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Keynote Speech

Programming Education for Primary School Children

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***Abstract*—**Our programming education activities at public primary schools in the last five years are briefly shown. Several courses linked with course units in science were developed, so that they are useful not only for programming study, but also to enhance understanding the corresponding course units. Total 1108 children in 8 public primary schools participated. From comprehension tests and questionnaire surveys we see that computational thinking has been enhanced through our activities.

***Index Terms*—**Programming education, computational thinking, logical thinking, simulation, primary education

I. Introduction

In England national curriculum "Information Technology (IT)" bacame an independent compulsary subject in primary education in 1995. IT was renamed as ICT in 1999. Since 2013 the subject was chagned to "Computing", in which children study how computers and computer systems work, and how they are designed and programmed[1]. In may parts of the world similar contents are now taught in compulsory or elective subjects. Copmutational thinking is important because it allows us to solve problems, design systems, and understand the power and limits of human and machine intellignece.

In Japan "Information (or Informatics)" was introduced in upper secondary education in 2003. We believe that such education program is important to small children in primary education as well as secondary education. For example, to simulate natural and scientific phenomena, animal movements, etc., by a computer program, children have to observe the phenomena much better. By careful observation they understand elements of the phenomenon and processes they operate. That understanding enables them to model and simulate the phenomenon. In simulation they can understand the phenomenon better by trial and error with different parameters. In that way we hope they develop logical and computational thinking. We have been conducting programming education at local elementary schools for the last five years. In this keynote speech, we report our activities.

II. Scratch

We use Scratch[2] developed at MIT Media Lab as a programming tool. Scratch is a free visual programming language which runs on Windows, MacOS, and Linux. Its interface language is translated into more than 40 languages, and Japanese is one of them. Japanese version of Scratch uses Hiragana and Katakana (phonetic alphabets), not Kanji (Chinese characters), and so it is easy to use even for first grade children. Since Scratch is free, children may continue their activities at their home if their parents install Scratch on their PCs at home.

Fig. 1 Scratch screen

III. Programming Education

Programming education becomes popular, and there are many private computer courses around. In that sense a child can join such a course if he/she wants and his/her parents allow and can afford it. We believe, however, that programming and computational thinking is necessary for all children. So we have our activities in public primary schools in their official curriculum, so that all children benefit regardless of their parents' understanding and allowance. We are thus developing sample course materials with actual practices, which could basically be used by primary school teachers too.

We design our course contents to be linked with course units in mainly science, so that children can understand the course units better by the programming practices in addition to programming study itself. This happened to be in line with the recent MEXT policy announced in 2016 to start programming education in primary schools from 2020.

Fig. 2 Simulation of giraffe walking

Fig. 3 Classroom

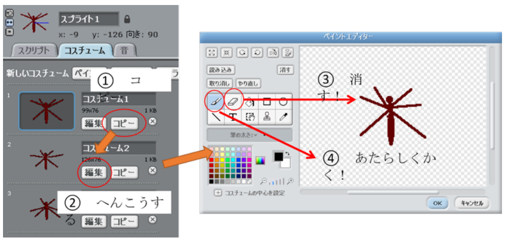


Fig. 4 Draw a Water Strider

IV. Curriculum Development and Practice

We have so far developed several course contents, which are shown in Table I. We picked up topics from course units in mainly science. In the beginning of our course, it is necessary to teach basic usage of computers especially to small children. Most of public primary schools now has a PC room where basically two pupils share a PC. In some cases we brought about 10 laptop PCs so that each pupil can exclusively use a PC. In other cases we invited primary school children to our Tokyo Tech campus, and conducted the activities.

Our activities were attended by 1108 children in 32 classes in 8 public primary schools in Tokyo. All the children actively participated the courses and seemed to enjoy the activities. There are, however, two types of teachers; teachers actively engaged in the course processes who wanted to implement their own courses, and teachers just watching the activities who would like to avoid their own involvement.

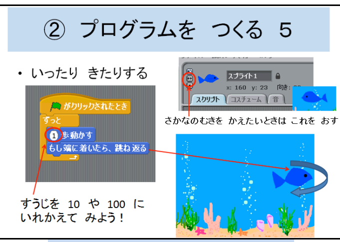
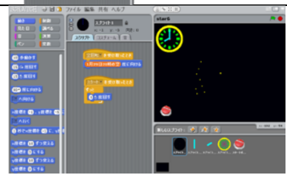
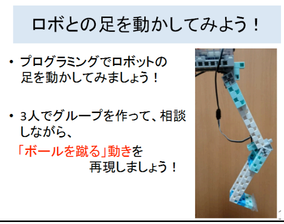
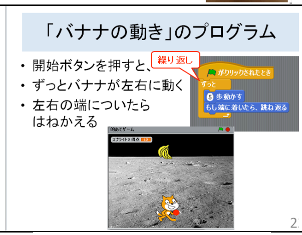
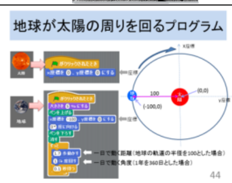
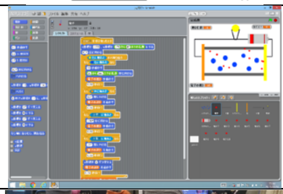
(a)

