# Improvement of a Tangible Programming Tool for the Study of the Subroutine Concept

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**Abstract.** We developed a tangible programming education tool "P-CUBE2" to aim at learning benefits of subroutine such as to create a function once and then reuse it. The target user of this tool are visual impairments and inexperienced persons who are not familiar with PC operation. We introduced the function mat, utterance function blocks and HIRAGANA (Japanese character) blocks so that user can learn subroutine concept. Users can create the function of utterance by combining and placing these blocks which on the function mat. The created function of utterance can be called on the main mat. By these operation, the user can control a robot which outputs sound as a controlled object. In this research, we introduce the system configuration of the P-CUBE2 and report the result of experiment for evaluation of the tool operability.

**Keywords:** Tangible programming tool · Subroutine concept
Visual impairments

## 1 Introduction

Personal computers (PC) installed programming software are often using in programming education. On the other hand, we developed P-CUBE which is a tangible [1] block type programming education tool [2] that user can learn programming without operating PCs. In addition, research and development such as E-Block [3], material programming [4] and GLICODE [5], which have an easy to use interface have been conducted even for low age groups. The user can learn three learning elements of sequential, conditional branch, and loop using these tool [6]. Since, users cannot learn a concept of "subroutine" using these tool. The subroutines are introduced in the field of actual information education. So, the purpose of this research is to add subroutine as a learning element of P-CUBE, and to confirm whether user can learn the benefits of a subroutine using P-CUBE which added function (hereinafter referred to P-CUBE2) [7]. In order to learn the concept of subroutine, we introduced a robot that outputs sound as a controlled object, and we created P-CUBE2 which can set the conversation contents using utterance function blocks.


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## 2 P-CUBE2

### 2.1 System Configuration of P-CUBE2

P-CUBE2 consists of two program mats and programming blocks which have RFID systems. One of the program mat is the function mat which is newly introduced in P-CUBE2, and another is the main mat. Figure 1 shows a system configuration of P-CUBE2.

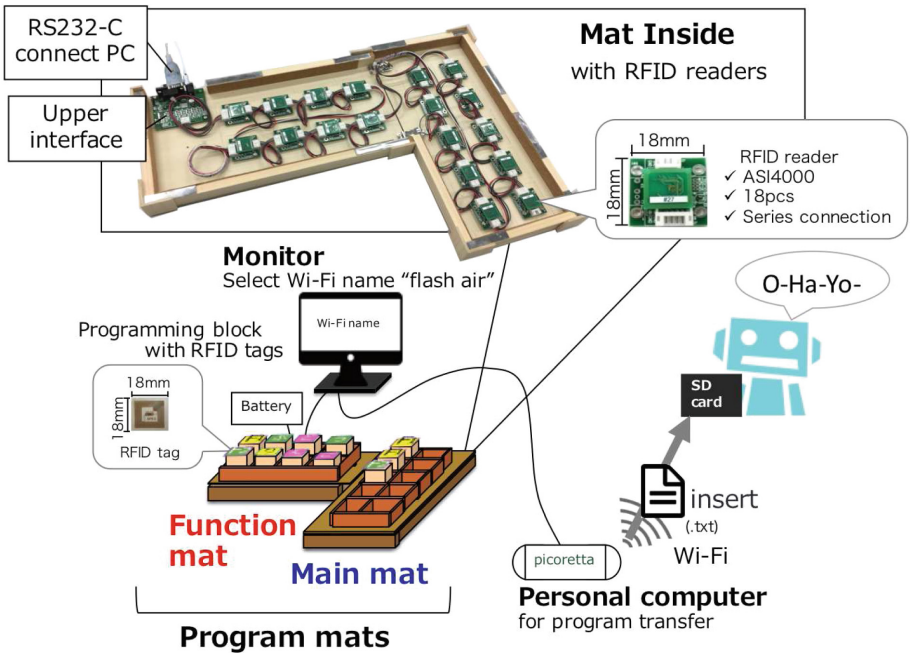


**Fig. 1.** System configuration of P-CUBE2.

RFID tags is attached to each side of programming block. The RFID reader "ASI4000IIC" of 18 are installed in the main mat to read the position information of the programming blocks on the main mat and function mat. The function mat has 8 separated by wooden frames and the main mat has 10 cells which users can make a main program. The function block is put on the left end of the function mat and three hiragana blocks is put on the right side of the function block. Users can create two functions in the function mat in this system.

