Research Article

Development of Teaching Support Material for Nurturing Cooperation through Play

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ABSTRACT

Educational activities with robots have been conducted at each stage – from kindergarten to junior high school. In this paper, we propose and verify educational material supporting collaborative operations through experiences related to people and objects. Specifically, three children used joysticks to operate a robot simultaneously. The robot could not move unless the joysticks manipulated it. We developed teaching support material that nurtured cooperation through play.

1. INTRODUCTION

An emerging problem in Japan is that coordination (cooperative and collaborative work, etc.) through appropriate group activities has not been assimilated by the country's changing social situations. Specific problems include the following:

1. People are unable to build good human relationships with others.

2. People are unable to work in groups.

3. People are unable to solve problems with other people through discussion.

In addition, it has been noted that Japanese children cannot successfully adapt to groups in kindergartens and elementary schools [1].

Conversely, in November 2014, the Japanese Minister of Education, Culture, Sports, Science and Technology consulted the Central Education Council who emphasized the quality and quantity of knowledge and learning, learning subjectively and collaboratively, learning to identify and resolve problems, and improving teaching methods. Hence, abundant research exists on learning methods in educational subjects [2–4]. However, there has been scarce research on nurturing cooperation using robots. Such research is important for personality development education.

Therefore, this study, proposes and develops cooperative teaching material and evaluates cooperation among children. Specifically, we provide children joysticks to operate a modified robot that does not move unless they manipulate it simultaneously.

2. PROPOSED TEACHING MATERIAL

The proposed teaching material is displayed in Figure 1 with the following concept:

1. Three children cooperate in maneuvering.

2. Remote control type (joystick).

3. Data recording (using a data logger).

Figure 2 indicates the system configuration for this teaching material. The joystick statuses (0 V or 5 V) of the three children are sent to a micro-controller [5]. Subsequently, the status of each joystick is stored in the data logger by the micro-controller or the data is transferred to a tablet PC through Bluetooth.

The algorithm for operating this teaching material is adapted to adjust the speed of the robot's crawlers by the following Eqs. (1)–(4):

$$\text{Speed}_{\text{Right}} = \frac{\text{Speed}_{\text{MAX}} \cdot \text{MD}_{\text{R}}}{3} \quad (1)$$

$$\text{MD}_{\text{R}} = \text{JS}_{1\text{R}} + \text{JS}_{2\text{R}} + \text{JS}_{3\text{R}} \quad (2)$$

$$\text{Speed}_{\text{Left}} = \frac{\text{Speed}_{\text{MAX}} \cdot \text{MD}_{\text{L}}}{3} \quad (3)$$

$$\text{MD}_{\text{L}} = \text{JS}_{1\text{L}} + \text{JS}_{2\text{L}} + \text{JS}_{3\text{L}} \quad (4)$$

Here, $\text{Speed}_{\text{Right}}$ ($\text{Speed}_{\text{Left}}$) is the speed of the right crawler (the left crawler) of the vehicle and $\text{Speed}_{\text{MAX}}$ is the crawler's maximum speed.

Furthermore, $\text{JS}_{1\text{R}}$ ($\text{JS}_{1\text{L}}$), $\text{JS}_{2\text{R}}$ ($\text{JS}_{2\text{L}}$), and $\text{JS}_{3\text{R}}$ ($\text{JS}_{3\text{L}}$) denote signals on the right side (the left side) of the joysticks of operators *A*, *B*, and *C*, respectively. The left and right sides of the joysticks are set to 0 when the robot is not moving, 1 when it is moving forward, and −1 when it is moving backward.

