A VISUAL CODE PROGRAMMING LEARNING SYSTEM FOR CHILDREN

Touya Hasegawa, Seishu Yamaguchi and Hiroshi Kamada*

Department of Media Informatics
College of Informatics and Human Communication
Kanazawa Institute of Technology
3-1 Yatsukaho, Hakusan, Ishikawa 924-0838, Japan
{ b1746187; b1644911 }@planet.kanazawa-it.ac.jp
*Corresponding author: kamada@neptune.kanazawa-it.ac.jp

ABSTRACT. *Currently, the demand for IT human resources is increasing worldwide, and from 2020, classes for training programming thinking skills will be compulsory at Japanese elementary schools. As the importance of programming learning is increasing these days, we have developed a system for learning programming in an easy-to-understand manner using an actual programming language for children who are interested in programming in elementary school programming learning. The system is mainly divided into a programming learning part that makes it easier for children to get interested by using optical illusions, and a programming function learning part that uses pictures and animations to convey programming functions in an easy-to-understand manner. As a result of conducting an evaluation experiment of the system, it was found that even children can learn in an easy-to-understand manner.*
Keywords: Programming learning, Optical illusions, Animations, Children

1. **Introduction.** Currently, the demand for IT human resources is increasing. "International society interest in exposing more students to computer science before entering university" [1] and "tutorials and code puzzles are commonly used in beginner programming" [2]. In Japanese education, "programming classes will be fully implemented in elementary schools from 2020, programming classes will be fully implemented in junior high schools from 2021, and will be implemented in high schools from 2022 as the grade progresses. Information utilization ability is positioned as a qualification and ability that is the basis of learning similar to language ability" [3]. Education is being promoted to train programming thinking ability. However, it is difficult for children to learn programming with the conventional systems [4-7] for learning programming using code, because the conventional systems are for students. For these reasons, there is a need for a system that allows children who want to learn programming to learn programming so that even children can easily work on it.

This study has made it possible for children to learn code programming with interest. The use of optical illusions has made it possible for children to continue learning with interest. Also, by explaining the function arguments using animation, even children can understand code programming. Problems with conventional systems are described in Section 2, solution in this system in Section 3, and evaluation experiment in Section 4, consideration is described in Section 5, and we conclude in Section 6.

2. **Problems with Conventional Systems.** In the system for learning programming using the code that currently exists, the functions used in the source code are explained in characters. Images may be used in some parts, but they are the image of the execution result or the source code of the program. As a result, it is difficult for children to learn programming.

There is a system called Scratch [8] that allows children to learn programming. Using Scratch, children can learn programming by combining tiles with words as shown in Figure 1. Children can easily create a program by combining parts like a puzzle. However, although this learning system is useful for training programming thinking and getting used to programming, it is not possible to learn programming using actual code. Therefore, it is necessary to consider a more understandable explanation method using actual code.
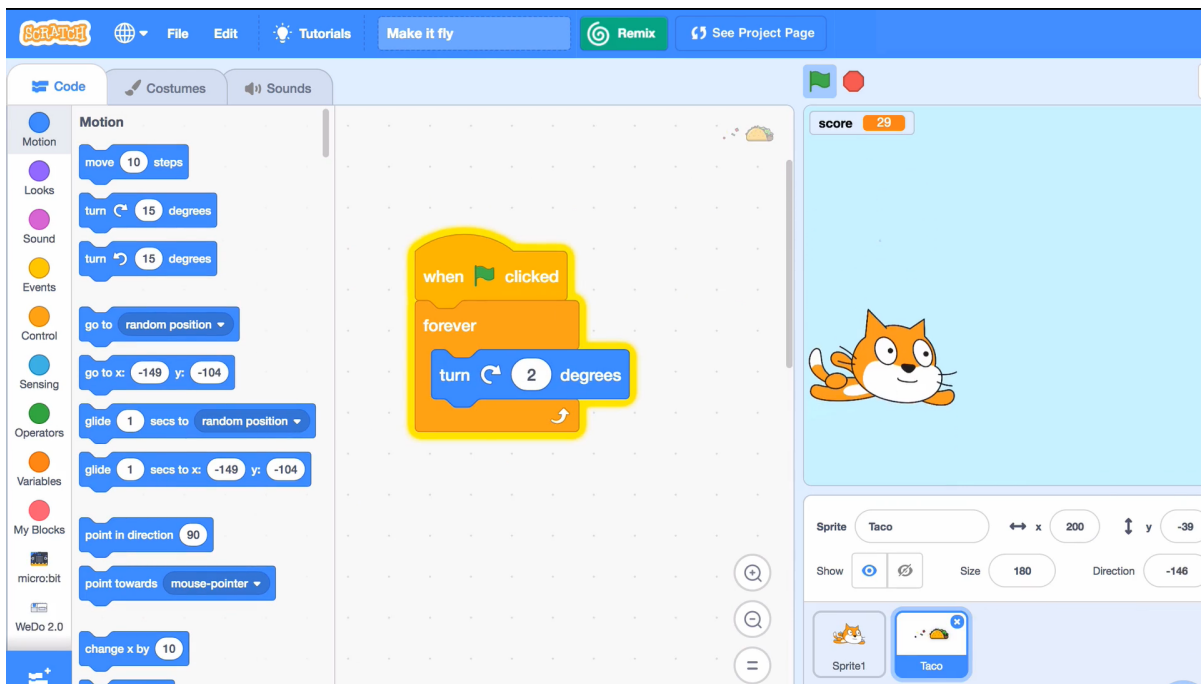