### 2.2 Programming Block

There are four kinds of the programming block. Figure 2 shows each of programming blocks.

**(i) Hiragana Blocks.** The Hiragana block is a block that controls the utterance of the controlled object. The shape of Hiragana block is a wooden cube

chamfering the upper part of it. One hiragana block is assigned one line of characters among 50 letters of Hiragana. Each surface of the hiragana block is assigned to one hiragana pronunciation. For example, the upper surface of the block indicates "KA" sound, and each side surface indicates "KI", "KU", "KE", and "KO".

**(ii) Function Blocks.** F1 to F4 are set in the function blocks of side as function name. The function block has the same shape of the hiragana block.

**(iii) IF Blocks.** The IF block is used to branch the utterance contents when the blue switch attached to the top of the controlled object turns ON or OFF. There are two types of IF blocks, "IF START" means the start point of the conditional branch and "IF END" means the end point. The left side of the IF START block to which convex information is given using the EVA sponge indicates the state of which the switch is ON. The right side of the IF START block not using the EVA sponge indicates the state of which the switch is OFF.

**(iv) LOOP Block.** The LOOP block is same block when P-CUBE system.

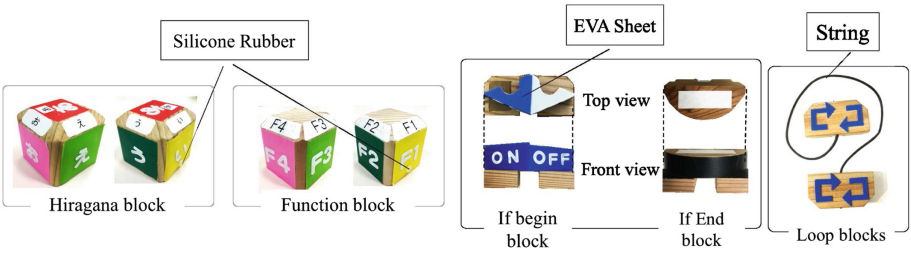


**Fig. 2.** Programming blocks of P-CUBE2. (Color figure online)

### 2.3 Controlled Object

Figure 3 shows a controlled object. The arduino Ethernet is built in the controlled object as a microcomputer. Furthermore, speech synthesis "LSI ATP3011F4-PU" which can make text data uttered was built in the arduino. The controlled

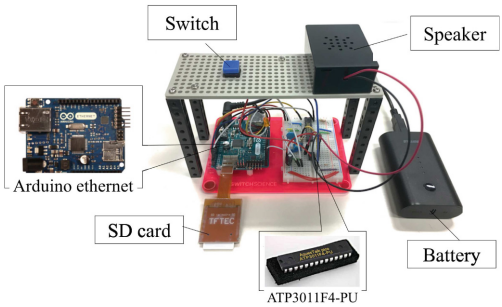


**Fig. 3.** Controlled object. (Color figure online)

object outputs sound data that words set in the program mat using LSI. The blue switch which is installed at an upper portion of the controlled object can be controlled by the conditional branch block.

### 2.4 Programming Operation

The programming procedure of P-CUBE2 is as follows.

1. Select a function block
2. Place a function block on the left end of the function mat
3. Select Hiragana blocks
4. Place hiragana blocks on the right side of the function block
5. Make a main program on the main mat using the same type of function block
6. Repeat steps 1 to 5
7. Read and transfer the position information of programming blocks to a controlled object via a PC
8. Execute a program.