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MD_R (MD_L) denotes the sum of JS_{1R}, JS_{2R}, and JS_{3R} (the sum of JS_{1L}, JS_{2L}, and JS_{3L}), and the signal of a majority decision by the operators is the output, as shown in Figure 3. With these signals of a majority decision, the robot cannot move unless an individual operator cooperatively manipulates their device with the other operators.
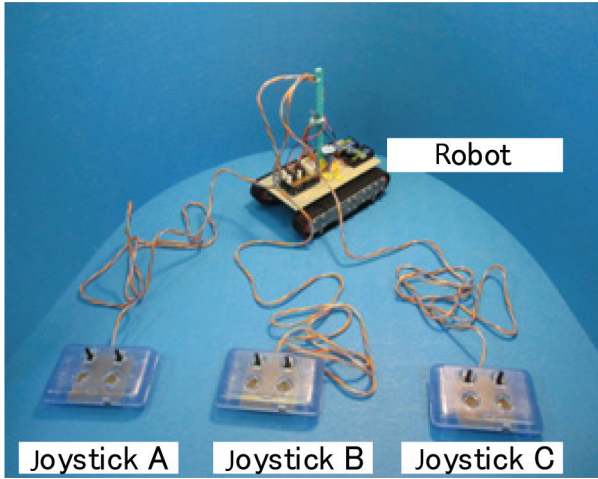

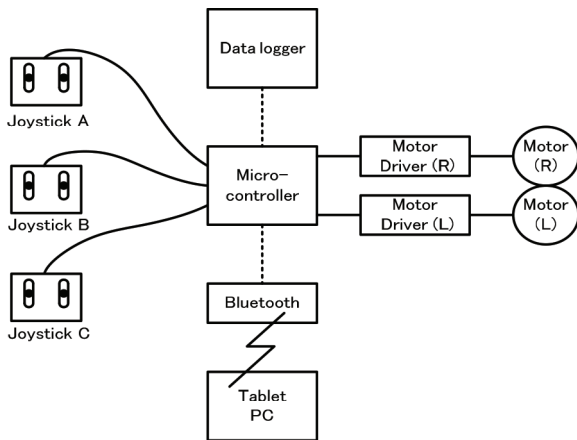**Figure 1** | Proposed teaching material

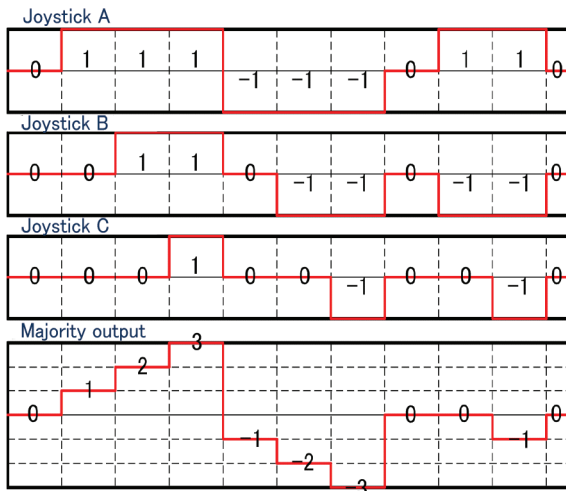**Figure 2** | Schematic figure of proposed teaching material

Figure 3 | Majority decision

3. CURRICULUM FOR NURTURING COOPERATION

The curriculum for nurturing cooperation using the suggested teaching methods is explained here. Since this method is to be used in elementary school classes as indicated in Table 1 this curriculum is conducted in 90 min classes (45 min, twice).

The lesson objectives are explained in the first 10 min. The following 20 min clarify the rescue activities using the proposed teaching material, rescue field (Figure 4), and rescue dummy (Figure 5). At this point, students are instructed that the robot must swiftly move to the dummy location for rescue. Moreover, the students with joysticks rescue the dummy without talking for 15 min. During the next 15 min, they rescue dummy while discussing the task. For another 20 min, they rescue the dummy according to the leader's instructions. Finally, the importance of cooperation is summarized.

Table 1 | Curriculum

Time (min)	Content
10	Learning about cooperation
20	Learning about rescue activities
15	Rescue activities without talking
15	Rescue activities with talking
20	Rescue activities based on a leader's instructions
10	Summarize the lesson

Figure 4 | Rescue field

Figure 5 | Rescue dummy

4. EXPERIMENTS AND RESULTS

We experimented to confirm the effectiveness of the teaching materials. The participants were three elementary school students. In the following two cases, the joystick statuses were compared and the effectiveness of the teaching material was confirmed.

