Practical Robot Edutainment Activities Program for Junior High School Students

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Abstract. In this paper, we describe the approach of the research activities in order to take advantage of the creativity and thinking abilities in practical research of the robot for junior high school female students. The students mainly understand the main idea and the definition of robots and they created them based on information and advice provided by our university and teachers. As a result, the students created the robots by their unique imagination.

Keywords: Robot edutainment · Education

1 Introduction

Recently, the decline in the students' positive attitude towards science has become a problem in Japan. We can realize, that the high difficulty of the science study in junior high schools is one of the main reasons of the decline [6], and the curriculum towards the examination study also makes science harder to enjoy and understand for high school students [4]. According to previous research, we can understand, that mostly the female students' interest and motivation in science has decreased compared to the male students [5]. The Japanese government puts great effort in order to solve this issue by promoting the science subjects to female students.

Yamawaki Junior and Senior High School aims to encourage female students to become active leaders and be a productive member in the society. As one element for achieving this aim, they started the Science Island Project (SI Project) in 2011. In SI Project, they put more effort on experimental trials to visually

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show the results of experiments and make it more interesting. The SI Project also plans and implements a variety of scientific efforts. They have some scientific facilities such as various laboratories, outdoor experimental fields, and so on. Every May, they participate in a school trip to Iriomote Island, during the trip they collaborate with a research institute which is located in Iriomote Island. They research and observe the ecology of organisms and plants in the island. Yamawaki Junior and Senior High School collaborates with some universities in the research fields of robotics, biology, computer science, and so on. Tokyo Metropolitan University has been supporting robot research and design, and has been carrying out robot experimental workshops at summer.

Recently, Japan Science and Technology Agency (JST) carried out Science Partnership Program (SPP) [3]. SPP aimed to support observation, experiment, exercise, and problem solving learning activities regarding science, technology, and mathematics. We also received support from the SPP until 2014 and we had been carrying out robot experimental workshops during summer [7,8]. However, in recent years, it did not lead to further study and in order to support the interest of the students in science education, it only provided science activities only for short period of time.

Thus, JST started to implement continuous research activity program "Promotion of Pre-University Research Activities in Science" [2]. This program aims to increase the students' learning motivation and ability to use the future's scientific and technological resources and also to improve the research experiences of teachers through cooperation with different universities and research institutes.

Yamawaki Junior and Senior High School received support for this program from fiscal year 2015 and they cooperated with Tokyo Metropolitan University and with The University of Electro-Communications and they started practical science research activities program that targeted junior high school third grade students. In robotics, biology, computer science, we have been conducting practical science research activities program (scientific research challenge program) for one year that have been carried out by junior high school third grade students and teachers.

In this paper, we describe the research activities approach to take advantage of the creativity and thinking abilities in practical research of the robot that have been carried out by the students and the teachers. The structure of the paper is as follows. In Sect. 2 we introduce and propose an effective approach of the robot research practical creation activities for junior high school students. Section 3 presents the robots that were created by junior high school students. Section 4 shows the process and result of the research program in the first year. Conclusions are drawn in Sect. 5.

2 Approach of Robot Research Practical Creation Activities for Junior High School Students

In this program, junior high school students participated in the research activities. The goal of the program is that the junior high school students acquire skills to identify challenges, to solve problems and to be able to go into further details based on the results that were obtained. The junior high school students decided the structure and the contents of the research activities by themselves and they carried out the activities, and researched the scientific methods.

The practical research creation activities of the robot were carried out by junior high school students at the third grade stage, so they had some limitations. We realized, that we had to teach them how to create and design a robot properly.

We tried to take advantage from the creativity and thinking skills of the students. First, we asked the students about their idea of the robot they want to build, and about their goals they would like to achieve by using the robot. The students used white boards and bill board paper, they collected their ideas, and they planned the robot based on their imagination.

