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Utilization of Hybrid Rocket as an Educational Material for Science Classes in a Public Junior High School

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Abstract
The revised courses of study for a junior high school will be noticed by the Ministry of Education, Culture, Sports, Science and Technology in Japan in the near future. The school hours for experimental trainings in Science and Technology will be reduced when it's imaged from its circumstances of the past courses of study. However, it is difficult to conduct time-consuming experiments and trainings in a public junior high school due to extra costs, extra works other than a regular lesson and teaching, and so on, though most teachers have high volition and consciousness for the education in a school. Therefore, effective science educational materials have been required.
Junior high school students are interested in the space anatomy, space technology and so on. A rocket is considered to be a motivation to let students be interested in science or technology. A hybrid rocket is being used for a commercial space rocket to move a human-being to the space. In this study, a small hybrid rocket was developed as an educational material using conventional materials. The aim of this study is the validation about the effectiveness and problems of the utilization of hybrid rocket as an educational material for normal science classes in a public junior high school.
A collaboration science class was performed using the hybrid rocket in second grade of Oohata Junior High School in Kumagaya. The questionnaire survey of the science class showed that students recognized that they made a rocket by themselves and most students enjoyed the class and want to do again. As a result, the utilization of the hybrid rocket as an educational material with the cooperation between a junior high school and a university was very effective not only in order to achieve the purpose of a science lesson, but also in order to evoke the interest of engineering and science.

1. Introduction
As a school year rises, the ratio of student with the interest in science decreases. The ratio of student who recognizes the importance of science decreases as shown in Fig.1. Over the years, it has been a problem in Japan that junior high school students do not actually feel the significance and usefulness of studying science.

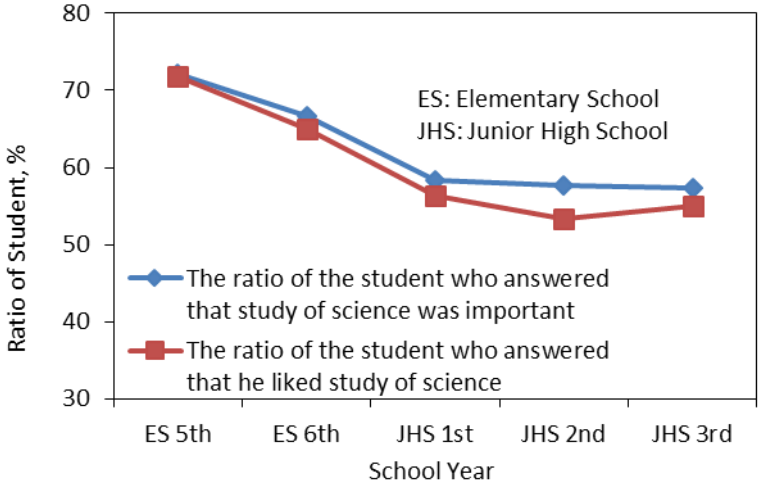

Fig. 1 The Consciousness for Science of a Young Student [1]

It's said that substantiality of empirical learning is important in order to let a student recognize the significance of studying. However, the school hours for experimental trainings in Science and Technology will be reduced when it's imaged from its circumstances of the past courses of study as shown in Fig. 2[2], even if the courses of study of a junior high school will be revised by the Ministry of Education, Culture, Sports, Science and Technology in Japan in the near future.

