ABSTRACT

The environmental education with ideal teaching tools (e.g., a small-scaled experimental kit) is essential for raising the public’s, especially student’s, awareness of many environmental issues. This study was undertaken to develop a do-it-yourself model instrument of acid rain and estimating its applicability to the environmental education. Our novel model tool consists of a body (17 cm width, 6 cm depth, and 17 cm height), an acid gas injector, acid four rain reservoirs, and a drop supply pump. An alternative model instrument that can be more readily assembled was also suggested. Based on our novel approach, we carried out several model experiments with educatees (i.e., high school and college students, and adults). The results of questionnaires indicated that educatees achieved a very deep understanding of acid rain through an experienced model experiment. A 77 to 89% of educatees experienced the reappearance experiment of acid rain by our model instrument felt that it was very useful as a teaching tool of environmental education.

Key words: Acid rain, Environmental education, Teaching tool, Model experiment, Pollutants

1. INTRODUCTION

Many of the decisions people make on a daily life affect our environment; for example, how often you drive, which items you can recycle, what you order for dinner, and what you use for weeding. The most important thing for environmental protection is to reach an understanding and to become fully aware of the fact that our daily life affects our environment (Foster, 2001; Gamba and Oskamp, 1994). In order to do so, environmental education is essential. Environmental education should be directed to encourage public, especially students, to be enthusiastic about nature and the environment and to expand their knowledge of the environmental problems (Dimopoulos et al., 2008; Stanišić and Maksić, 2004; Bogner, 1998). 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 (Cutter-Mackenzie and Edwards, 2013; Liefländera and Bognera, 2004). As a result, individuals can develop a deeper understanding of environmental issues with the acquisition of the skills to make informed and responsible decisions (Casey and Scott, 2006; Pooley and O’Connor, 2000).

In practical terms, unfortunately, there is little chance and limited scope in the education of current environmental issues (e.g., climate change and acid rain). Furthermore, the traditional environmental education has usually practiced with text and pictorials. However, there has not been a clear relationship between the informal environmental education with text and pictorial and its visible results. The experiences in the UK over many years have shown that it has become increasingly difficult to practice environmental education if one relies on traditional educational teaching tools (e.g., text and pictorial) (Hungerford and Volk, 1990).

There is no doubt of the need to promptly provide the formal environmental education with innovative teaching tools which children and adults crave to learn the principles of environment problems without dealing chemicals in text.

The aims of this study is to introduce a teaching tool for effective environmental education in school and community, to improve understanding of environmental issues (in the present study, rain processes) by participating in a model experiment, and to finally bring about behavioral changes in students with regards to the environment.

2. PRELIMINARY QUESTIONNAIRE

In order to investigate what is the ideal education method of environmental issues for educatees, we carried out a questionnaire survey. The question was “What
do you think the best method for learning about envi­
ronmental problems is?”. The questionnaires were
handed out during the college festival opened to the
public. The randomly selected 144 high school stu­
dents, 94 university students, and 123 adults completed
the questionnaire on their own. The adult group was in
their 30s to 60s and the ratio of men to women in this
group was 50:50.

The pie charts in Fig. 1 summarize the results of the
questionnaire. Regardless of the survey targets, “Heu­
ristic learning” accounts a high rate (53%, 53%, and
40% of high school students, university students, and
adults, respectively). This suggests that many students
and adults want to understand about environmental
issues by discovering the mechanisms (or principles)
and by learning from their own experiences rather than
by telling something from instructors.

“Liaison with university was the next better method
to “Heuristic learning” in the groups of high school
students (32%) and university students (28%). Mean­
while, in the case of adults, “Heuristic learning” was
followed by “Autonomous learning”.

This result indicates that many respondents agreed
that “Heuristic learning” is one of the greatest methods
for learning about environmental problems. In other
words, a large number of students and adults desire
something that helps them to better understand the es­
sentials of environmental issues.

3. DEVELOPMENT OF
SELF-MAKABLE MODEL
INSTRUMENTS FOR ACID RAIN

Normal rainwater has a pH of 5.6 due to the pres­
ence of carbonic acid from the reaction between car­on dioxide and water. Rainwater with pH value below
5.6 is considered as acid rain. Acid rain can directly
affect some organisms, like trees and fishes. While acid
rain does not affect humans as dramatically, it can in­
directly cause health problems, particularly lung issues.

Among various environmental issues, especially glo­
bal scale ones, acid rain will be a good target environ­
mental problem because it is easily verified by simple
pH measurement. Moreover, the experimental result
properly make educatees consider about “How can you
relate this experiment to what happen on Earth?” or
“What actions could help with the prevention of acid
rain?”. Ultimately, they will have to make the decision
themselves to take individual actions, such as turning
devices off when they are not in use, better insulating
homes to avoid excessive heating or cooling system
use and more.

In the present study, therefore, we suggested a self­
makable model instruments for acid rain as a teaching
tool of environmental issues. Our model instrument
was designed for students. Although students are the
target of model experiment, the appropriate age is older
than 12 years. Our model instrument is also intended
for adults, for example, local villager. It mainly con­
sists of a body (17 cm width, 6 cm depth, and 17 cm
height), an acid gas injector, four acid rain reservoirs,
and a drop supply pump (see Fig. 2).