The universities provided the necessary parts for the students and teachers in order to create the robot, based on the student's idea. We supported the preparation of the robot by programming and circuit design. We used the budget paid by JST to purchase parts, equipment, and materials.

First, in the creation activities, at the programming and circuit design, the students and teachers created the robot, based on the reference book and the manual they were reading. We gave advice and recommendations to students and to teachers when they had problems with the robot. However instead of solving their problem, we encouraged the students to find the solution by themselves.

3 Manufactured Robots

One goal of this program is to create a robot in order to support assisting the ecology research in Iriomote Island. Therefore, we planned to create an underwater and a soil investigating robot.

In the robot creation we used Arduino [1], which is a micro computer device being able to handle digital and analogue input and output data, and it is possible to control the device by connecting the breadboard circuit and a variety of input and output devices. Arduino can be controlled by programming in C language. Arduino is easy to be used even for beginners including junior high school students.

3.1 Underwater Robot

The purpose of the underwater robot is to examine the ecology and water quality in the sea and in the river. The functions and elements which are mounted in an underwater robot are as follows: the movement mechanism in the water, the remote control device of the robot, a camera which can take pictures under the water and send the image to the PC, and a container for storing the device and preventing flood.

The movement mechanism contains the following ideas: wheels, obstacle avoidance, left and right turning. We can control the movement mechanism by two motors. The remote control applies an infra-red remote control. The control board of the movement mechanism and the infra-red remote control uses Arduino Uno which connected to a breadboard circuit that incorporates the motor control device and the infra-red receiver. We can switch ON and OFF each of the motor screws by infra-red remote control. In order to remotely send the picture to PC from far away locations such as underwater, we apply a compact wireless camera with LEDs that can be connected to PC with Wi-Fi connection.

In order to store all of the above equipment, we used a mason jar as a container for storing the device and preventing flood. We placed the devices into a mason jar, and sealed it strictly, and we also bonded the screws on the side of the bottle using a sucker in order avoid floating. The complete underwater robot is illustrated in Fig. 1.

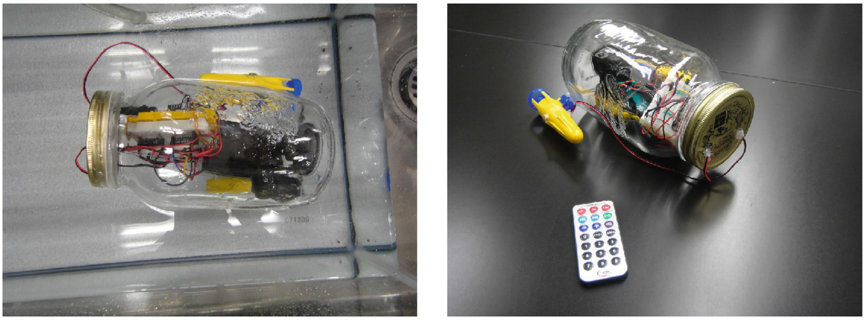


Fig. 1. Underwater robot

3.2 Soil Investigating Robot

The purpose of the soil investigator robot is to explore the ecology and microorganisms and status in the soil. In this time, we assume that we dig a hole to certain depth in advance and the robot can explore the composition of the soil. The functions and elements which are mounted into the soil robot are as follows: an elevating device to vertically move the robot in the soil, a container for storing the device, sensors to measure the temperature and humidity in the soil, wireless devices for data reception, and a camera which can take pictures of the soil and send the image to the PC.

LEGO Mindstorms were used as the motivating power of the elevating device. The line that was connected to the device at the head was hooked on the groove of the LEGO Mindstorms' rotary motor. Elevating by the pulley formula was used to elevate the device by the button operation of the control box of LEGO Mindstorms. Moreover, in order not to leave to a certain distance from the soil and in order to facilitate the withdrawal of the device, we created a guide rail using a curtain rail and wood.

A capsule type container was made from plastic is applied into the robot in order to match the width of the guide rail to the container for storing the device. We used Arduino nano as the control device of temperature and humidity sensors and a wireless device in order to downsize the container.