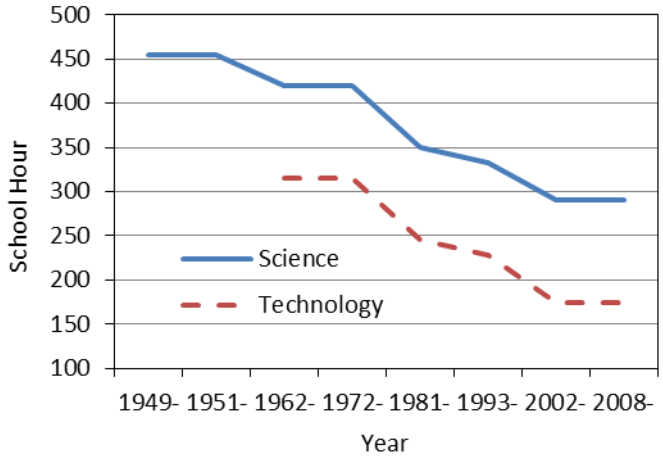

Fig. 2 The School Hours of Science and Technology

Furthermore, in order to improve a student's individual skill and volition, teachers have to understand the personality of each student further, and find the time for students to face each other, cooperating with an organization outside of the school. However, it is difficult to conduct time-consuming experiments and trainings in a public junior high school due to extra costs, extra works other than a regular lesson and teaching and so on[3], though most teachers have high volition and consciousness for the education in a school. Therefore, effective science educational materials are required.
As Junior high school students are interested in the space anatomy, space technology, rockets and so on, pictures of rockets are commonly included in a Japanese Science textbook to stimulate the interest towards science. Therefore, a rocket is considered to be a useful tool in increasing the motivation of a student studying Science and Technology. The aim of this study is to develop a rocket as an educational material, and to validate the effectiveness and problems of the utilization of rocket as an educational material for normal science classes in a public junior high school.

2. Rocket as an Educational Material

In a rocket, the heat energy occurred by a chemical reaction (combustion) of fuel and an oxidizer increases the pressure in combustion chamber, and changes to kinetic energy. Therefore, Technology about Energy Transformation in the subject "Technology", Force and Pressure, Movement and Energy, and Chemical Change in subject "Science" are related.
Types of educational materials in a rocket are a balloon rocket, a plastic bottle water rocket, an alcohol rocket or a model rocket using explosive. A balloon rocket and a bottle water rocket are safe as an educational material. However a chemical reaction is not used to produce the thrust force. On the other hand, an alcohol rocket uses a chemical reaction because the combustion of premixed gas of alcohol and air produces the thrust force. However, the combustion finishes almost instantaneously and the flame is difficult to see. A model rocket with explosive is similar to a real industrial rocket and is more powerful. However the engine cannot be modified to produce more thrust force. In addition, caution is necessary for handling and safe keeping because an explosive is used. In addition, a bottle water rocket and a model rocket with explosive cannot be launched in a science laboratory.
Practical rockets are divided to two types. One is liquid propellant rocket, and the other is solid propellant rocket. However, a hybrid rocket was used in a commercial space rockets to move private citizens to space. For example, a hybrid rocket is used in "Space Ship I and II" manufactured by "Scaled Composites" [4]. A hybrid rocket is simple in structure compared to a liquid rocket. A hybrid

rocket doesn't use gunpowder, so it is safer and lower in cost compared to a solid rocket. Furthermore, as hydrochloric acid isn't included in exhaust gas, so a hybrid rocket is gentle to the environment.
In this study, a small hybrid rocket was developed as an educational material using conventional materials such as a carbonate plastic bottle, polyethylene, aluminium, steel, nichrome wire and oxygen gas as shown in Fig. 3. The parts used for the small hybrid rocket are shown in Fig. 4(a). The parts were combined as shown in Fig. 4(b). The experimental apparatus is shown in Fig. 5. The oxygen gas was supplied with the pipes of Fig. 5. The air in the bottle was exchanged with the oxygen. A nichrome wire and 10V direct electric power were used to ignite the rocket.

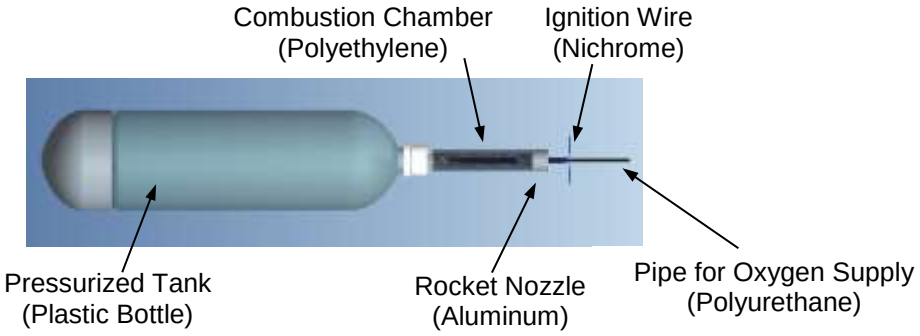

Fig. 3 Schematic of Hybrid Rocket as an Educational Material

(a) (b)

