Junior High School Rescue Robot Challenge for Fostering Problem-Solving Skills

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Abstract

"Junior High School Student Rescue Robot Challenge" is an annual activity organized by Hiroshima University in cooperation with a construction equipment manufacturer. The Challenge has been continued for 18 years with a given theme of rescuing. The policy of the program was essentially changed, nonetheless, from 2022, in which the both problem-finding and problem-solving skills were emphasized. The theme of "the Challenge in 2022" is totally operated by students, which includes from proposal of the problem to be solved in disaster-stricken areas, to finding resolutions by making prototype rescue robot by modifying remote-controlled excavator model of 1/14 scale.

Keywords: Rescue Robot, Junior High School, Technology Education, Robot Evaluation, Modified Excavator

1. Introduction

Sustainable Development Goals (SDGs) were proclaimed at the UN Summit, in 2015, which will be attained by 2030 according to the statement of **"**The 2030 Agenda for Sustainable Development**"**. Around the same time, "Society 5.0" was proposed in "Fifth Science and Technology Basic Plan" [1] by Japanese Cabinet Office, as an image of upcoming society structure. It will be expected that the Society 5.0 will play a central role to achieve the SDGs in Japan. Recently, the Sixth Plan was also publicized [2] with advanced guidelines for Society 5.0 to realize SDGs more realistically. The plan focused on innovation creation by fostering **"**human resources who can create new value**".** Besides that, the whole society around the world had affected remarkably, from 2010s, by global environmental changes, political and economic uncertainty, COVID-19 epidemic, and so on. There is a growing need for innovation creation to solve a wide variety of social issues, which is called "social change-type innovation" [3].

According to above mentioned situations, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) also revised "Courses of Study" from 2008 [4][5][6], focusing more on social issues in school study and aiming to create new values, putting the both "problem finding and solving skills" in the central position for school education.

In such context, our Robot Challenge had been changed as well. "Junior High School Student Rescue Robot Challenge" had started as "the Contest" since 2005, by staffs in teacher training course of technology and information, Hiroshima University. The policy had been changed to "the Challenge" since 2015, and the name as well, with a support by a counterpart company of construction equipment manufacturer. We introduced, from that time, the both problem-finding and problem-solving approaches, but the theme itself was given one from the program side.

Ultimate revision of the program took place in 2022, in succession to tragic cancellation of the Challenge in 2021, because of COVID-19 pandemic. We noticed that the variation of the disasters was going to be wide. Therefore, we had changed from the basic framework of the program. Now, the problem-finding is also involved for students' task. After finding the problem to be solved, the students will build a prototype rescue robot to resolve the problem.

We also revised the evaluation system as we latterly mentioned.

2. Challenge Theme in 2022

2.1. *Challenge Theme*

Since “the Contest” era, the central theme of the Challenge was “Rescuing Quickly a dummy doll from a large 1/8-scale simulated earthquake site to a safe zone.” [7][8] Large-scale field (1 to 3 meters ling) and the dummy dolls were prepared by the program staff. The students made rescue robots on which the dummy doll was placed, and so on. The evaluation had focused on the time required for rescue, ideas for rescue methods, humanitarian viewpoints, and especially the "gentleness" of the robot to the dummy during the rescue.

The theme of the challenge in 2022 has been significantly changed expecting further growth of junior high school students' ability to find and solve social problems. The project was started from problem-finding by themselves. After finding a problem, they are going to build a prototype rescue robot by modifying a 1/14-scale remote-controlled excavator shown in Fig.1. We did not restrict the problem to be chosen, but had a restriction of the selection of problems, it may be a disaster-stricken area, because of the excavator model.

Fig.1. RC excavator to be modified

2.2. *Rescue Robot Idea Evaluation Method*

The evaluation of rescue robot ideas was consisted of two major evaluating sessions.

The first was evaluation of ideas, including from problem-finding to problem-solving, that is, what kind of situation were chosen and how rescue activities could be performed. Each team made a worksheet of conceptual plan with drawings and submit it to us. Before the worksheet making and submission, we instructed them how to incorporate measurement and control techniques. The worksheets were evaluated from following three viewpoints:

(1) Innovation (10 points)
Is it an innovative idea that utilizes shovels?
(2) Feasibility (10 points)
Is it a highly feasible concept or idea?
(3) Functionality (10 points)
Whether the concept/idea is expected to be sufficiently effective for the rescue activities set up.

Based on the above evaluation, all 10 teams were past the first selection.

For the second evaluation, each team made the rescue robot and put it in disastrous area to rescue people or something they assumed. Rescue activity was taken by video and the submitted to us. Documentation on the robot was submitted as well. Those materials were evaluated through an online conferencing system (Teams) in a public session. Three judges were selected to evaluate and announce the results. The following two items were evaluated for the robot:

(1) Feasibility/Improvement (30 points)
How much was the robot fulfilled the planned ideas shown in the first worksheets, and how much was it improved and realized, through real robot making process.
(2) Design (30 points)
Whether the robot's features and performance can be understood by users (or three judges who see it for the first time).