The procedure of set up of model instrument is as
follows:

(1) Fix four-leg on a basal plane.
(2) Set walls (both side and center) and pierce four
raindrop nozzles.
(3) Set the back and acid gas inlet (make a hole at
middle of left side wall then insert a rubber bung).
(4) Set the surface having two holes of pH meter electrode, acid rain reservoirs, a drop supply pump, and two acid gas channels.

(5) Set two digital pH meters on the back and insert pH meter electrodes into the holes of upper side body.

An illustrated explanation for the procedure of making the model instrument is shown in Fig. 3. Following this flow, our model experimental tool comes easily assembled. Most parts are available by purchasable materials at modest expense. Our small scaled model instrument costs below US $50. Photo 1 shows the real view of the model instrument for experiment of acid rain.

An alternative model instrument that can be more readily assembled was also suggested (Fig. 4). The components of this alternative experimental tool are quite similar to upper one. However, the making a body of model instrument is unnecessary i.e., a commercial transparent-plastic tank can be employed instead of a body assembled from transparent acrylic plates. This alternative model tool allows children ages 10 and up to easily make and assemble their own model instrument.

4. MODEL EXPERIMENT AND RESULTS

4.1 Procedures of a Collection of Automobile Exhaust Gas

The procedures of exhaust gas collection from a tailpipe were as follows:

(1) Wrap the outside of the tailpipe with a piece of thick cloth (or many layers of newspaper).

(2) Compress the plastic bag with a volume about 40-50 L to remove all of the air from it.

Fig. 2. Completely assembled model instrument.

Fig. 3. Making procedures of model instrument for the experiment of acid rain.
(3) Hold the plastic bag against the cloth (or newspaper) that is wrapped around the tailpipe.

(4) Have someone start an engine while another person is ready to collect the exhaust gas and twist the plastic bag closed once it fills with the car exhaust.

Common pollutants of diesel emission include unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx) or particulate matter (PM). Although total concentration of pollutants in diesel exhaust gases typically amounts to some tenths of one percent, automobile exhaust gases have been found to be toxic to humans (Heeb et al., 2011). A caution is therefore needed to avoid the inhalation of automobile exhaust gases during collection and handling.

4.2 Procedures of a Model Experiment

The procedures adopted in this study for the experiment of acid rain were as follows:

(1) Prepare a weak acidic solution such as commercial emollient (i.e., beauty wash) with pH 5.8. This commercial emollient has an advantage of experimental time reduction compared to neutral water.

(2) Drop two or three Bromocresol Green (BCG) pH indicator into both rain reservoirs. BCG is a dye of the triphenylmethane family. In aqueous solution, triphenyl methane dye ionizes to give the monoanionic form (yellow around pH 4.0), that further deprotonates at higher pH to give the di-anionic form (blue around about 5.6).

(3) Fill a drop supply pump with this commercial emollient and then slightly press a drop supply pump.

(4) Check falling droplets from rain drop nozzles by visual identification.
(5) Inject automobile exhaust gas (or the vapor of nitric acid) as acid gas through an acid gas channel to acid rain reservoir.

(6) Visually check the color and pH changes of rain water filled in an acid rain reservoir.

4.3 Results of Model Experiment

Photo 2 illustrates the discoloration of artificial rain water caused by automobile exhaust gas with 10 mL amount. As shown in Photo 2, the color of acid rain water was change to blue to yellowish.

The time required reach to discoloration (from blue to yellow) of rainwater was one minute. As a result, this model experiment allows students (or adults) to visually demonstrate how acid rain is formed. When 10 mL of automobile exhaust gas was employed in model experiment, the time required for an entire model experiment was about five minutes.

The result of pH measurement for both acidic (pH 3.4) and test (pH 5.8) solutions by pH meter also indicated that our model experiment for acid rain was successful.

5. USEFULNESS ASSESSMENT AS A TEACHING TOOL

In order to evaluate the availability of the model instrument suggested in the present study for educatees’ (i.e., both students and adults) understanding of the principle of acid rain, the questionnaires asking “Do you understand the principle of acid rain?” and “Do you think this model instrument has a novelty value as a teaching tool?” were conducted before and after the model experiment. Fig. 5 shows the variation of degree of understanding for the principle of acid rain before and after the model experiment. Before the experiment, a 56.5 to 65.9% of educatees replied positively. Meanwhile, an 80.2 to 80.9% of educatees gave an affirmative answer after the experiment. This result suggests that our experiential model experiment was readily intelligible to almost all of educatees who joined in our participative model experiment.

According to Fig. 6, a 77 to 89% of educatees felt successful when they experienced the reappearance experiment of acid rain by model instrument. As a result, the environmental education through the practical model experiment cloud improves educatees’ capacity to understand the fundamentals of environmental problems. In other words, the effect of the environmental lesson can be enhanced when an explanation is accompanied by concrete educational tools.
6. CONCLUSIONS

Daily attitudes and motivation to improve environmental quality and environmental education have proven to be a key resource to determine public’s awareness to the environmental issues. As such, a novel model instrument of acid rain was designed in this study. Our model instrument provides a realistic experience of acid rain based on the participative model experiment to educatees as well as teachers. The result of the questionnaire after model experiments demonstrates that our model instrument is useful as a practical learning tool. In the present study, the real automobile exhaust gas was employed in reproduction of acid rain. Therefore, through the model experiment suggested in this study, people will become aware of the relationship between their daily activities including driving a car and environmental problems and finally encourage public to change their daily behaviors in an environment-friendly manner.

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