Fig. 4 The Parts of Hybrid Rocket

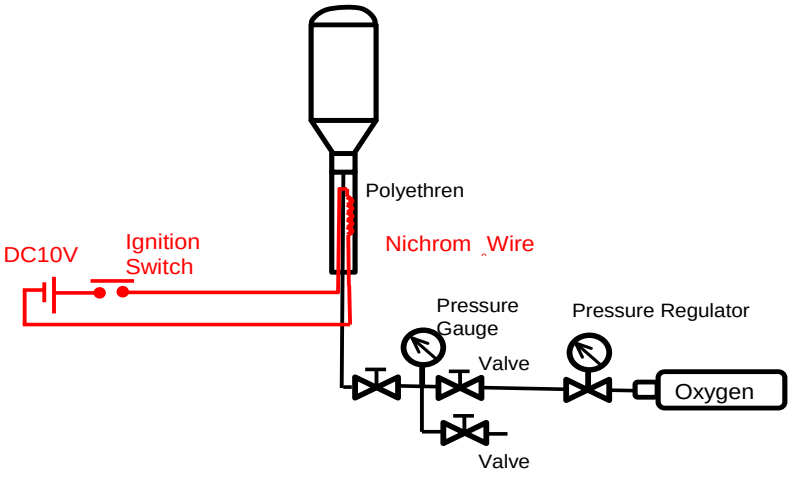

Fig. 5 The Experimental Apparatus

3. Science Classes

We performed a collaboration science class using the hybrid rocket in second grade of Oohata Junior High School in Kumagaya. The age of the students are thirteen or fourteen years old. As the second grade had 3 classes, we continuously carried out three sessions of classes with 10 minutes rest in between each class. The number of participated students of a class was 34 in Class 1, 30 in Class 2, 34 in Class 3, and 98 in total. A class period is 50 minutes. The students were divided to 9 groups. The number of one group was three or four students. The number of girls and boys were approximately equal. Eleven undergraduate university students cooperated voluntarily as teaching assistants. The title of the class was "Advanced chemical reaction". The objective of the class was to understand combustion as an example of an advanced chemical reaction.

In first 8 minutes, the structure and principle of a rocket were explained briefly. In the next 20 minutes, the rocket is constructed. In another 15 minutes, the rocket was launched in the class room. At the end of the class, we summarized today's lesson and encourage to study. Spontaneously questionnaire survey was conducted to the enrolled students. The pictures of the class are shown in Fig. 6.

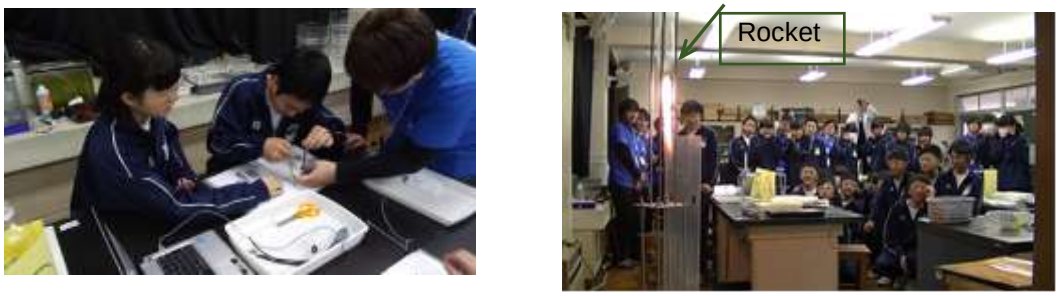

Fig. 6 The Situation of the Science Class

4. Results of Questionnaire Survey

The results of questionnaire survey of the science class showed that most students enjoyed the class and want to do again. As shown in the good aspects in the lesson of Fig. 7, more than 70% students pointed out that a rocket flew, and they recognized that they made a rocket by themselves. This had good experience and influence for the students. The bad aspect of this class is that the rocket did not fly as is shown in Fig. 8. More than 17% students pointed out that a rocket could not fly due to short lesson hour. Though the method for assembly of the rocket should be improved, several students wrote in the free description column of the questionnaire survey that “I was impressed” and “I was moved”. It is supposed to be useful to increase the interest in science.

