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Science teaching through practical work: Preventing children from shying away from science

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Abstract

A science class for elementary school children entitled: "Amazing Summer Experience of 2014 in Yamashina ward" was held for the purpose of enhancing interest in science and preventing children from shying away from science. A total of 156 participants: elementary school students (n = 113) and their parents (n = 43) attended, the following two experiments (Exp) were conducted: Exp-1) preparation of colorful artificial salmon roe by the reaction of sodium alginate with calcium; and Exp-2) demonstrating a resin-powder that absorbed much water with its high water-absorption property. During the classes, all students wore safety glasses and white lab coats for their safety, and performed experiments in a laboratory in our university. Wearing safety glasses and a white lab coat was an effective way to keep students focused on the experiments. Interestingly, there were critical questions about the experiments from the students. The nature and content of the questions indicated a general scientific understanding and a high level of interest in the experiments. Almost all students (97%) responded affirmatively that they "understood well" or "could understand more or less" on a questionnaire administered after the experiments. Moreover, the questionnaire results showed that their interest in science was enhanced by the class, and 94% of students responded positively to questions asking whether they had more interest in science after the event.

Note: This study was awarded the 2014 Kyoto Citizens' Charter for Nurturing Children for the promotion of "Practical Application Promotion Award" of science teaching.

Keywords: shying away from science, elementary school students, practical science experiments

1. Introduction

Recently, Japanese children in elementary school have been shying away from science. In a similar development, junior and senior high school students are also following the trend away from science, creating an urgent problem not only in Japan but also in many developed countries.[1] The trend in Japan is especially more drastic and urgent than that of other countries, and many children are not interested in studies related to science.[2] One of the reasons for this problem is a decrease of the amount of science experiments in classes because teachers in the school do not have enough ability of science experiments. Moreover, suitable environments such as experimental installations, enough time to prepare, information about experiments and so on are not put in place in many schools.[3-5] On the other hand, Industries in Japan utilize advanced science and technology and innovative technology have contributed to the high economic-growth of Japan science after World War II, the modern comfortable lifestyle of the Japanese people depends much on industrial earnings from companies in Japan even this day. However, a hollowing out of a technology-oriented and innovation-generation will be produced if the present trend of young people shunning science continues. In fact, this trend of shying away from science has already caused a significant and serious diminished consciousness and reduced interest in the development of science and technology, especially among the young people. In addition, the quality of arts students has also decreased concurrently, suggesting that shying away from science is directly linked with a reduced overall motivation for learning. [1] Thus, preventing the rejection of science by children is one of the most urgent and important topics in modern educational research.

In line with this urgent call for changing the mind-set of the modern youth, we have been holding science classes for kids as a part of regional volunteer efforts to encourage and stir interest of elementary school students in science by involving them in conducting experiments with the participation of their parents under the

supervision of higher-level academics, and in cooperation with the "'Human Development¸ Network Executive Committee of Yamashina ward" since 2011. In these science classes, we examined how we could prevent the young from shying away from science and in fact reverse their disinterest in science. In 2014, we administered a questionnaire to monitor perception from the local community by heralding the occasion as "Amazing Summer Experience of 2014 in Yamashina ward".

2. Methods and Subjects

2.1 Subjects

A total of 156 participated in the study: 113 elementary school students (age range: 9-12 years; grades 3-6) and their parents (n = 43) from the Yamashina ward (our preliminary studies using grades 1-6 showed discrepancy in experimental interests), and the questionnaire after experiments was conducted to all participants in order to collect various information. Students attending local elementary schools were randomly selected for the study by the aforementioned executive committee of the ward.

2.2 Methods

The participating elementary school students were divided into two classes of ca. 60 students each (accompanied by their parents):, i.e., morning and afternoon classes (each class lasted for 1.5 hours, and the science class was held twice in a day). In addition, 6 academics in our university and 16 volunteers in Yamashina ward as a lecturer attended each class (staff : student ≈ 1 : 3). In these classes, two experiments (Exp) were designed as follows: Exp-1 involved preparation of colorful lookalike artificial salmon roe by taking advantage of the reaction of sodium alginate with calcium (calcium lactate); and Exp-2 demonstrated a powder (Kenis, Ltd.), or a similar product, which absorbs much water rapidly, can be also taken from a diaper etc.. Each student conducted the experiment

Fig. 1: Original text used in the class: (a) cover and (b) contents of the text.

themselves under guidance from authors. In addition, an original text (total number of pages: 17) with information about the experiments was prepared and provided to each student (Fig. 1) as a guide to facilitate better understanding. After finishing the experiments, the questionnaire investigation was distributed to all attending students and parents, and the collected responses were analyzed. Moreover, students were allowed to take home almost all instruments used in the experiments free of charge, for them to further conduct experiments as and when they desired at home.

