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Trial of Programming Education for Junior High-school Students by Using Bipedal Robots

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***Abstract*—** This paper aims at showing a trial programming education for junior high school students by using small bipedal robots. A gap of student skills and knowledge about programming before this kind of activities in elementary school has been observed in Japan. Since the bipedal robot has various functions, we thought it could be used appropriately for both beginners and masters of programming. The students were interested in programming the robot and its movement, but they had various opinions on the activities because its style is similar to human being, they expected it to move as human being and requested more advanced and smooth movements. Besides, the robot was only one object which the students can move and control in the session, variety of the projects are needed to be suitable to the environment where the various students having different skills and knowledge learn in the same classroom at the same time.

Keywords-programming education; *biopedal robot; junior high school students; mandating the programming education*

I. INTRODUCTION

"Programming education" is one of the most important agenda in primary and secondary education for a couple of years in Japan. Many school teachers and officials in cities and prefectures have been forced to be engaged in programming activities to prepare programing courses by themselves and/or to collaborate with a private company, NPO, special school, and/or university, whether they like it or not. According to a recent report from the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), 52% of Education Board in the municipal level have already introduced some kind of programming education at least in a part of elementary schools in the last academic year 2018-2019. The percentage was increased from 16% at the previous year, but the smaller a local government's population size is, the more likely they feel the difficulties to introduce the programming education [1].

The authors have accumulated many practices of programming education for elementary school pupils since 2011. It was made clear that programming education raises children's capabilities and motivation for the activities [2][3],

and they also change the teachers' mindset for the programming to be more affirmative [4].

Through teaching programming, it is also found that the students get interested in actual three-dimensional objects moved and communicated by the program they made, rather than only in the two-dimensional movement and sound on the display. Therefore, we carried out the programming education using big humanoid robots in cooperation with a private company in 2018 [5]. However, the main function used for the humanoid robot was communication with users, and the robot was rarely ordered to physically move probably because it has the similar height and weight as the elementary school student, and the movement was considered too hard. Moreover, it was difficult to offer one robot to one participant due to its high cost.

This Research is a trial of programming education using a small humanoid robot to understand pros and cons of the robot usage in the one-to-one setting where many robots were used in a classroom of elementary school. This trial was meant to develop a foundation of effective utilization of the robot for the programming education.

II. MANDATING THE PROGRAMMING EDUCATION IN ELEMENTARY SCHOOL

In many countries programming education is becoming a “movement” in school education, especially as for the head start to the coming information society. Japanese government decided that the programming education would be a requirement from 2020 at elementary schools by amending the elementary school teaching guideline. [6]

Programming education is recognized as an occasion for the students to acquire the ability and attitude to understand computer programs in our daily life and utilize the programming, not just to master coding. In order to support the smooth introduction of programming to the elementary school education, "Guidance of an elementary school programming education" was published in March 2018 (2nd edition was released in November 2018) [7], and the skills and knowledge has been expected to be shared among the school teachers and officials, while the schools have been trying to introduce the programming in collaboration with other organizations such as private companies, non-profit organizations, other specialists in ICTs and universities.

In the guide book MEXT set the definition of "Programming Thinking", which is expected to be cherished by programming education, as follows:

"the ability to think logically in order to realize a series of intentional activities such as what combination of movements should be required, which symbol corresponding to each movement should be used, and how they should be improved to be approached to the intended activity."

Moreover, the abilities and qualities expected to be nurtured by programming education are organized, like those in subjects, along with "three pillars of the competencies" as follows, and

"learning power and humanity, etc."), and the progress should be on the basis of the development stage.

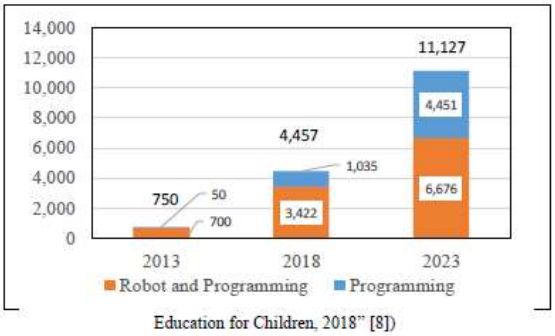
> **[Knowledge and skills]**
> Notice that the computer is used in our daily life, and that there are required sequences in problem solving.
>
> **[Abilities to think, to make decisions, and to express themselves, etc.]**
> Nurture "programming thinking" based on students' developmental stage.
>
> **[Learning power and humanity, etc.]**
> Nurture the attitude of trying to utilize the functions of computer to build better life and/or society based on students' developmental stage.

There is a criticism mainly from educators that the guidance does not match to the main concept of the programming education because the description is just like a drilling tutorial in order to evaluate their learning outcome similar to the other subjects. Besides, even though the second pillar, [Abilities to think, to make decisions, and to express themselves, etc.] would be taught in the programming activities, the other two pillars are less noticed among the teachers. It is expected that only two - four class hours per year are used for the programming because of the tight curriculum schedule when applying the programming education. The two pillars will be taught by a short guidance before the programming, but we think they are equally important for the learners as the programming skills. How do they treat the "humanity" in such a short term?

