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Research Article

Junior High School Rescue Robot Challenge to Develop Problem-Solving Skills

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ABSTRACT

The "Junior High School Student Rescue Robot Challenge" is an annual activity organized by Hiroshima University in cooperation with a construction machinery manufacturer. The challenge has been running from 2008, with a theme of evacuating injured people from disastrous suite. The theme was given from organizer. In contrast, we had changed policy of the Challenge project from 2022 corresponding to newly emerging social issues. The theme of "The Challenge in 2022" was entirely run by the students, which includes from proposing of the problem to be solved in disaster-stricken areas, to finding solutions by making prototype rescue robot by modifying remote-controlled excavator model of 1/14 scale. Evaluation points by judges also updated. Ten teams of junior high school students were participated in the challenge 2022. They could set distinctive theme and tried to resolve the problem positively and proactively modifying and attaching unique parts to the excavator.

1. Introduction

An activity of "making rescue robots by junior high school students" has been started, since 2005, by the staffs in Teacher Training Course of Technology and Information, Faculty of Education, Hiroshima University. The activity was originally called "Junior High School Student Rescue Robot Contest", then had been changed to "Junior High School Student Rescue Robot Challenge" since 2015, corresponding to changing images of rescue activities by Robotics. Robotics and related technologies are going to be used for problem solving of newly emerging social requirements.

In recent years, numbers of social demands have been emerged. For example, A global statement of Sustainable Development Goals (SDGs), was proclaimed at the UN Summit in 2015. The key idea of the SDGs was the simultaneous pursuit of the sustainability, which tends to be conservative, and the development, which has the opposite character, i.e. innovations. Such a controversial setting of the goals by the UN means that the problems in contemporary life are becoming more complicated and contain multiple facets and vectors, such as global environmental changes, political conflicts and/or economic uncertainty, etc. in a problem, so that the solutions must also be multi-faceted ones.

The Japanese government also advocated a new image of a multi-faceted society as "Society 5.0", in the "Fifth Science and Technology Basic Plan" [1] of the Japanese Cabinet Office. They asserted that the upcoming Society 5.0 inevitably includes both "real" and "virtual" aspects, and cultivating human resources that can achieve the mutual and simultaneous development of the both real and virtual societies is key to a fruitful future. Society 5.0 will play a central role in achieving the SDGs.

Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) also offered revised "Courses

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of Study" from 2008 [4][5][6], introducing problem-solving training for real-world social issues into school studies. They focused on cultivating quality to create new values for young generations, placing both "problem finding and problems solving skills" at the center of position for school education.

As we see from the above discussions, the problems of current life are becoming more complicated and multi-faceted, so we need to create new approaches for problem solving, which must be more innovative.

To accomplish above mentioned requirement, we decided to update "The Challenge". We have found, though previous The Challenges, that robot making by young students can be applied as an innovative training content, because the making of robots essentially involves multi-factors of hardware and software, etc. The experiences of making robots must be a good training for finding solutions to real social problems.

2. Brief history of the activity

The original contest was started by a trigger of tragic earthquake in our country. Therefore, in the first years, the central theme was "Quickly rescue a dummy doll from a disaster site to a safe zone". The size of the site was 1/8-scale (1 to 3 meters long) and the rescue situation was changed in each year [7][8]. A dummy doll was placed on rescue robots made by students. Then the students manipulated the robot (wired remote control) to evacuate quickly but safely from the disastrous site. The time of evacuation and the shock to the robot (it was equipped with an acceleration sensor) were measured and evaluated. This original style of competition continued for 10 years.

In 10 years, the social issues and requirements were gradually changed, as we see in the introduction, so that we discarded the policy of "The Contest" and introduced "The Challenge" with new policy, from 2015. We asked for a company for comprehensive support of the execution of the activity, and fortunately we found a counterpart company of construction machinery manufacturer.

After changing the policy to "Challenge", we put more emphasis on the multiple evaluating view point. We introduced four viewpoints of "Innovation", "Resilience", "Trendsetter", "Collaborative Power". On the other hand, The main activity of evacuation from the disastrous site (or came into the site to find injured people) by robots was essentially not changed.

Meanwhile, the globe was shocked by COVID-19 epidemic. We had to cancel the year 2021 Challenge. The global epidemic was practically new experience for most people living today. The epidemic clearly showed that the size and variety of global catastrophes would be increasing.

