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Research Article

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

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ABSTRACT

The "Junior High School Rescue Robot Challenge" is an activity held every year by Hiroshima University in cooperation with construction machinery manufacturers. The challenge has been ongoing for 18 years with the given theme of rescue. However, starting in 2022, the program's policy has essentially changed, with emphasis placed on both problem-finding and problem-solving abilities. A prototype rescue robot was created by modifying a radio-controlled excavator model, and students were responsible for everything from proposing problems to be solved in the disaster area to finding solutions.

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.

Introduced a new perspective to technology education that focuses on both problem-finding and problem-solving skills. The theme was changed to "Junior High School Rescue Robot Challenge," which started with the students discovering a challenge. They then modified a remote-controlled excavator to create a real robot. Ten teams of junior high school students participated, finding unique problems and creating real robots exactly as they imagined them, which was effective in fostering innovative minds among the younger generation.

Due to the COVID-19 pandemic, the challenge was canceled in 2021, with final revisions to the program taking place in 2022. We realized that there were many variations in disasters and changed the basic framework of the program. Currently, problem finding is included in students' assignments. After finding a problem to solve, students created a prototype rescue robot to solve the

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problem. We also reviewed the evaluation system described below.

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

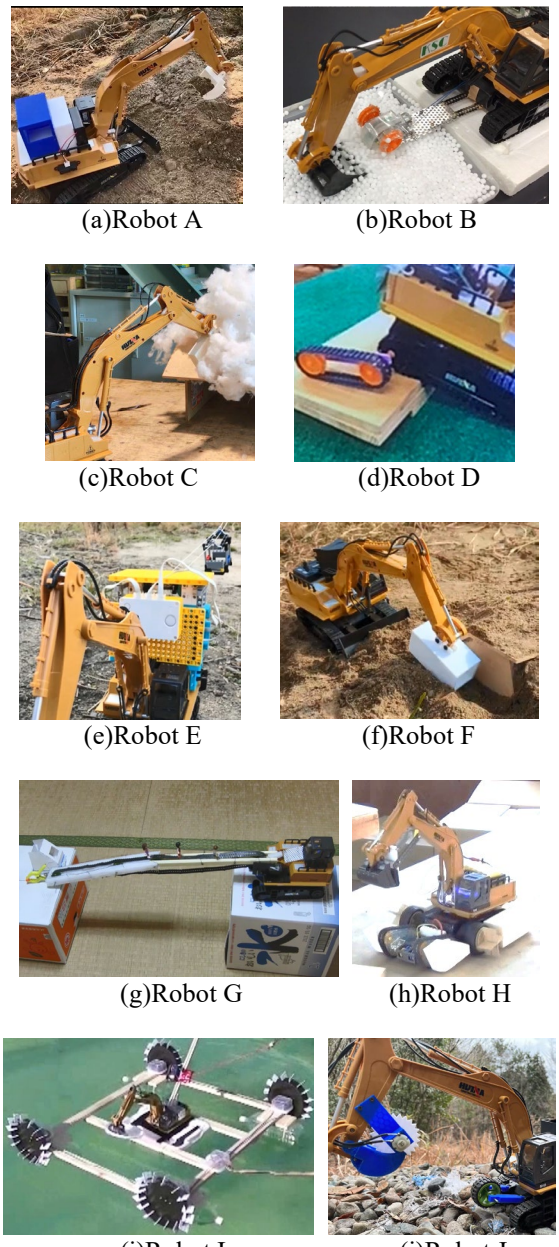
Team	A	B	C	D	E	F	G	H	I	J
Realization / Improvement	21.0	22.0	19.0	17.0	25.0	18.0	22.0	24.0	25.0	23.0
Design	17.0	21.0	24.0	19.0	22.0	20.0	23.0	21.0	23.0	24.0
Robot Point	38.0	43.0	43.0	36.0	47.0	38.0	45.0	45.0	48.0	47.0
Objectivity	10.5	9.5	11.0	9.0	12.0	10.5	10.5	9.0	11.5	12.0
Expression	13.0	11.0	11.5	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

A new perspective has been introduced to technology education that focuses on both problem-finding and problem-solving skills. In line with this, the ``Junior High School Rescue Robot Challenge'' started with students discovering a problem and creating a real robot by modifying a remote-controlled shovel. Ten teams of junior high school students participated, found unique problems, and created real robots exactly as they imagined them. This challenge was effective in fostering an innovative mindset among the younger generation.

References

1. Japan Cabinet Office: The 5th Science and Technology Basic Plan (2016) (in Japanese)
2. Japan Cabinet Office: The Sixth Science, Technology and Innovation Basic Plan (2021) (in Japanese)
3. Center for Research and Development Strategy, Japan Science and Technology Agency: Trends and challenges of mission-oriented science, technology and innovation policies for solving social problems (2021) (in Japanese)
4. Ministry of Education, Culture, Sports, Science and Technology: Elementary School Curriculum Guideline 2017-03 Notification (2017)
5. Ministry of Education, Culture, Sports, Science and Technology: Lower Secondary School Curriculum Guideline 2017-03 Notification (2017)
6. Ministry of Education, Culture, Sports, Science and Technology: Upper Secondary School Curriculum Guideline 2017-03 Notification (2018)
7. Kazuo Kawada, Masayasu Nagamatsu, Toru Yamamoto: A Practice of Rescue Robot Contest in Junior High Schools, Journal of Japanese Society for Engineering Education, Vol.58-2, pp.33-39 (2010) (in Japanese)
8. Kazuo Kawada, Keisuke Iuchi, Keita Murai, Hiroyuki Y. Suzuki: Junior High School Rescue Robot Challenge using Shock Sensitive Tiny Dummy Robot, Journal of Robotics, Networking and Artificial Life, Vol.8(2), pp. 90–93 (2021)

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