We will have another problem on the programming education. Some children whose family has high income, and/or strong interest in information and infotech are going to a cram school for programming to prepare for the coming ICT society, and to tell the truth, to have a good score of the short-term programming education offered in their formal school because it will be involved in their school reports. [8]

It is quite natural to have a big gap of the skills and knowledge on programming among the students based on their economic condition, and basic content of the programming education could not control all the school students who have huge gap in their abilities. Offering lessons which gives programming tasks suitable for various students from "beginners" to "masters" is essential to the class management and it should have effective impact to all the students.

Figure 1. Number of cram schools teaching programming for children. (Source: Coeteko & Funai Soken (2018) "Market Research on Programming Education for Children, 2018" [8])



"Humanoid robot" is considered to be one of the solutions for such a problem. It has various functions and can be used appropriately for beginners and masters of programming education. Moreover, when considering the "new system" of our society in the near future, it is also important to get familiar with the humanoid as our fellow, friend, and/or family. Besides, it is suitable with the "humanity" in the third pillar of the abilities and qualities to be nurtured by programming education.

III. OVERVIEW OF THE SMALL BIPEDAL HUMANOID USED FOR THE PROGRAMMING

We tried to use the small bipedal humanoid robot, “Qumcum,” for the programming education in elementary school. It was developed by CRETARIA Inc. in Kyoto, Japan. The shape of this robot is quite simple, and the circuit board inside can be seen through the transparent front cover so that the pupils regard it as a "ROBOT". The platform is Arduino Leonardo. It has seven servo motors to move arms, legs and head, which are custom-ordered to makes them rotate 180 degrees. It realizes bipedal walk (static), moving two legs and adjusting the hip joint and ankle joint of each leg by stored program (it is difficult to realize dynamic walk by the limited number of sensors and motors.). The three remaining motors are used for both arms (shoulder joints) and the head (neck joint only for swinging the head).

A PC is linked by Bluetooth, and enables to offer the Scratch programming environment, which many children are familiar with, and the special commands only for Qumcum are prepared at the bottom of the main menu. Other than the movements, it has a sound sensor and an ultrasonic sensor, and a microphone and a loud speaker, an LED light and a voice synthesis LSI so that it can indicate some colors, make BEEP sound, speak Japanese language in the link with a perceived sound and/or a physical obstacle. That is, it has the eye to see, ear to hear, mouth to speak, and two arms, two legs, and single head for moving and showing a sign to the others. Then, it has much potential as a partner of the student in the classroom setting.

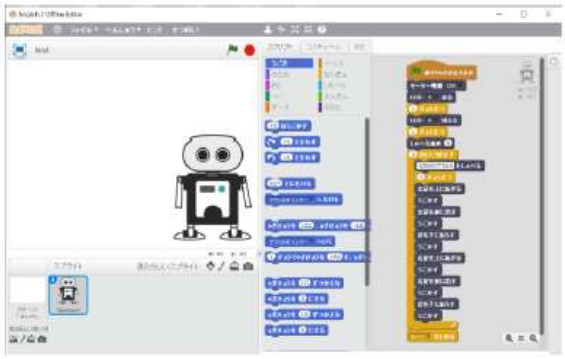


Figure 2. Programming by Scratch for Qumcum

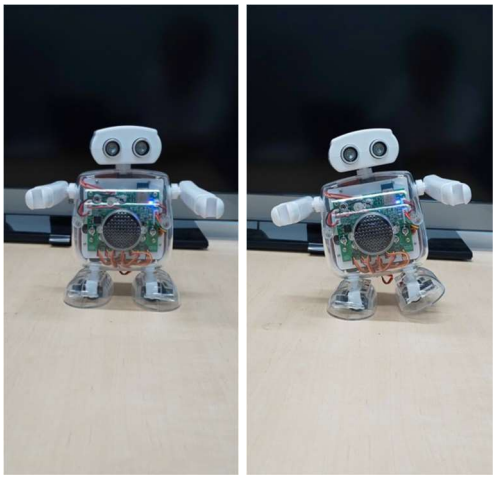


Figure 3. The shape of robot standing (left) and walking (right)

IV. METHODOLOGIES:

We observed junior high school students programmed the bipedal robot and asked some questions about the impression of the robot and possibilities of using the robot for a programming education in school. The experiment was just a trial status and conducted in the classroom of the university, Tokyo Institute of Technology, in April, 2019.

In total five participants joined the programming session; three for first-year students and two for third-year students in junior high school. One of the third-year is female and the

others are male. They are not experts in programming, but have much amount of experiences to participate the programming education which uses Scratch, Mindstorm or WeDo of LEGO, etc. at the school, and the university.