The presentation was evaluated on the following two points:

(1) Objectivity (15 points)
Whether the performances of the rescue robot can be understood and analyzed objectively and accurately by three judges.
(2) Expression (15 points)
Whether the features of the rescue robot was expressed, throughout the presentation, in an easy-to-understand manner.

In addition, the results of the first evaluation were also taken into account.

3. Robot Evaluation Results

The 7th Annual Middle School Rescue Robot Challenge in 2022 (in Japanese fiscal year of 2021) was held on February 12, 2022. A total of 10 teams participated. The results of the first and second rounds of judging are shown in Table 1 and 2, respectively.

The appearances of the robots they built are shown in Fig.2. Their robots had buckets, cabins, rollers, crawlers, traveling parts, and so on, by modifying excavator parts and utilizing its functions with clever modifications.

Table 1. First Evaluation Results

Team	A	B	C	D	E	F	G	H	I	J
Innovation	4.6	5.0	6.8	5.5	8.0	5.8	8.1	7.4	8.4	7.3
Realization	8.1	8.1	7.2	7.6	5.6	7.3	4.9	5.1	5.3	6.4
Functionality	5.8	7.3	6.3	6.5	7.3	5.9	7.4	7.6	7.1	7.1
Total Point	18.5	20.4	20.3	19.6	20.9	18.9	20.4	20.1	20.8	20.8

Table 2. First Evaluation Results

Team	A	B	C	D	E	F	G	H	I	J
Realization / Improvement	21.0	22.0	19.0	17.0	25.0	18.0	22.0	24.0	25.0	23.0
Design	17.0	21.0	24.0	19.0	22.0	20.0	23.0	21.0	23.0	24.0
Robot Point	38.0	43.0	43.0	36.0	47.0	38.0	45.0	45.0	48.0	47.0
Objectivity	10.5	9.5	11.0	9.0	12.0	10.5	10.5	9.0	11.5	12.0
Expression	13.0	11.0	11.5	8.0	11.0	10.0	11.5	11.0	13.0	11.0
Presentation Point	23.5	20.5	22.5	17.0	23.0	20.5	22.0	20.0	24.5	23.0
Total Point	61.5	63.5	65.5	53.0	70.0	58.5	67.0	65.0	72.5	70.0

4. Discussion

This challenge asked middle high school students to propose a rescue robot by modifying an excavator. We hope, by the Challenge, the students will develop their problem finding as well as problem solving skills. Judgements given from the first and second rounds of evaluation are shown in Table 1 and Table 2.

Table 1 shows that the total score for innovation, realization, and functionality. Many team got around 20 points (on a 30-point scale).

It is noteworthy point that, among three evaluation points there can be found somehow trade-off relationship. For example, teams A, B, D, and F have a low innovation rating although a high realization rating. This may show that these teams took more realistic solutions for the problems. In contrast, teams E, G, and I are rated high for innovation but low for realization because they were tried to add further functions that looked hard to be realized than others. These results indicate that these three evaluations were able to accurately assess the balance among concepts, ideas and reality of the robots

(a)Robot A (b)Robot B (c)Robot C (d)Robot D (e)Robot E (f)Robot F (g)Robot G (h)Robot H (i)Robot I (j)Robot J

Fig.2. Robots made by junior high school students

they made.

Table 2 shows the evaluation of realization/improvement points of the robot they made. Unfortunately, the teams with poor motion video were rated low evaluations. In design evaluation, the robots which were scarcely modified from those of commercially available power shovels got low scores.
As for the evaluation of presentation, the objectivity was rated by the use of documents and quantitative data. The teams which provided realistic evidence were highly evaluated. In the expression, which is the evaluation of comprehensibility of the presentation, the teams that proposed a clear rescue sequence got high scores. These results indicate that these evaluations were able to accurately assess the robots and presentations made by the junior high school students.

Appearances of robots built by a junior high school student shown in Fig.2 clearly indicate that the students manage to born a brand new rescue robots from their brains. No two robots had the same appearances nor the same function. The robots built by the 10 teams can be classified into the following three categories.

(1) Modification of the bucket part (Fig.2 (a), Fig.2 (b), Fig.2 (c), Fig.2 (f) and Fig.2 (j))
The bucket was modified to make it easier to scoop debris or to have other functions.

(2) Modification of the traveling part (Fig.2 (d), Fig.2 (h) and Fig.2 (i))
New parts were added to make it easier to travel over rubble, and floats were added to enable movement over water.

(3) Adding new functions (Fig.2 (e) and Fig.2 (g))
The excavator had added functions completely different from those of shovels, such as shoveling and leveling.

In total, we can conclude that the junior high school students who participated “the Challenge in 2022” were able to set and solve their own problems, indicating that our revision of theme setting for “the Challenge” was effective.

5. Conclusion

We introduced a new perspective in technology education which is focused on the both "problem finding and solving skills". According to that, theme of “Junior High School Student Rescue Robot Challenge” was changed, which started from problem-finding by students. Then, they were going to make real robots by modifying remote-controlled excavator. Ten teams of junior high school students were participated the Challenge and found unique problems to be solved and made real robots which fulfilled their images. We believe that the Challenge had worked for fostering innovative mind for young generations.

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