To deal with such newly emerging problems, we need to completely change the approach to the problem. One possible approach will be "social change-type innovation" [3], which focuses on both problem finding and approach for problem solving. Then, we also changed the basic policy of the challenge, such as including problem-finding for the students' task. Students set the situation of the activity by themselves, and after finding the problem to be solved, they will build a prototype rescue robot to solve the problem. Through this updated version, we expected to further develop the ability of junior high school students' ability to find and solve social problems.

Fig.1. RC excavator to be modified

3. Challenge Theme in 2022

3.1. Challenge Theme

The theme of the 2022 challenge has changed significantly changed. We announced to the participants that the project was started from problem finding by themselves. After defining a situation to be solved, then you will build a prototype rescue robot by modifying a 1/14-scale remote-controlled excavator (Fig.1). No restriction was required for problem finding, but there were several practical restrictions in excavator model, such as size, power and other performances, to be used.

3.2. Evaluation Method

The evaluation was consisted of two main evaluation sessions.

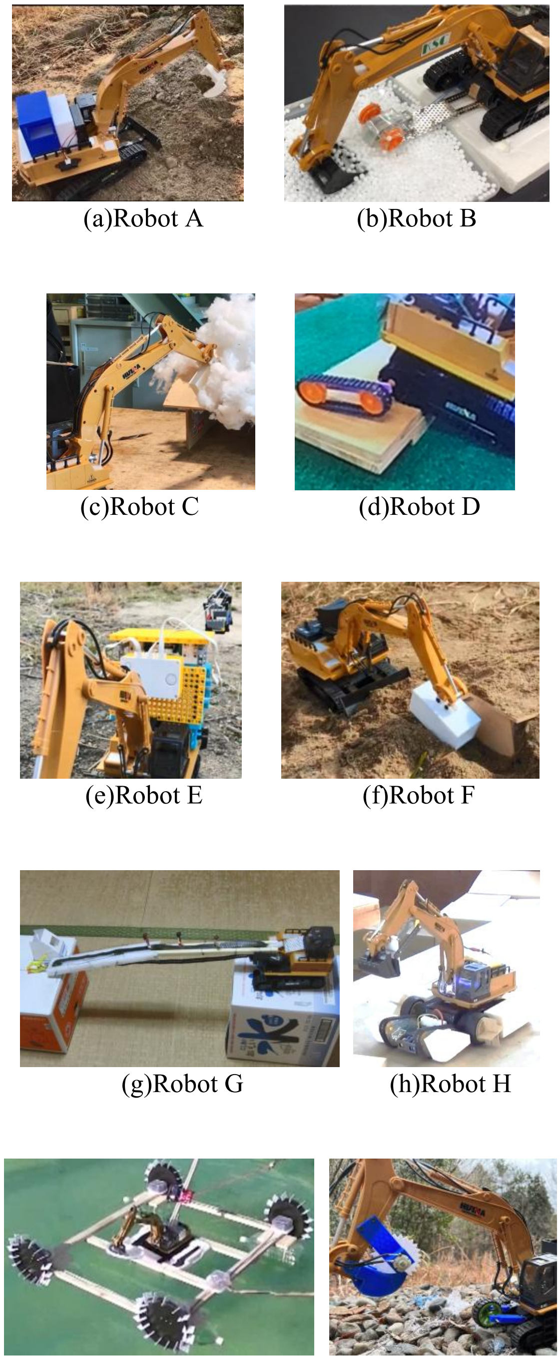
The first session was the evaluation of ideas. The participants made and send a conceptual plan worksheet, in which the whole project was planned with drawings, including problem finding to problem solving. The choice of the situation and the way of carry out the rescue activities, and the method of implementing measurement and control systems are evaluated.

The worksheets were evaluated from following three viewpoints:
(1) Innovation (10 points)
(2) Feasibility (10 points)
(3) Functionality (10 points)

Based on the above evaluation, all teams (10 teams) participating in the 2022 Challenge were past the first selection.
For the second evaluation session, each team made a real rescue robot and put it in the disaster area to perform rescue activity. The rescue activity was taken by video and submitted to us as data. Documentation about the robot was also submitted. These materials were evaluated by three judges selected from university teacher and the counterpart company, using an online conferencing system (Microsoft Teams). The following two viewpoints were utilized for evaluation.
(1) Feasibility/Improvement (30 points)
How well did the robot realized the ideas planned in the first worksheets, and how well did it devised and improved through the robot building process.
(2) Design of the overall plan (30 points)
Whether the robot's features and performance can be understood by users.