In order to remotely send the picture to PC from far away location like deep down in the soil, we apply a compact wireless camera with LEDs that can be connected to PC with Wi-Fi connection.

The complete soil robot is illustrated in Fig. 2.

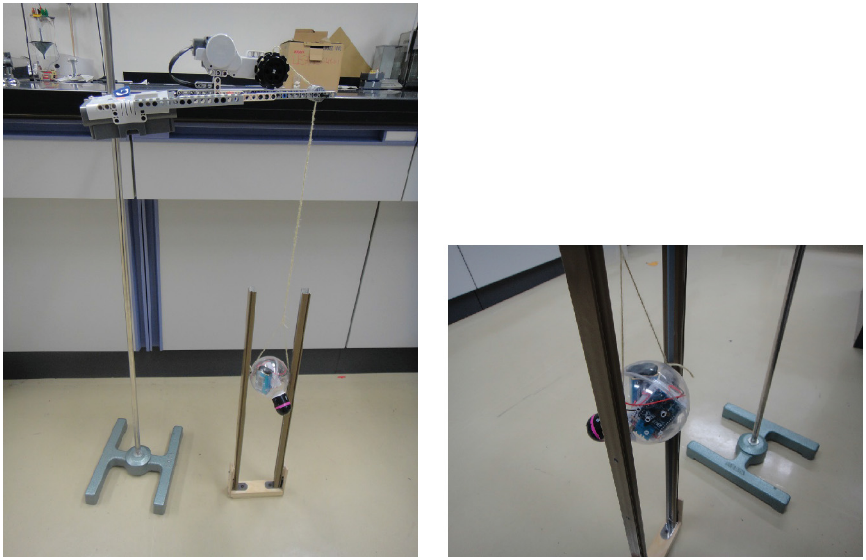
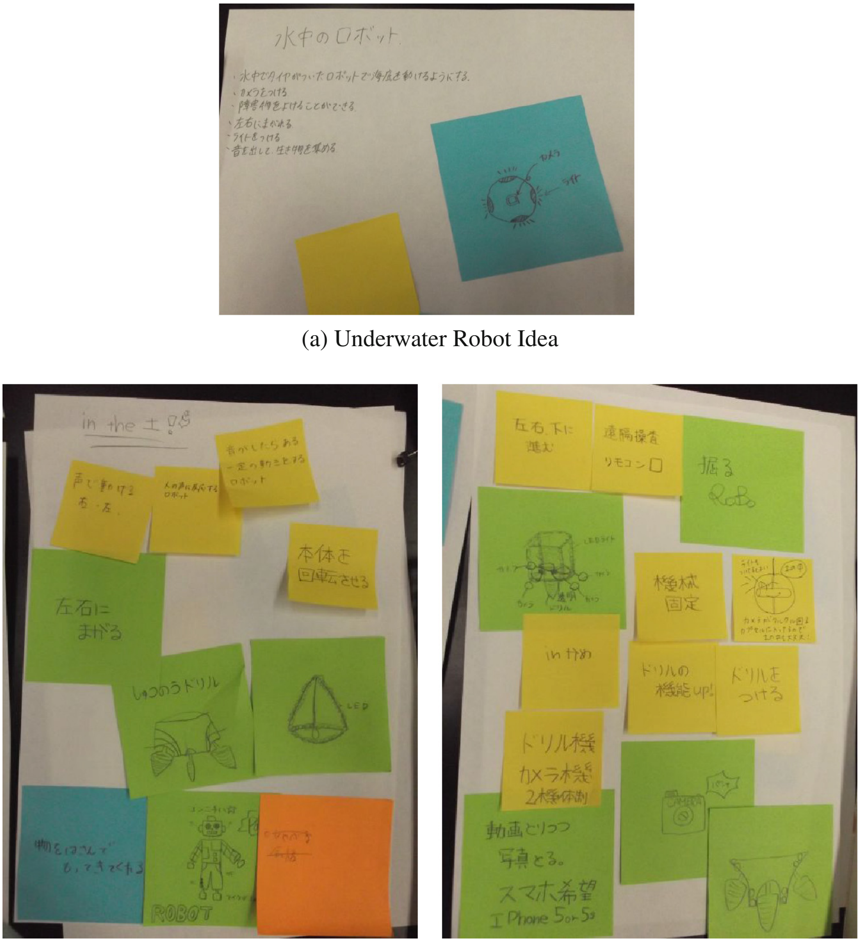


