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Journal of Robotics, Networking and Artificial Life
Vol. 10(1); June (2023), pp. 77–83
ISSN (Online): 2352-6386; ISSN (Print): 2405-9021
https://alife-robotics.org/jrnal.html

Research Article

Report on Underwater Robot Festival Junior Division Aimed at Marine-Debris Cleanup

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ARTICLE INFO

Article History

Received 29 November 2022
Accepted 03 July 2023

Keywords

Robot competition
Education of robotics

ABSTRACT

A marine-cleaning robot competition was featured at the junior division of the Eighth Underwater Robot Festival held at Iwakuni, Japan in 2022. The theme of the competition was “Life Below Water,” which is the 14th goal of SDGs, and consisted of poster presentations on marine-debris problems and a robot competition to compete in debris-collection ability. In addition, questionnaires were sent out before and after the competition to analyze the level of understanding of robot development and SDGs after the competition. This paper reports an outline of the junior division and results of the educational effect using questionnaire analysis.

1. Introduction

Despite environmental problems, such as global warming, have been discussed for a long time, the “marine-debris problem” has recently attracted attention as a theme in environmental problems. Various discussions have been made on managing debris that drift on beaches and floats in the ocean, thereby polluting the ocean as well as the beach. In addition, the floating microplastics accumulate in fish and other organisms in the ocean, which affect humans and other organisms that eat them. The Sustainable Development Goals (SDGs) adopted by the United Nations Summit in September 2015 set 17 goals for a sustainable and better world [1]. The 14th goal, namely, “Life Below water,” includes the problem of marine debris. Henceforth, efforts to solve marine-debris problem have become active in Japan and other countries. In April 2017, the Beach Clean Robot Project, which aimed to create a society in which robots and citizens work together to clean the sea, was launched, and efforts were being exerted to use robot and other technologies to clean beaches in Munakata City, Fukuoka Prefecture [2]. In addition, the Seabin project in Austria proposed and commercialized Seabin to collect floating debris in the sea [3]. The problems of marine debris attract worldwide attention, however not everyone is approaching the problem with a sense of urgency. In addition, evoking interest in the marine-garbage problem is necessary, particularly the younger generation. We have been working on educating junior and high school students through robot contests. Among others, the Underwater Robot Contest has been held in context to

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social issues, such as marine-resource issues, which has inspired students to become aware of social issues. The Underwater Robot Contest consists of an Autonomous Underwater Vehicle (AUV) division that competes for the ability of an underwater robot to autonomously operate, a freestyle division that competes for ideas of robots in various forms, such as biomimetic, and a junior division for junior and high school students. This paper presents the junior division of the 8th Underwater Robot Festival held at Iwakuni City, Yamaguchi Prefecture in 2022. In the junior division, a competition was held under the theme "marine-debris problem." The competition consisted of a "poster presentation" in which teams presented a summary of the marine-debris problem in a poster and a "robot competition" in which robots were designed to collect marine debris and competed with one another in terms of ability. This paper describes the details of the junior division competition and discusses the verification of the learning effects by analyzing the questionnaire responses before and after the competition.

2. Outline of Junior Division

The teams of junior division were ranked according to the total score of the poster presentations and robot competition [4]. In this section, an outline of the poster presentation and robot competition are presented.

2.1. *Online prelecture*

Basic kits were distributed in advance to participating teams. The kit contained the minimum necessary circuits and components to operate the robot. Circuit components, such as microcomputers, motor drivers, light-emitting diodes (LEDs), switches, and breadboards for constructing the circuits were distributed, along with containers for waterproofing circuits and underwater motors and gears. The microcomputer was connected to a smartphone via Wi-Fi, and the participating teams operated the developed robot using their smartphones. In addition, because the participating teams consisted of students with and without knowledge of robot development, an online prelecture was conducted for all the teams on how to construct circuits and assemble programs. The lecture included the processes of creating an environment for microcomputer programming, configuring LED-lighting circuits, switch circuits, and motor control circuits, programming, and connecting to Wi-Fi. Each team was provided a half-day lecture.

2.2. *Poster presentation*

The purpose of the poster presentation was to evoke interest in the garbage problem in the sea by investigating and summarizing the marine-debris problem by each team. Students from technical college, regular high school, and technical high schools participated in the junior division. The poster presentations were held to share various ideas and knowledge from different cultures and to help students discover new values by learning from each other. The following items were required to be included in the poster and were subject to review:

- Poster title and names of the team, school, team members, and teacher
- Investigations on debris problems in the ocean and rivers
- Issues to be solved in garbage collection
- Ideas to solve these issues
- Proposal for garbage-collecting robot
- Conclusions
- References

A photo taken during the poster presentation session is shown in Fig. 1. The participants were divided into two teams: one presented the poster and the other asked questions. They discussed each poster for 5 min. All participating students voted for the best poster, and the score was calculated based on the number of votes.