3. Results and Discussion

In the resolution of the problems for shying away from science, the experience which both children and teachers conduct science experiments is essential.[3-5] However, occasions which they conduct experiments in the school have been decreasing because of the above reasons (teachers' ability of science experiments and unsuitable environments for science experiments). On the basis of this fact, we hold the following science classes focused on elementary school students.

In the present science classes, total of 239 students applied for 120 positions allocated for the science classes, showing a high interest in the science experiments: this confirms previously reported evidence that elementary school students are interested in these experiments, as described in a previous study.[6]

The practical sessions showed the science classes were conducted in a laboratory at our university (Fig. 2). The science classes were not only effective in mimicking interest in the experiments but also contributed to regional effort in promoting education because none of the students and only some of their parents had any laboratory experience at the university. Due to their keen interest in the science classes, students stayed focused on the experiments, enabling efficient delivery of a high-quality educational and safe performance of the experiments. As all the students wore safety glasses and white lab coats, in following the class and conducting the experiments, the attire instilled discipline and full attention to the importance of safety in the laboratory. Together, the safety attire and smooth running of the class and experiments provided a sense of achievement in the participating students. These safety attires could play an auxiliary role in enhancing the interest in science, because the students could get the feel of being a 'scientist' by wearing the functional attire and protective goggles. Indeed, the

Fig. 2: Appearance of the science class with students wearing lab coat and safety glasses (a); and students were conducting the experiment under guidance of the academic staff of our university (b).

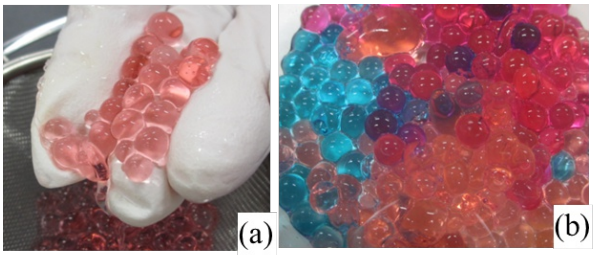

Fig. 3: (a) Prepared artificial salmon roe. (b) Lookalike artificial salmon roe colored by commercially available pigments.

following comments were elicited on the questionnaire about the safety glasses and white lab:

> "I was pleased to get a feel of for what it is like to be a scientist"
>
> "I could understand the importance of lab coat and goggles for safety purpose"
>
> "I was interested in the attire and goggles because I had not worn or used them before"

In the experimental situations, Exp-1 and -2 utilized familiar phenomena and easily procurable equipment to make students realize that many interesting phenomena exist around us in daily life.

In the case of Exp-1, students conducted an experiment on making artificial salmon roe by allowing sodium alginate to react with calcium, both reagents which can be purchased from any pharmacy (Fig. 3). Students prepared the colorful artificial salmon roe by utilizing pigments (red, blue, and yellow). They then adjusted and added appropriate pigments based on their observations of the shape and color of the artificial salmon roe to make the final product of their choice. Next, the students conducted an experiment utilizing the high water-absorbing resin, which was purchased online. Many students marveled with enthusiasm about the resin-powder rapidly absorbed water and became swollen with added water (Fig. 4). Moreover, they further conducted an experiment where the absorbed water was again released from the swollen resin by the addition of sodium chloride on the resin surface, leaving the resin flaccid (after water had been removed

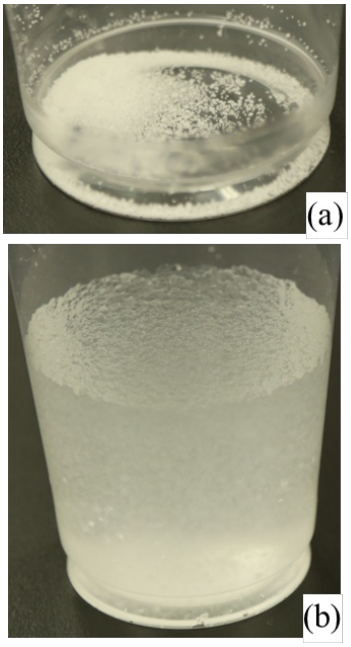

Fig. 4: (a) High water-absorption resin before addition of water. (b) Swollen resin after addition of water.