Fig. 2. Soil robot

4 Process and Results of the Robot Research Practical Activities

The first year of this program was conducted from April of 2015 to March of 2016. Eight junior high school female individuals participated, and they were divided into 3 groups. In April, we started with the orientation and the introduction of the program. Based on the students' plan, they collected ideas about the robots they wanted to create. As the target of this program, in order to carry out scientific research activities cooperating with the biological field, which is another research field in this project, we decided to create the robot to be used to support the assisting in the ecology research in Iriomote Island. As a result of this project, the groups created underwater robot and soil investigating robot.

First, the students gathered their ideas about the robots and they wrote them on white board and on bill board papers (Fig. 3). Based on the ideas, junior high school's teachers, university cooperators, and the students proposed



(a) Underwater Robot Idea

(b) Soil Robot Idea 1

(c) Soil Robot Idea 2

Fig. 3. Robot ideas

and prepared the devices and equipment for implementing the robots within the budgets.

Full-fledged robot research practical creation activities was started in June (Fig. 4). As basic lecture, the students learned programming with a sample program of Arduino.

4.1 Process of Underwater Robot Creation

The underwater robot group successfully created the robot using the available equipments and mounted devices and following the instruction of web pages and reference books (Fig. 5). The students used the following equipments to achieve

Fig. 4. Scene of the robot research practical activities

their goal: they used a waterproof spray to the container for waterproof, they changed and connected short codes in order not to be disconnected from the breadboard circuit, and the device was stored in the mason jar.

The problems were malfunction of wireless camera and malfunction of infra-red receiver and how to store the devices in the mason jar.

In wireless camera, there were the following problems: difficulty of wireless connection with PC, and the duration of the camera's battery. It is recommended that the camera has high-quality wireless connection and long-life battery, but there are issues with the limited budget and compatibility. In infra-red receiver, the following problems occurred: incorrect reactions related to electricity and circuit because the circuit of the receiver was shared with the circuit of the motor driver, and it affected the motor and the circuit including the magnet. These problems were resolved by fixing the program code so the circuit could receive the remote control and could stop the response of the infra-red and moving the motors after a few seconds by making the infra-red circuit be different from the motor circuit. By putting the devices into the mason jar, the following problems occurred: malfunction of camera, direction and arrangement of the circuit and device, disconnection of codes of the circuit. We could not repair the malfunction of the devices because the mason jar was sealed like an envelope in order to prevent the flooding of the devices. We tried out the following method to find the solution: we used short codes, we fixed the codes and the devices, we set infra-red receiver in the position where the receiver can always see the infra-red.

4.2 Process of Soil Robot Creation

The soil investigator robot group successfully created the program and mounted equipments and devices by using manuals, websites and reference books. The students devised the following things to design the soil robot: they proposed the guide rail from themselves in order to facilitate the guide of the movement of the device, they made the foundation of the guide rail using woods, they did experiments outside pro-actively to improve and test the devices in a real natural environment (Fig. 6).