FIGURE 1. Operation screen of Scratch [8]

In the conventional programming learning system, the function that students want to learn is explained in characters as shown in Figure 2. After reading the explanation about the function, students study on a sample program that is an example using that function, and if students make a mistake or cannot understand it, students read the explanation in letters again and then try to understand the example again. The explanation of programming is given only in letters such as the book [9], in which the figures show only the execution results. It is difficult for children to understand programs only by reading conventional books.

FIGURE 2. Conventional learning system

3. **Solution in This System.** In order to carry out learning with children in mind, this system builds a learning system as shown in Figure 3. In this system, the visual explanation is given using colors, figures, and animations, and optical illusions are used for sample programs that use functional arguments. This solution makes it possible to learn while having fun visually.
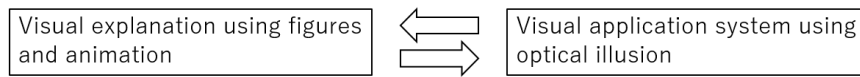
FIGURE 3. Learning system in this system

3.1. **Functions of this system.** Starting this system, children will see a button that takes children to a screen that explains how to use it, and buttons that says Illusion 1, Illusion 2, Illusion 3, and Illusion 4. Clicking the buttons of illusions 1 to 4 will move children to a screen that has a learning function for the contents of different illusions. Here children can learn programming. Figure 4 shows images of screen transition until learning starts after the system starts, including the screen for explaining how to use it and the screen for the learning function. Selecting the illusions used in this system, we referred to the system [5], and we referred to the system [10] for how to operate the screen using the mouse, keyboard, and space key.
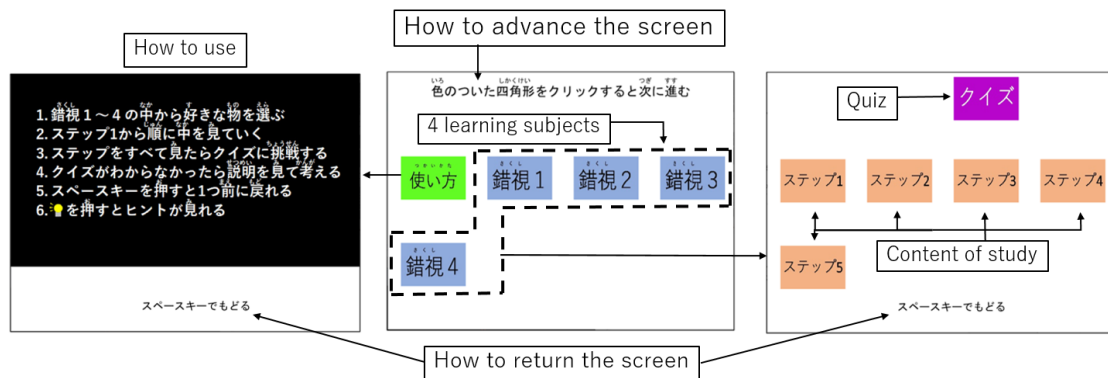

