Creative Engineering Design Activity Using Aluminum Foil

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Abstract

Today, in a world that is rapidly changing, we are experiencing a sharp downturn in the economy. In such an age, we need to raise youngsters who can adapt to the global challenges and changes of the future. The concept, "Engineering Design" is very important in engineering education. It relates closely to creativity, since engineering is design in the broadest sense of the term. Also engineering is the discipline for invention and innovation, which require creativity. In this educational experiment, seminars and workshops were carried out in the United States and Japan, by using aluminum foil for the creative activity. During these events, students designed and built their own boats using aluminum foil sheets of a fixed size. They competed with each other to create the boat that would hold the most cargo. The problem was solved by counting the number of washers (used for cargo in Japan) or pennies (used for cargo in the U.S.) each boat held while floating in a tub of water. Participants thoroughly enjoyed this activity. They ranged in age from young children to grownups and learned the importance of creative design. This creative activity has three special merits for engineering education. 1. It provides students in formal courses of elementary, secondary and post secondary education with an inexpensive hands-on activity. 2. It is a great introductory lesson for freshmen in many colleges, as they begin their experimental courses. 3. It is a great way to recruit students to higher level educational organizations.

Introduction

We live in a challenging and ever changing world. Therefore the students (our future leaders and scientists) must be able to adapt and survive in such an environment. The concept, "Engineering Design" is very important in engineering education. It relates closely to creativity, since engineering is design in the broadest sense of the term. Also engineering is the discipline for invention and innovation, which require creativity. The authors Barry and Kanematsu maintain a strong interest in creative education and have collaborated with each other for several years pursing many international creative education projects(1)-(9). They are promoting an outreach program to turn youngsters onto science and engineering. Since design is essential for engineering education, it is important for children to have a concrete image of design and/or engineering design in advance. However, in many cases the educational materials provided by teachers in educational organizations are expensive and difficult for the teachers to use. As a result, the teachers are not able to effectively promote positive images of engineering and design. Therefore, it is very important to propose simple, inexpensive and effective hands-on creative design activities for children. This will allow educators to promote engineering and to improve communication between the engineering section in higher education and the general public.

In this experimental education project, a simple, inexpensive and enjoyable hands-on activity in creative design was carried out by youngsters at various locations in Japan. The activity provided the children with enjoyable learning experiences and a concrete image of engineering design. This paper includes a description of the project activity and a discussion of its results.

BOAT ACTIVITY AND ITS PRACTICE

The boat activity was originally introduced in the book entitled "Develop Critical Thinking Skills, Solve a Mystery, Learn Science(10), (11)" by Barry and Kanematsu. It was devised by Barry. This book was written to enhance the readers' creativity and critical thinking skills, while they enjoyed its two mysteries. In the second mystery of the book, the heroine, a high school science teacher named Ms. Ann Philips, devised the boat activity for use by her students on Invention Night. This was an open house school event, where students had an opportunity to display their creative work and inventions. Here is the citation from the book(12).

> *Obtain several pieces of aluminum foil (12 inches by 12 inches/30 centimeters by 30 centimeters). Use each sheet to design a boat that will hold many pennies while floating in a plastic container of water. Test your boats. Which boat design holds the most pennies while floating in water? How many pennies does it hold? Share your boat invention with the class.*

Fig.1 Experimental settings for the boat activity.

In fact, the procedure used by students in Japan is as follows. Pieces of aluminum foil (15 centimeters by 15 centimeters) were prepared. Instead of pennies, washers equivalent to US pennies in weight were prepared and provided for the students. They independently built and designed their own boats to float and carry cargo (washers). Plastic containers shut tightly with buckles were used as tanks of water for floating the boats. As previously mentioned, these items are not expensive and can be obtained easily. Fig.1 shows an example of the experimental setup.

