	117	-0.137	0.135	0.001	0.245
Und.g	-0.174	0.847	0.047	-0.021	0.167	0.079
Und.e	-0.012	0.780				
Int.g	0.267	0.772				
Lea	-0.001	0.057	-0.87	-0.019	-0.079	-0.088
Num.e	-0.234	-0.118	0.688	0.148	-0.067	-0.081
Num.a	0.168	-0.062	0.848			
Env	0.212	0.345	0.685			
Act.e	0.018	0.306	-0.022	0.822	0.058	0.082
Pet	-0.038	-0.284	-0.051	0.911		
Dup	-0.695	0.148	-0.081	0.319		
Act	0.377	-0.147	0.238	0.721		
Int.e	-0.187	-0.23	-0.124	-0.253	0.767	0.087
Exp	0.023	0.301	0.149	0.045	0.672	0.036
Sex	-0.443	0.035	-0.091	0.113	-0.184	0.711

Daily encountering to environmental issues

Impression on the model exp.

Environmental education

Domestic situation

There, 17 variables were successfully classified into 6 factors. Among them, the percentages of variance for four predominant factors are 30.1%, 26.5%, 18.4%, and 11.2% for factor 1, 2, 3, and 4, respectively, with 86.2% of the cumulative (factor 1-4). Com, Med, and Rec were grouped in factor 1 and interpreted as daily encountering environmental issues. In factor 2, Und.G, Und.e, Int.e, and Lea, which means the impression on the model experiment, were classified. The third factor seems to express the environmental education because it is correlated with Num.e, Num.a, Env, and Act.e. The domestic situation (i.e., Pet, Dup, and Act) was grouped into the fourth factor. Through the result of factor analysis, it can reasonably be said that the daily attitudes and motivation to improve or maintain environmental quality and the knowledge and understanding of the environment and environmental problems, and environmental education are a crucial requirement for students to change their awareness and sensitivity to environmental issues.

6. Conclusion

Many junior high school students are interested in understanding climate change/global warming. Daily attitudes and motivation to improve environmental quality and environmental education have proven to be a key resource to determine students' awareness to the environmental issues. As such, several-type model instruments of global warming were designed in this study. Our model instrument provides a realistic experience of global warming based on the participative model experiment to students as well as teachers. Our model instrument was also designed to increase students' knowledge of the global warming concept and to encourage a direct sense of connection between energy use in their everyday lives and environmental quality. The result of the questionnaire after model experiments demonstrates that our model instrument is useful as a practical learning tool that help students and teachers make a visual connection between energy use and its effect on the environment. Furthermore, the visual demonstration of the temperature variation according to gas kinds can improve students' capacity to understand for environmental problems and subsequently instigate changes in attitude about environmental issues.

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