### 2.5 An Example of Program

Figure 4 shows a program example of conditional branch. “OHAYO” is defined for the function F1 and the speech function “MATANE” is defined in the function F2, and the output result is changed depending on whether the switch to be controlled is pressed or not. The output of the program continues to utter “OHAYO” defined by the function F1 while not depressing the switch. Meanwhile, as long as user press it, controlled object will continue to utter “MATANE” defined in function F2. The function block can set a utterance content. For example, a control object can speak “OHAYO” a control object can “O”, “HA” and “YO” of Hiragana Blocks on the function mat. “OHAYO” means Good morning and “MATANE” means See you in Japanese. Users can create program of the controlled object only placing programming blocks on the main mat based on program structure.

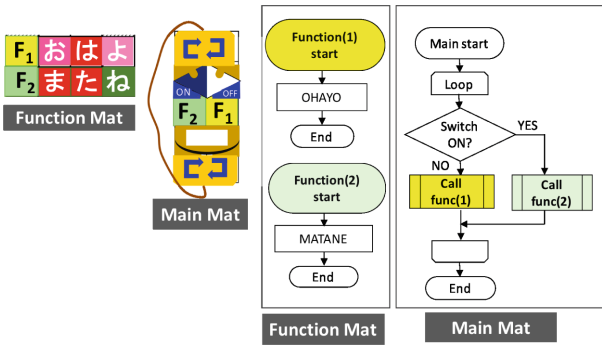


**Fig. 4.** Example of a conditional branch program.

## 3 Design of Programming Blocks Related Subroutine Concept

We created utterance function blocks and hiragana blocks as programming blocks. Figure 5 shows utterance function block and the Hiragana block.

### 3.1 Utterance Function Block

The current function block is represented by a combination of "F" representing Function and a number on the side of the block. The students of first year of secondary education (12–13 old years) learn a number used in mathematical problems called function in Japan [8]. Therefore, we created the function block incorporating object oriented (utterance function block) so as not to confuse program function with mathematical function.

The utterance function block is a block having the same usage method and meaning as the function block explained so far. The shape is a cube and each side has a groove of about 0.16 in. The block of material is white wood (specific gravity 0.45) and the mass is about 1 oz. In order to mean the concept of utterance we add urethane resin that imitated lips of human to the blocks' side. By imitating the feel of the real space object (lip), it is thought that it makes it easier to grasp the meaning (utterance) of the block. We applied Braille representing 1 to 4 to the chamfered portion and convex information by silicon so as to correspond to the four kinds of functions. The groove processing of each side block was applied so as not to impair the fit feeling of the block.

### 3.2 Hiragana Block

We adopted CUD (color universal design) in the Hiragana block and considered color usage so that information is properly transmitted to those who are different from ordinary in color appearance. The character is black, and the background color where characters overlap is white. By clarifying light and darkness and not superimposing colors, we consider that letter information will be specifically conveyed. The block of shape is hexagonal prism, the material is balsa (specific gravity 0.1), and the mass is about 1/3 oz. The information of the five letter hiragana of the vowel "a" to "o" was given to the side face of the hexagonal prism. The convex information of the arrow is given to the remaining side face to express the character flow.

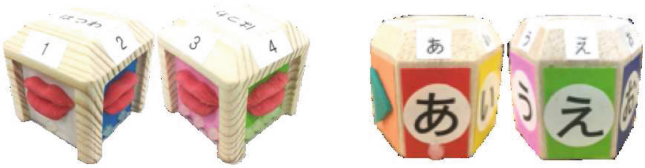


**Fig. 5.** Utterance function block and hiragana block.

## 4 Survey on Operability of Blocks

### 4.1 Programming Workshop Using P-CUBE

We conducted a programming workshop "Let's makes a program to run a mobile robot." for visually impaired children at the event "Jump to science summer camp 2017 [9]." The workshop participants were six high school students and seven junior high school students who have no experience in programing. Seven of them uses braille and the remaining six use extended character point. All participants are engaged only in creating program (placing programming blocks). We know that visually impaired children feel a sense of incompatibility with the block floating when they put the blocks in a wooden frame. In this paper, we define the sense of fitting blocks into wooden frames as "feeling of fit".