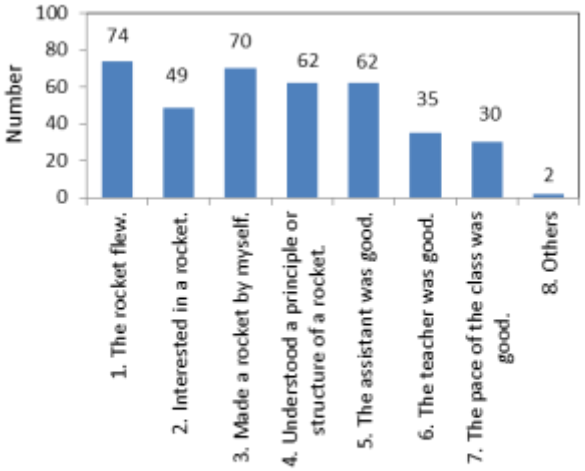

Fig. 7 Good Aspects in the Lesson (Questionnaire Survey)

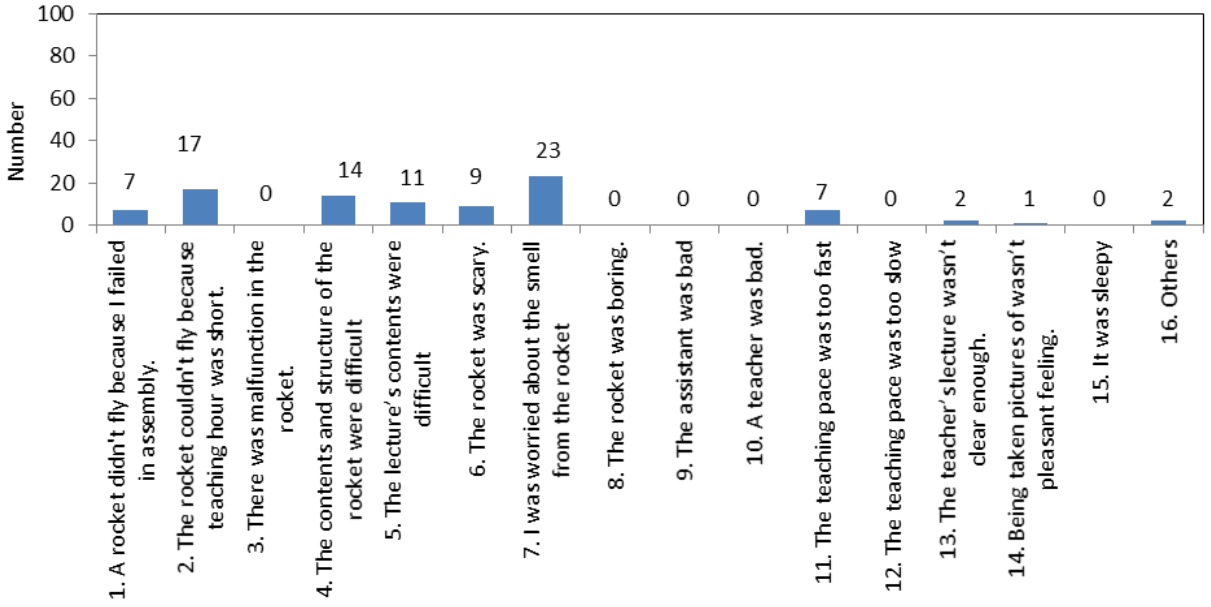

Fig. 8 Bad Aspects in the Lesson (Questionnaire Survey)

5. Conclusions

The rocket could be be launched in a science class room regardless of weather. As a result, the utilization of the hybrid rocket as an educational material with the cooperation between a junior high school and a university was very effective not only to achieve the purpose of science lessons, but also in order to evoke the interest of engineering and science, though the smell of the combustion may be a small problem.

Acknowledgement

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