The final presentation was performed by participating teams by online conference style. The presentation was also evaluated by three judges applying the following two points:
(1) Objectivity (15 points)
Whether the robot's performance was evaluated and analyzed objectively and accurately.
(2) Expression (15 points)
Whether the features of the robot were clearly and comprehensively explained to the audience, throughout the presentation.

The final score was the sum of the above scores, the scores in the first session was also included.



(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

4. Robots and Evaluation Results

The 7th Junior High School Rescue Robot Challenge in 2022 was held on February 12, 2022. A total of 10 teams from different cities in Hiroshima Prefecture participated. Figure 2 shows the appearance of the robots they built, which were equipped with buckets of various designs, cabins, rollers, crawlers, moving parts, and so on. It appeared that their modifications were filled with fresh ideas and made with sophisticated parts and assemblies. The evaluation results of the first and second sessions are summarized in Table 1 and 2, respectively.

Table 1 shows that the total score for innovation, realization, and functionality. Many teams scored around 20 points (on a 30-point scale). Table 2 shows the evaluation of the realization/improvement points of the robot they made.

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

5. Discussion

As for the evaluation of first session (Table 1), all teams received high scores of around 20 or more (30 is the maximum). This result shows that the majority of junior high school student who participated in the Challenge were positive and proactive in worked into the new style of the Challenge theme.

Their enthusiasm can be seen in their products. The appearances of the robots built by a junior high school student shown in Fig.2 clearly indicate that the students managed to create a brand-new rescue robot from their brains. No two robots had the same appearance or the same function. Each rescue robots equipped with different and highly original parts adopting for distinct situations.

These originalities suggested that they thought of and completed the entire project by themselves, from problem identification, situation definition, problem-solving approach, to actual robot making and trial the rescue activities in simulated (but real) situations. The results actually exceeded our expectations. The Students only grew in both problem finding and problem solving skills, due to the new theme setting of the challenge.

Another noteworthy point was found in Table 1. There was somehow trade-off relationship between three evaluation points among the scores of each team. That is, teams A, B, D, and F have low innovation scores but high realization scores. This trade-off relationship suggests that these teams chose more realistic solutions than innovative challenges.

In contrast, teams E, G, and I have high innovation scores but low realization scores. Their ideas were more innovative, but they also required more sophisticated functions with additional parts that were difficult to produce.

These results indicate that we can evaluate tendency of the concept of the project carried out by each team by checking the balance of the three scores of innovation, realization and functionality.

For the second evaluation, the score was more deviated because further evaluation points were introduced.

As for the realization/improvement and design (above two points in), three judges first watched the videos sent by each team and then gave the judgments. Unfortunately, several teams received low scores because of their poor motion videos. In addition, robots with little modification from the original power shovels received low scores in the design evaluation,.

After watching the final presentation, objectivity and expression were evaluated. For objectivity, the score was mainly based on how much they used quantitative data and how carefully they wrote the documentation. The

teams that provided realistic and quantitative evidence were highly rated.
In terms of expression, comprehensive presentations were highly rated. In particular, presentation with clear rescue sequences received high scores.

Finally, we will examine the differences between the robots they built. From our point of view, the robots built by 10 teams can be divided 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 has been modified to make it easier to scoop debris or to perform other functions.

(2) Modification of the Moving 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 make it possible to move over water.

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

Based on the above evaluation results, we believe that the four points of evaluations of, Innovation, Resilience, Trendsetter, and Collaboration were correctly and effectively evaluated. In addition, scores of evaluation points showed a trade-off relationship. By this relationship, we were able to effectively evaluate characteristics of robots, that is, whether the aim of project had oriented toward for innovation, solid safety, rescuing speed, and so on.
During previous challenge activity, the theme was quick evacuation, there was a tendency of the scores were determined by more the operator's technique than on the robot's functionality. The scores of The Challenge 2022, on the other hand, clearly indicated distinctive contrast on score of each team, from various viewpoints of robot's idea, feasibility, functionality, etc.

6. Conclusion

We introduced a new perspective to the theme setting of "Junior High School Student Rescue Robot Challenge". The new version of the challenge theme included the whole project, starting from problem finding, rescue situation setting, solution proposal, robot building and problem solving by students. We provided the participating teams with a remote-controlled excavator model, and the students made real rescue robots by modifying it.

Ten teams of junior high school students were participated in the challenge and tried the whole project positively and proactively. Ideas put on their robots were fulfilled with unique images. We believe that this newborn challenge had effectively worked for fostering innovative mind for young generations.

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