### 4.2 Experimental Overview

In order to evaluate the feeling of fit in each block of the added hiragana block and utterance function block, we carry out some program task and questionnaire survey for subjects. In addition, we conduct survey on tool operation as using P-CUBE2 and scratch. The scratch is visual programming language [10]. Subjects were 8 college students who never used programming tools for the programming beginners. We conduct a questionnaire before the experiment. After that, we explain the specification of each tool and set up time to refer to the prepared manual. Next, we conduct each of the four tasks and a questionnaire to investigate the operational feeling of the tool after completing all the tasks. We compare the operational feeling of both tools by questionnaire. Figure 6 shows examples of program creation of tasks. The output result of the program was audio data.

### 4.3 Results

Their response to free description type questionnaire answer about operability of each tool is as the following.

**P-CUBE2**

- I felt that ingenuity was applied to the shape of the mat and the block so that it was easy to fit in the wooden frame.
- The hole size of the mat and the size of the block are just right.
- It was not tight.

**Scratch**

- I was able to programming by visually assembling blocks.
- It was easy to understand program because it is color-coded for each function.
- I felt inconvenience when even if I adjusted the cursor many times, I was not able to fit icon in the frame.

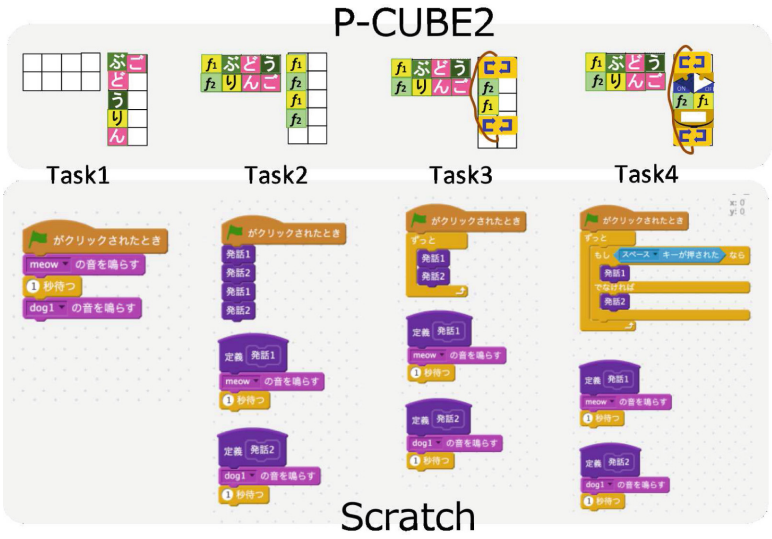


**Fig. 6.** Example of answer of tasks.

From these results, we consider the discomfort caused by floating the block could be improved. Also, like Scratch, it can be said that there is no inconvenience to fit in the target position such as not being able to fit the cursor. However, there was an opinion that "It is hard to find hiragana". In addition, we also set up questions to select learning elements that can be learned by both tools. Half of subjects selected not only sequential, conditional branch, loop, and subroutine but also variables. It was suggested that variables can also be learned.

## 5 Discussion and Conclusion

We developed P-CUBE2 which is a tangible block type programming education tool, and is intended to add subroutine as programming concept into P-CUBE. We introduce the function mat, utterance function blocks and HIRAGANA blocks to P-CUBE so that user can learn subroutine using P-CUBE2. In previous studies, P-CUBE2 is suggested a tool that can learn the concept of subroutines [7]. In this paper, we surveyed on operability of tool which P-CUBE2 and scratch. In scratch, users were perplexed by the cursor operation but they were not perplexed by block operation in P-CUBE2. Little as yet researched about the mechanism of usefulnesses to use tangible programming tool. Therefore, we are working on analysis of tool operation. In the future, we will continue verifying the learning effect of P-CUBE2.

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