Table 1: Questionnaire on the understanding of the experiments

Items	Count (%)
I could understand fully.	81
I could understand more or less.	16
I could not understand.	1
Others	2

Table 2: Questionnaire on the change of interest in science before and after class

Before the class		
Items	Count (%) for students	Count (%) for parents
Science is my favorite subject.	42	33
I neither like nor dislike science.	46	56
I do not like science	4	8
Others	8	3
After the class		
Items	Count (%) for students	Count (%) for parents
I became more and more interested in science.	60	61
I developed a liking for science.	34	36
I am not interested in science.	3	3
Others	3	0

from inside the resin).

Intriguingly, some students asked the following perceptive questions:

> "Why and how can a diaper absorb urine even though urine is a solution containing sodium chloride ?"
>
> "Can the resin absorb seawater ?"

These questions indicate a high understanding and much attention to science by students. Actually, answers in the subsequent questionnaire revealed that almost all students (97%) could understand "fully" or "more or less" (Table 1). Moreover, after we gave a brief explanation of the principles in both experiments without the use of technical terms, students could understand better, implying that simple non-technical explanations played the most important role for students' understanding.

We subsequently asked students to answer questions with regard to any change in their interest in science before and after the class. The results (Table 2) demonstrated that negative responses (50%) quoted "I neither like nor dislike science" and "I do not like science", while over positive responses (42%) ticked "science is my favorite subject" were obtained before experiment. However, after the class, students' interest in science was elevated, where positive responses (94%) quoted "I became more and more interested in science" and "I developed a liking for science" over negative responses (3%) saying "I am not interested in science". Many accompanying parents also provided positive responses on the questionnaire survey similar to children (Table 2). In addition, the following requests and comments from parents were gleaned from the questionnaire:

> "This science class is a good opportunity for children to conduct experiments not practically available in school"
>
> "I hope that such a science class can be held several times a year"
>
> "I would rather experiments related to medicine and the human body be done, because these would encourage children to aspire to be a scientist in future"
>
> "I would prefer experiments on chemical reactions not conducted in school"
>
> "I would prefer experiments on the principles of electric generation, static electricity and LED"

Moreover, free descriptions in the questionnaire revealed the following comments:

> "I become interested in science as a result of conducting the experiments myself"
>
> "I could understand science well by conducting the experiments"
>
> "Conducting the experiments myself was more

interesting than just watching."

"Although I failed in the experiment, the experience was useful because it made me interested in science"

"Although I had known the property of the high water-absorbing resin, I was surprised that the resin absorbed more water than I expected"

The results confirmed that conducting the experiment by oneself could play an important role in enhancing the interest of that person in science. These effects would be consistent with the concept of Dale's Cone on experience.[7] Therefore, our results strongly suggest that incorporating more science experiments into the modern science curriculum at the elementary school level can be an important factor in preventing students from shying away from science.

4. Conclusions

In summary, science classes entitled "Amazing Summer Experience of 2014 in Yamashina ward" were held for elementary school students and their accompanying parents. The classes were favorably received by the students. Wearing safety glasses and a white lab coat while doing experiments in a new environment (laboratory) enabled students to stay focused on the experiments. Moreover, results of the post-event questionnaire revealed that the students' interest was markedly elevated after class, and almost all students (94%) became more interested in science.

On the other hand, our research utilizing the science class has a limitation that the follow-up investigations for each children were difficult because the science class is held only twice (morning and afternoon classes) a year. Thus, we are currently preparing for the next session of science classes incorporated the method enabling further collecting information. Moreover, that science class is expected to elucidate if the reversal trend of disinterest in science could be confirmed, and if such classes would consistently elevate students' interest in science and preventing children from shying away from science.

Acknowledgements

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Competing Interests

Authors have declared that no competing interests exist.

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