Fig. 1 Poster presentation

2.3. *Robot competition*

In the robot competition, the participants competed based on how many PET bottles, jelly containers, and Styrofoam balls they were able to collect, which were considered as marine debris. A 2.2-m-long and 4.5-mwide pool was used for the competition field, as shown in Fig. 2. The depth was set from approximately 60 to 70 cm. The competition field was divided into team areas and a debris area. Two team areas were set at the edge of the pool, and the robots of the two competing teams were placed in separate areas at the start of the competition. The debris area was located at the center of the competition field, and marine debris was collected in this area. The competition time was 5 min, and the teams were allowed to restart the robot for any number of times if some problems occurred. However, for restarting, some conditions were set, such as returning the marine debris touched by the robot to the debris area. The list in Table 1 indicates that each type of marine debris had a different number of floating pieces and scores. Points were added as "collected debris" only if the following conditions were satisfied.

- The marine debris that the robot lifted above the water surface was considered as "collected debris." If part of the debris touched the water surface or is in the water, it was not considered as "collected debris."
- If part of the robot touched the end line of the own team area (Fig. 2: red line in the competition field) during the competition time and the "collected debris" was successfully placed outside the competition field from the robot by persons of the team at the end-line side, this debris was considered "collected debris" and was awarded points.
- The "collected debris" in the robot or placed outside the competition field at the end of the competition was given a score.

After completion of the prelecture, each team developed the robot for one–two months. The participating teams did not necessarily develop robots using the distributed basic kits but were allowed to have their own modifications and improvements. However, the following conditions must be satisfied.

- The robot must have a projected area within the range of an A4 paper (210 mm × 297 mm) when the robot was directly viewed from above at the start and restart of the competition.
- The voltage of the power supply for the robot should be nominally 7.2 V or less, and the use of an external power supply was not permitted. In addition, when batteries were connected in series, the total voltage must not exceed 7.2 V.
- The use of lithium polymer batteries was prohibited.
- No restrictions were imposed on the weight or height of the robot.

Fig. 3 shows the pool in which the robot competition was performed. Many of the participating teams had developed a type of robot that scoops up debris and collects it in boxes. However, a unique idea involving a transforming mechanism, such as the robot [Fig. 4(a)] of Mechatro System Club of the National Institute of Technology, Tokuyama College, was presented. This robot transformed into a submerged state to collect debris inside the robot body [Fig. 4(b)], and lifted the debris above the water surface as shown in Fig. 4(c). In addition, some teams adopted their own batteries and motors, while others adopted Bluetooth for communication with robots and operated them with game controllers.

Table1 Debris type and score per piece

Debris type	The number of floating pieces	Score per piece
PET bottles	10	10 point
Jelly containers	30	5 point
Styrofoam balls	50	3 point

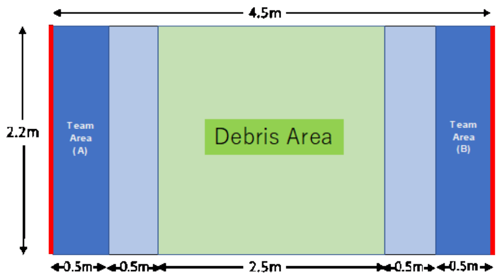


Fig. 2 Schematic of the competition field

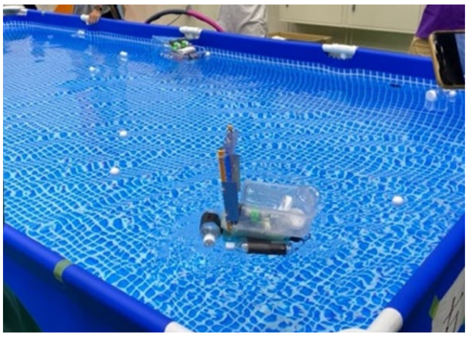
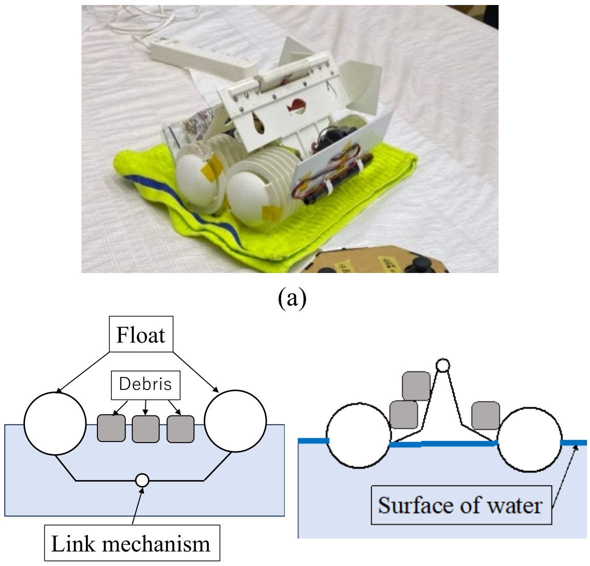


Fig.3 The pool in which the robot competition was performed.