(b)

Fig. 5 Children visited Tokyo Tech

Fig. 6 Simulation of balance scale

TABLE I. Topics of Programming

Title	Target	Contents	Photos
My private aquarium!	1st grade -	Make a private aquarium and let fish swim by a simple program. Children can experience and enjoy programming.	
Replicate the leg movement of animals (human, elephant, giraffe, and insect)!	1st grade -	Observe how animals walk, and simulate the leg movements of animals	
Simulate constellation movement!	3rd grade -	Simulate the movement of Cassiopeia around the North Star.	
Simulation of human limb joints by robot	4th grade -	Simulate movement os human limb joints and make a robot leg kick a ball	
Create a game	4th grade -	Make a simple shooting game to understand basic programming processes	
Simulate the solar system!	5th grade -	Make a simulator of the solar system mainly the sun, the earth, and the moon	
Simulate electrical current flow!	5th grade -	Model and simulate electrical current flow to understand invisible electron movements	
Simulation of balance scale	5th grade -	Make a simulator for a balance scale and actually check the balance	

V. SOME FINDINGS

In addition to programming activities, we conducted tests and questionnaire surveys. There are some findings and we show you some of them.

Fig. 7 shows the comparison of children's comments before and after the activities of elephant leg movement simulation [3]. Before the activity they just watch the video unthinkingly. It is clear that they watch the video carefully during the activity, and wrote a lot of comments especially on leg movements.

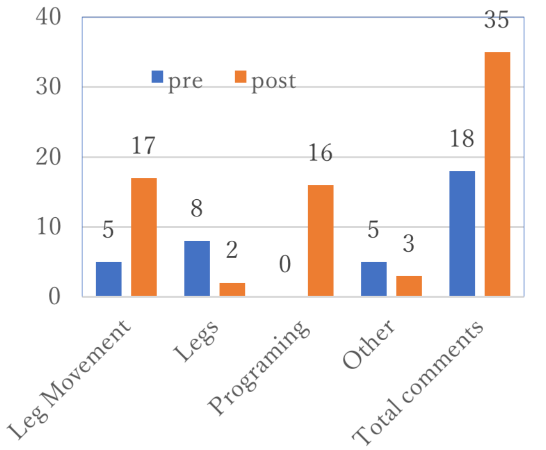


Fig. 7 Comment comparison (N=58)

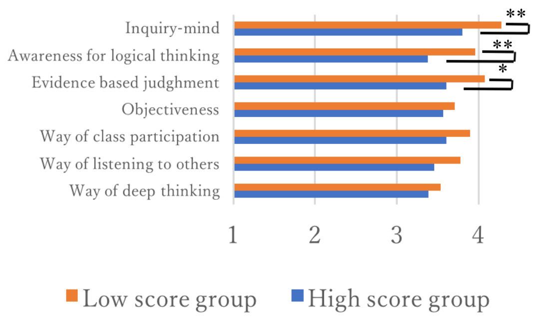


Fig. 8 Comparison of critical thinking disposition

We compared critical thinking attitude between two 5th grader children groups; one with high scores (N=67) and another with low scores (N=41) in a comprehension test in programming (sequence, repetition, conditional branch, and variables) conducted after a lecture and before making a shooting game. Twenty-item questionnaire survey was conducted beforehand [4]. As shown in Fig. 8, high score group has significantly high "inquiry-mind", "awareness for logical thinking", and "evidence-based judgement" than low score group [5].

We also found from the questionnaire survey related to electrical current flow simulation that children who are interested in programming have significantly higher inquiry mind (they want to try new things one after another, p=.002), way of deep thinking (inputs are rephrased by their own terms, p=.014), and way of listening to others (listen to others with checking the contents, p=.008).

VI. CONCLUSIONS

Our programming education activities in public primary schools are briefly introduced. Through the activities children showed great enthusiasm to programming and they enjoyed the activities. We believe that they acquire computational thinking, which is necessary in this new era, by proper programming education. We have to offer equal educational opportunities to the young.

ACKNOWLEDGMENT

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