Workshops were held in Tokyo and Suzuka in November 2008. The workshop in Tokyo was carried out on November 22, 2009 as one of many projects included in the Science Agola that was sponsored by Japan's Science and Technology Agency (JST). There were many booths where participants could see and enjoy seminars, workshops, attractions, etc. Our hands-on experiments were carried out in one of the booths. Children and their parents passed by our booth and looked at the setup. Then some of them decided to participate in our activities. Each time, we explained the activity challenge to the group of participants. After listening to our explanation, they designed, built, and tested their boats for carrying cargo. We posted a notice every time a participant achieved a new high score for the number of washers carried in a floating boat. This information seemed to motivate the new participants to challenge the record. Most of the participants were elementary school children and parents. However, some grownups

also joined the hands-on activities.
The workshop in Suzuka was held on November 29 at Suzuka National College of Technology. The participants included 27 elementary school children who belonged to Suzuka's Children's Invention Club. Their ages ranged from 10 to 12 years old. In this case, the participants were grouped into subgroups composed of 3 to 4 children. They struggled with the challenging problem as a subgroup. At the beginning of the workshops, we explained the experimental procedure and the goal of the activity to them. They struggled with the challenge enthusiastically. After completing the hands-on activities, they used posters to summarize their achievements. Their posters, achievements, design, teamwork etc. were evaluated in terms of the group's overall results and performance. The groups displaying excellent work received awards. Fig.2 shows an award ceremony.

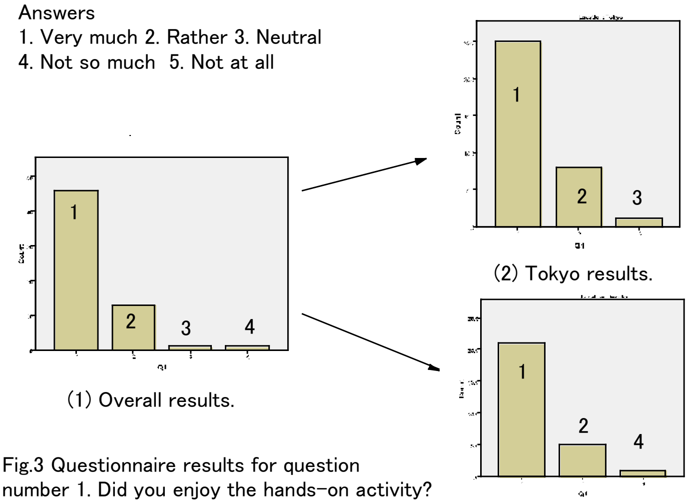
Fig.2 The award ceremony after the boat activity in Suzuka.

At the final ceremony, students showed their boats and described the concepts of their boat designs. The boat design, with a deep and narrow bottom, had the tendency to hold the maximum number of washers.

Results and questionnaires

We asked each participant to complete a questionnaire, in order to obtain information about their boat activity experience. There were four questions. 1. Did you enjoy the hands-on activity? 2. Do you like science? 3. Was the teacher friendly to you? 4. Do you want to join the activity again in the future? Fig.3 shows the results for question #1 (Q1). In both Tokyo and Suzuka, the results showed that the participants had a high degree of satisfaction with their boat activities. Actually, most of the participants enjoyed it, regardless of their age.

Answers
1. Very much 2. Rather 3. Neutral
4. Not so much 5. Not at all



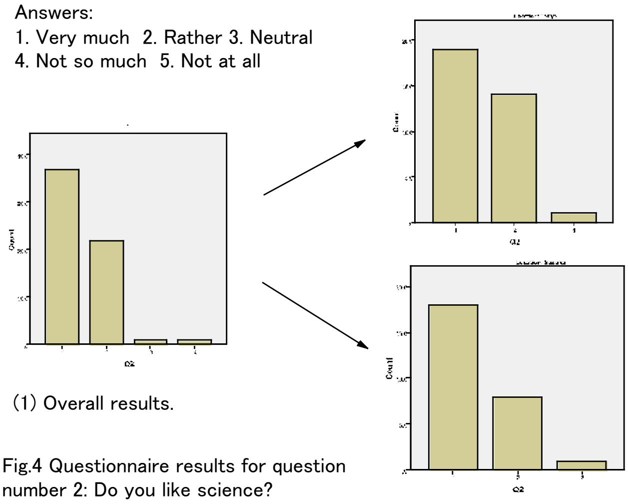
(1) Overall results.

(2) Tokyo results.

(2) Suzuka results.