(a)

(b) (c)

Fig. 4 Robot made by the Mechatro System Club of National Institute of Technology, Tokuyama College and its mechanism. (a) Overview of the robot. (b) Before transformation. (c) After transformation

2.4. *Results of the Junior Division*

Table 2 lists the results of the overall junior division competition. The winner was determined by the sum of the scores from the robotics competition and poster presentations. The overall awards were given to the top three teams; Tables 3 and 4 list the top two teams in the poster presentation and robot competition. Table 5 lists the other awards. The Yamaguchi Governor's Award was given to the team with excellent performance by the governor of Yamaguchi. The Mayor of Iwakuni Award was presented by the mayor of Iwakuni to the team with excellent results. Special awards were given to teams that excelled in ideas, technology, and other aspects. The Fighting-Spirit Award was presented to the team that individually participated and struggled. The first and second places of the overall award are shown in Fig. 5. Both teams presented robots that scooped up collected debris using their arms. In the poster session, a lively exchange of ideas was demonstrated, and robots with various ideas performed well in the robot competition. The robot competition was first competed in the league, and the top teams in the league competed in the tournament, resulting in a total of 21 games. There was also a game in which all the debris placed was collected, and active competition between robots was seen. Teams that were composed of many students with basic knowledge of microcomputers demonstrated an advantage in the robot development, and most of the winning teams were from industrial schools. However, teams in which the robot did not work at all were few because relearning was provided to all the teams with no prior knowledge. We received a lot of feedback that the competition helped students with their robot education.

Table 2 Overall award

Award	Team Name	Affiliation
1st place	Noukou G's	Tabuse Agricultual Technical High School
2nd place	Know Sea's	Tabuse Agricultual Technical High School
3rd place	Kokkaginoushi no tsudoishi Minamata-shibu	Minamata High School

Table 3 Robot competition award

Award	Team Name	Affiliation
1st place	Noukou G's	Tabuse Agricultual Technical High School
2nd place	Know Sea's	Tabuse Agricultual Technical High School

Table 4 Poster presentation award

Award	Team Name	Affiliation
1st place	Umi no Gomi wo Nakushitai	Jyoto High School
2nd place	M・E・C Suirobo Doujinkai	Osaka Metropolitan University College of Technology

Table 5 Other awards

Award	Team Name	Affiliation
Yamaguchi Governor's Award	Tokuyama Kosen Mechatro System Club	Natinal Inst. of Tech., Tokuyama College
Iwakuni Mayer's Award	Gankou "Damashii"	Iwakuni Technical High School
Special Award	Dept. of Electronic Mechanics	Mifune High School
Fighting-spirit Award	Team 0	Individual participation


(a)

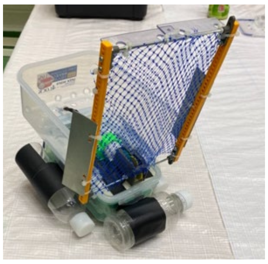

(b)

Fig. 5 Robots developed by the 1st and 2nd place teams (a) Noukou G's. (b) Know Sea's

3. Verification of Educational Effects

We distributed questionnaires about the changes in the level of understanding before and after the competition and assessed the educational effect. Answers to five questions about robots, circuits, and SDGs were aggregated and plotted in a graph. The contents of the responses are defined as follows:

A1: No understanding
A2: If I am taught, I can understand
A3: I can understand by myself
A4: I can understand and teach others

Fig. 6 shows a summary of the number of responses to the questionnaire on the level of understanding of microcomputer programming. After the competition, Response A1 significantly decreased, and Responses A2 and A3 increased. As explained in Section 2.1, prelearning was conducted before the competition. Fig. 6 shows that this competition demonstrated an educational effect on microcomputer programming. Fig. 7 shows a summary of the number of responses to the questionnaire on the level of understanding of circuit construction; Response A1 decreased, and Response A3 increased after the competition. The results implied that more students were able to construct circuits by themselves. Fig. 8 shows a summary of the number of responses to the questionnaire on the level of understanding of robot-mechanism construction, which did not reflect a remarkable change. However, a slight decrease in Response A1 and a slight increase in Response A4 were manifested. In addition, the number of students who provided Response A3 was the highest among the questions on understanding microcomputer programming, circuit construction, and robot-mechanism construction. Because many teams from industrial schools participated in this competition, many students had prior knowledge of the mechanisms. Therefore, we presume that the results shown in Fig. 8 were due to the fact that there were few students who had no prior knowledge on robot mechanisms. Fig. 9 and 10 show the summary of the number of responses to the questionnaire on the level of understanding of SDGs and marine debris. Currently, answers to A1 were few because education on SDGs is being conducted in various schools. On the other hand, the number of Response A4 increased, which was the highest number of responses in all the questionnaires. The results imply that this competition has contributed to deepening the understanding of the students on SDGs and marine-debris problem.