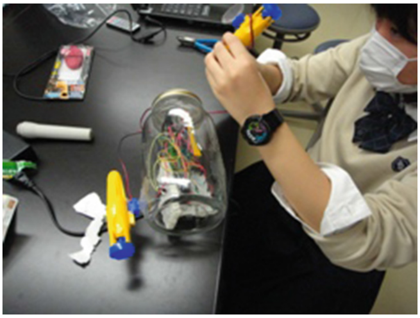


Fig. 5. Creation of underwater robot

During the experiment, the problem was that none of the devices were put in small capsule type container and the width of the guide rail did not fit the container too. When we put all of devices (camera, micro computer, circuit) into the container, the following problems occurred: the container was cramped and the view of the camera was blocked by the container. To resolve this problem, we attached the camera outside of the container. The width of the guide rail was re-adjusted many times to fit the capsule.

Fig. 6. Soil robot experiment

4.3 Presentation of the Result

In this program, it is recommended that the participants present the results of their research activities at the school, inside and outside. This year, we arranged the opportunity to present the result of their research activity in a cultural festival in October and they had to submit a report about their scientific research in March (Fig. 7) in Yamawaki Junior and Senior High School. The students presented the aim, the background and the purpose of their activity, their robots' features. They had to demonstrate their robots, it was also compulsory to show a video about the research, they had to share their impressions, reflections and

Fig. 7. Reporting of scientific research challenge program

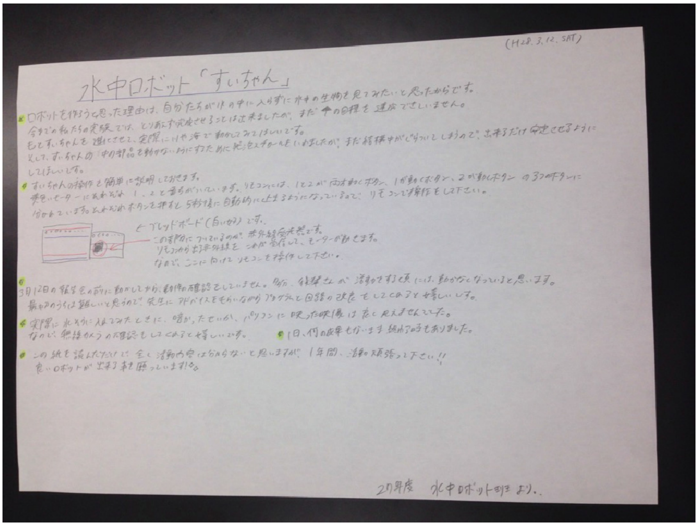


Fig. 8. Succession of the underwater robot

they also had to say a few words about their future work. This was the first time for the students using a PC for their presentation. Even though, the majority of the presentations was proceeded smoothly including other fields group of the research activities program there were also not very good presentations. In the presentation, they presented the following things: they gained the skill to perform and to design, they realized the importance of team work, the perseverance to solve the given problems, and most importantly, they felt the importance and the difficulties of their experiment based on failure and success in the activities. Which leads us to the conclusion, that the students got the interest and the curiosity to take part in more scientific research. At the end of this program, the junior high school third grade students who participated in the program, wrote their robots' features and future work's details of the robot on the bill board paper for the juniors who will participate in the next time in the program in order to support their work (Fig. 8).

5 Conclusion

In this paper, we described the research activities we tested, to take advantage of the creativity and thinking skills in practical research of the robot that have been carried out by the students and the teachers. As the result of the activities, we were able to create robots equipped with a radio functionality and movement functionality by unique ideas coming from junior high school third grade students with the cooperation of universities. Among the activities, it was also realized that the students worked on the research activities and the students are interested in scientific research depending on the topic.

In future works, we are going to improve the robots. In particular, we will do actual use of the robots in the ecology research in Iriomote Island. In addition, as an effective educational approach, it was possible to improve the knowledge and interest in the robotic field among students. The students can work with the learned scientific contents during regular classes. They can form their opinion and ideas in cooperative manner working in groups. We applied this program for junior high school female students. We can apply similar program for junior high school male students and another grade students as well. The students will be interested in the designing appearances of the robots. If we get more detailed data and evaluation of the influence of the program, we need to take the questionnaire to the students.

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