FIGURE 4. Images of screen transition until learning starts

3.2. **Learning function using optical illusion.** First, a learning function using an optical illusion will be described. It is possible to see and know what kind of illusion it is by moving a cursor to the rectangle on the right side of the screen using the illusion shown in Figure 5. It makes it easier for children to get interested. As shown in Figure 6, the content to be learned is also related to the illusion used as a concrete example so that the same illusion can be created if the learning content can be understood. This allows
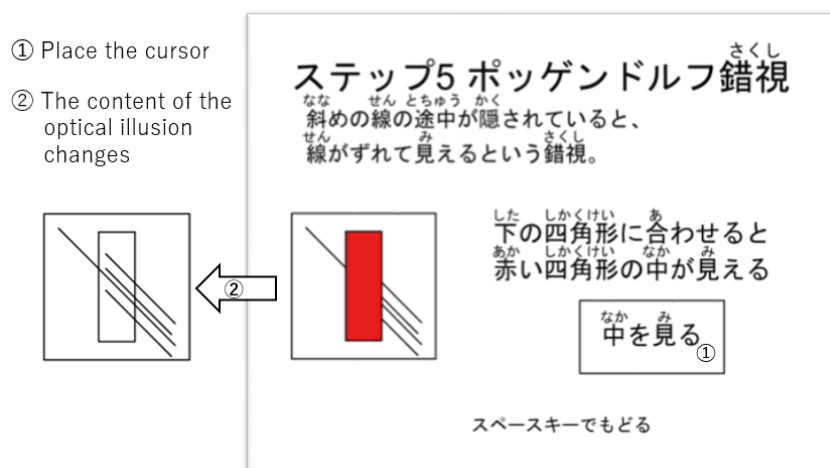

FIGURE 5. Learning system using optical illusion
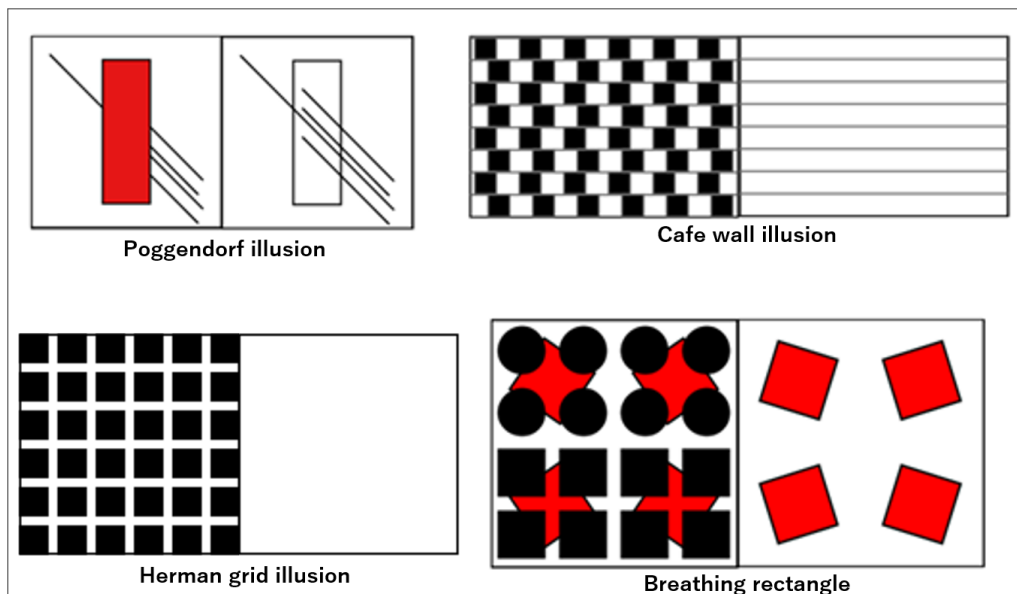
FIGURE 6. Example of learning steps

FIGURE 7. Optical illusion used in a concrete example

children to continue learning while maintaining high motivation. For specific examples of illusions, as shown in Figure 7, four types of different illusions are prepared: Poggendorf illusion, Cafe wall illusion, Herman grid illusion, and breathing rectangle. The content corresponding to each optical illusion can be learned. In each optical illusion area in Figure 7, the left side part is the illusion figure and the right side is the explanation figure about the illusion figure after moving a cursor.