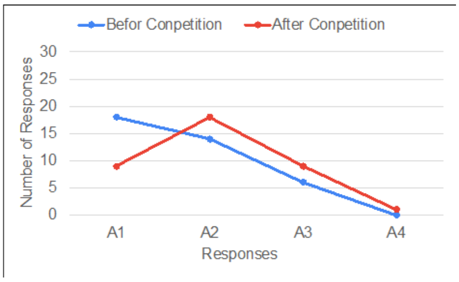


Fig. 6 Changes in the level of understanding of microcomputer programming

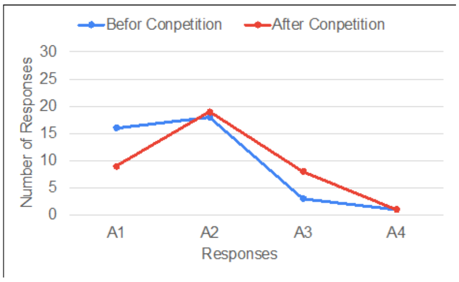


Fig. 7 Changes in the level of understanding of circuit construction

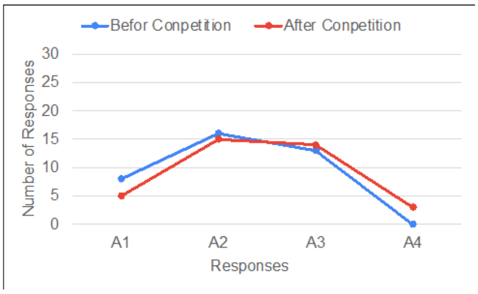


Fig. 8 Changes in the level of understanding of robot-mechanism construction

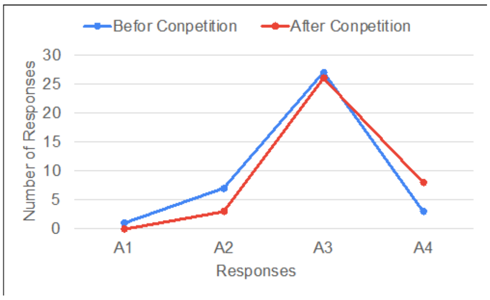


Fig. 9 Changes in the level of understanding of SDGs

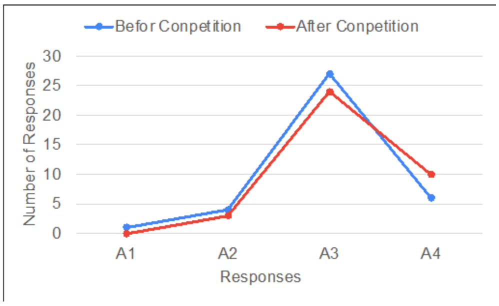


Fig. 10 Changes in the level of understanding of marine-debris problem

4. Conclusions

Eighteen teams participated in the junior division of the 8th Underwater Robot Festival where more than 120 participants joined. The junior division consisted of poster presentations and robot competitions in which the students competed for a place in the overall score. In the poster presentation, each of the 18 teams investigated the marine-debris problem and presented their posters. Students from different cultures such as technical high schools and national institutes of technology actively exchanged ideas and shared various values. In the robot competition, various types of robots were built based on the theme of marine-debris collection. Henceforth, we will re-examine the rules and try to improve the competition. Finally, the results of the analysis of the questionnaires provided before and after the competition confirmed the educational effect from the point of view of robot education, which focused on microcomputer programming and circuit construction. With regard to circuit construction and microcomputer programming, Response A1 remarkably decreased after the competition, which was considered to have had a great educational effect. We consider that the online prelearning conducted for each team two months before the competition led to their understanding of circuit construction and microcomputer programming. The questionnaire responses also implied that understanding of SDGs and marine-debris problem was intensified. This competition also contributed to the education on robots as well as the social problems.

Acknowledgment

This work was supported by Iwakuni Maritime Environment Test and Evaluation Satellite (IMETS), Yamaguti Prefecture, Iwakuni City, IEEE/Oceanic Engineering Society (OES) Japan Society, the Japan Society of Naval Architects and Ocean Engineers, Marine Technology Society Japan Society and Techno-Ocean Network.

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