Fig.3 Questionnaire results for question number 1. Did you enjoy the hands-on activity?

Answers:
1. Very much 2. Rather 3. Neutral
4. Not so much 5. Not at all



(1) Overall results.

(2) Tokyo results

(3) Suzuka results

Fig.4 Questionnaire results for question number 2: Do you like science?

Fig.4 shows the results for question #2 (Q2). It indicates that most of the participants liked science. Therefore, they could enjoy the activity and at the same time, this activity could make science lovers more enthusiastic.

Fig.5 shows the results for question #3 (Q3). It indicates that most of the participants had a positive impression about the teachers. However, the students in Tokyo were less favorable toward the teachers than the students in Suzuka. The reason might be because our activity's base is usually located in Suzuka.

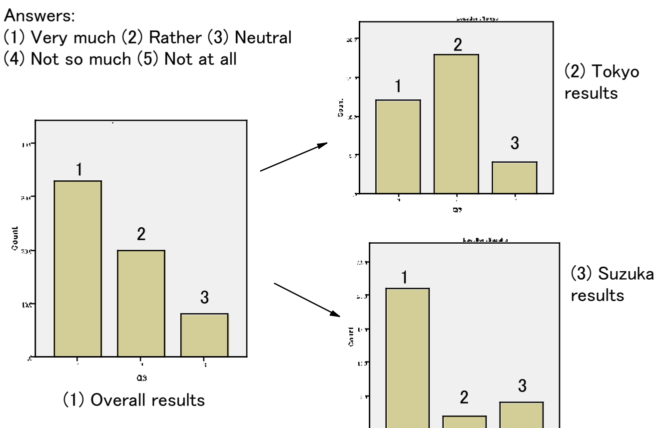


Fig.5 Questionnaire results for question number 3. Was the teacher friendly to you?

Fig.6 shows the results for question #4 (Q4). Children in Suzuka wanted to be back again more than those in Tokyo. However, most of the participants seemed highly-motivated to challenge this activity again in the future.

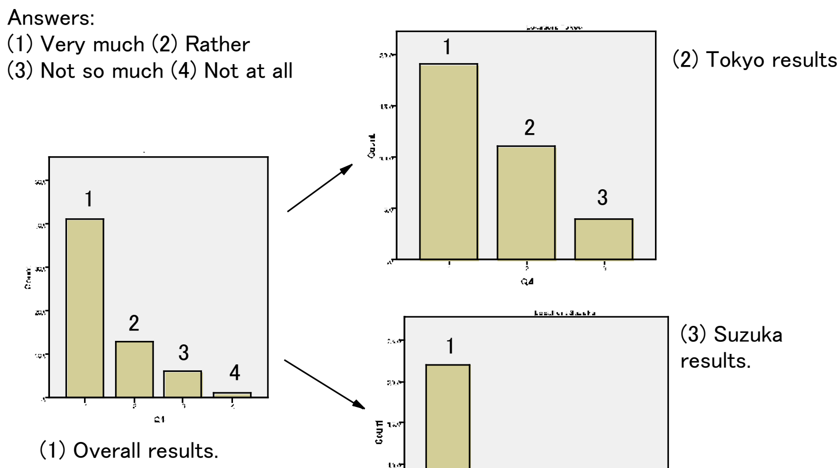


Fig.6 Questionnaire results for question number 4. Do you want to join the activity again in the future?

Conclusions

The simple, inexpensive and informative exercise in creativity, known as the Boat Activity, has been presented and described in this paper. Even though it only requires a few materials such as aluminum foil, washers, and coins, it is an excellent example of creative design. Also it is a great way to promote a positive image of engineering and engineering design. Our results indicate very clearly that the simple boat activity enhances the participants' interest and enthusiasm for science. Today the number of would-be engineers in the US and Japan is on a declining trend, which could have a detrimental effect on the manufacturing industry. It is invariably very important to teach children mathematics, physics and chemistry, so that they are familiar with a basic knowledge of science. Also we should give the promising children (our future leaders and scientists, etc.) very positive images of engineering and science. We want them to develop and promote their creative thinking skills, which are essential for successful careers in science and engineering. The boat activity can be used as one of these educational trials. You may want to try it with your students.

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