Case 1: Three students operate the robot without talking.

Case 2: Students operate the robot according to a leader's (selected from the three students) instructions.

Figures 6 and 7 demonstrate the joystick operation behavior of the students in Case 1. If the operations of the three students correspond, the MD_R and MD_L values are −3 or 0 or 3. It is obvious that the students are not cooperating because in several instances numerical values other than −3 or 0 or 3 occur.

Figures 8 and 9 indicate the joystick operation behavior of the students in Case 2. Since the operations of the three students almost concur, the numerical values of MD_R and MD_L are −3 or 0 or 3. Hence, it is obvious that cooperative operations are possible through a leader's instructions. Moreover, when the three students cooperatively operate the robot their joystick behavior synchronizes.

5. CONCLUSION

This paper offered teaching material to support cooperative development through direct experiences. The experimental results using
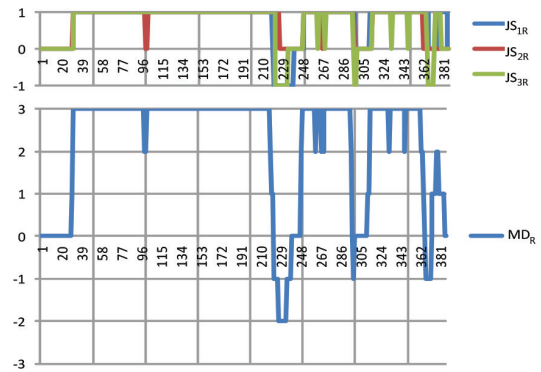

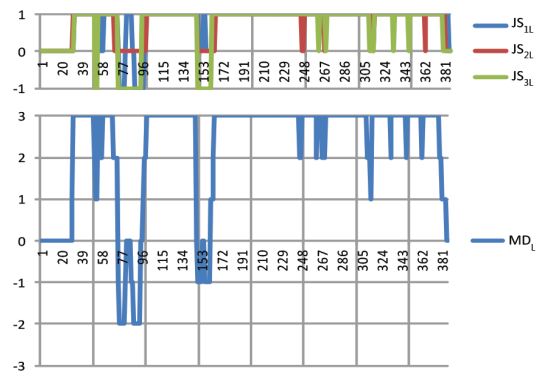**Figure 6** | Right joystick operation behavior in Case 1

Figure 7 | Left joystick operation behavior in Case 1
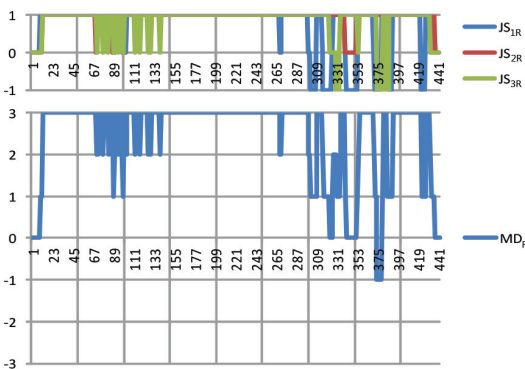

Figure 8 | Right joystick operation behavior in Case 2

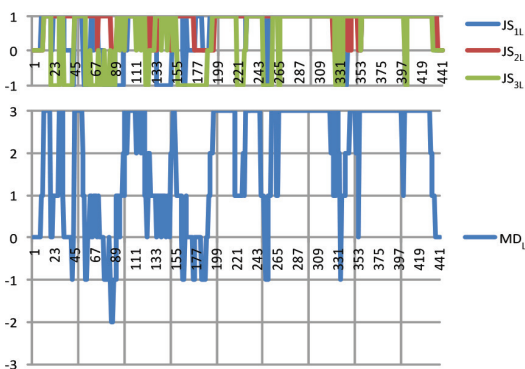**Figure 9** | Left joystick operation behavior in Case 2

the proposed teaching material indicated that joystick operations synchronized when students operated cooperatively.

In the future, we intend to develop the teaching material and curriculum and put them into practice at an elementary school. We will utilize questionnaires to reveal the opinions of students and teachers to verify its effectiveness.

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