The participants were requested to use the small bipedal robots for programming. It was the first time for them to see the small robot though they have much experience of the programming with the other type of robot. Since they have skills and knowledge on Scratch programming, they did not have instruction of Scratch and ICT devices, etc., but have information only the commands for moving the small robot Specific topic and task was not offered to the participants. They tried to program freely to play with the robot, and/or to find and solve their own tasks. The session was one and a half hour, and each student used one robot.

After the session, they were interviewed about the robot and programming in a group. It was mainly a free discussion, guided by the planned questions as follows:

- Impression of the small bipedal robot and programming
- Pros and cons of the robot and programming
- Room for improvement of the robot and programming
- Comparison with other programming tools and robots (compared with their former experiences)
- Probability of implementation of the robot programming for a programming education in elementary and/or junior high school.

Figure 4. The students learning in the tryal session

V. RESULTS

The participants showed positive reaction to the robots and smoothly started their own programming without any problem. It might be because the language used was Scratch. If other languages are used, they should have lesson of the command and language before the class. The program which one participant made is shown in Figure 5 below.

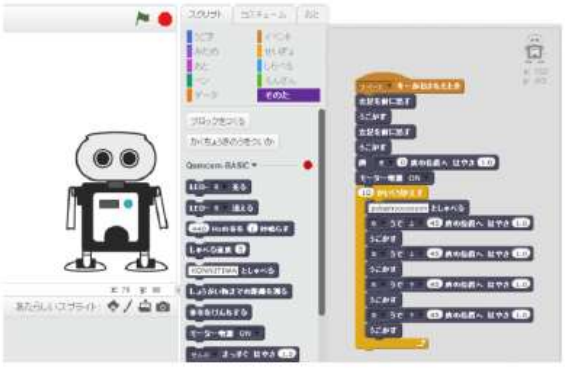


Figure 5. Example of programming by a participant

At the first step most of them used sound commands to let the robot speak something. After that they tried to move the robot by using arms and legs. Since the command for walking needs special treatment some instruction was needed to show the walking activity.

As the results of the interview survey, they had various opinions on the robot and its activities as a programming education. Their impression was mainly positive such as cute,

friendly, human being, easy to understand, etc. But since its style is similar to human being, they expected its movement as a human being and requested more advanced and smooth movements. Additionally, they had many ideas to move the robot like a human being such as dance, carrying something, and found the limitation of the robot at the same time. It supposed it can lead to the complex movement of animals. Table 1 shows their comments to the interview survey.

TABLE I. PARTICIPANTS' COMMENT TO THE INTERVIEW SURVEY

Impression
✓ Cute.
✓ Smaller than the robot we used several months ago
✓ Since the robot is three-dimensional, it is easy to understand.
✓ Similar to a human being.
✓ Attractive and friendly in the aspects of figure, shape, and voice.
✓ Easier to program than my expectation.
✓ Walking by two legs is very similar to a human being, and it is understandable.
✓ Different from the robot having rolling wheels.
Modification proposal to the robot
✓ I want it to move its head in a vertical direction for bowing, nodding, and/or looking up.
✓ I want its elbow to be bent.
✓ It should be slightly bigger.
✓ Comparing the vertical movement of the head and the vent of the elbow, the head should be moved.
✓ Since it inclines when walking, it should always stay level. (Walking of a human being is so.)
✓ It is interesting, and it will be popular.
✓ This one is more attractive than games.
✓ I ask the robot to do my homework in the future.
Probability of implementation of the programming session
✓ In classroom activities, I would like to use one robot, not by a group.
✓ Comparing doing by myself and in a group, I would like to do alone.
✓ Comparing speaking and moving, I would like to select moving.
✓ How about a movement which carries a thing?
✓ I would like to let the robot do what is helpful.
✓ I would like to let it dance.
✓ Comparing pictures in the window and a robot in the real world, pictures in the window is enough.

VI. CONCLUSION

The students tried to program the small bipedal robot, and it is observed that they got interested in the humanoid robot and concentrated in the programming which moves it as a human being.

Making the robot walk by two legs is very difficult and needs an advanced adjustment, but it was not recognized by the students because bipedal walking is quite natural for human being, and that is, they regarded the robot as a similar object. Then they requested the robot to stay horizontally and to turn from side to side in order to use this robot as a useful tool, for example, to carry something. Moreover, there was another opinion which asks to move the head up and down (like a bow), and to move the elbow. One reason is to hold something and another reason may be to make it more similar to the movement of human being.

We suppose that the more advanced contents can be offered by using this bipedal small robot and beginners and masters can use it in a same manner in school. One robot should be distributed to each student, however, it is still slightly expensive for the realization. Besides, the robot was only one object which the student can move and control in the session, variety of the projects are needed to be suitable for the environment where the various students having different skills and knowledge learn in the same classroom at the same time.

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