3.3. **Function explanation function.** Next, the function of the function explanation will be described. This function description can be found by pressing the hint button at the bottom right of steps ② and ③ in Figure 6. As shown in Figure 8, it is a function to explain the functions that appear in the learning step when the hint button is pressed,
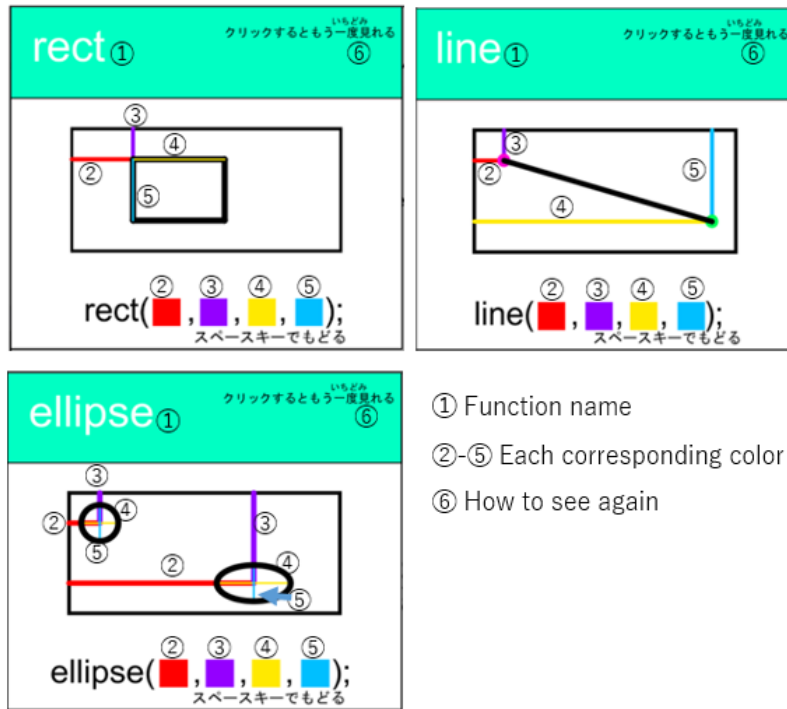
FIGURE 8. Function explanation screen used in this system

using figures and animations instead of words. The aim is to help children understand the arguments of functions in a visually easy-to-understand manner and to deepen their understanding of programming more easily by providing explanations using figures and animations. In addition, by setting the explanation of the function related to the learning content on the learning screen, the learning can be proceeded more smoothly.

3.4. **Selectable quiz function.** Next, the selection format quiz function will be described. This is a function to check whether the content learned in the learning step is actually acquired. The quiz given by this function is a selection format, and it is a question using the contents learned in the learning step. As shown in Figure 9, the content of the problem is related to the optical illusion in the learning step. In this way, by immediately tackling the problems related to the learned knowledge, strengthening the retention of knowledge is aimed. A selection format instead of a description format is used so that children can easily work on it. A specific example of the quiz function is shown in Figure 10. The quiz screen is shown on the left side, and execution results corresponding to the options are shown on the right side.
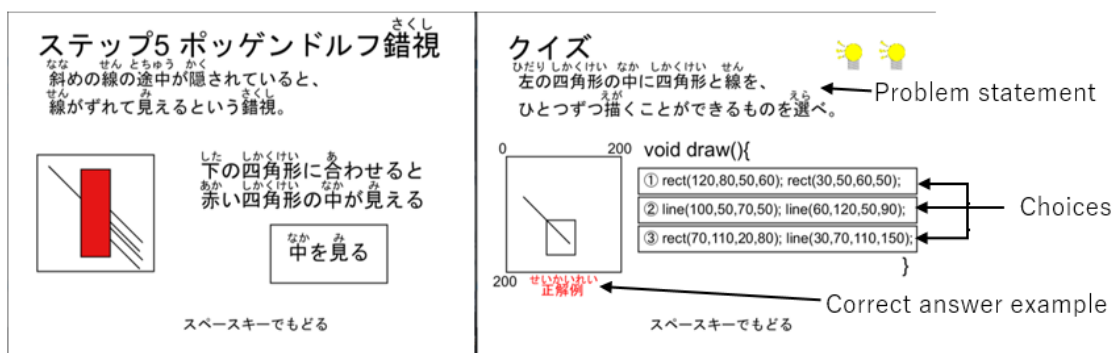

FIGURE 9. Contents of the optical illusion and quiz function in the same step
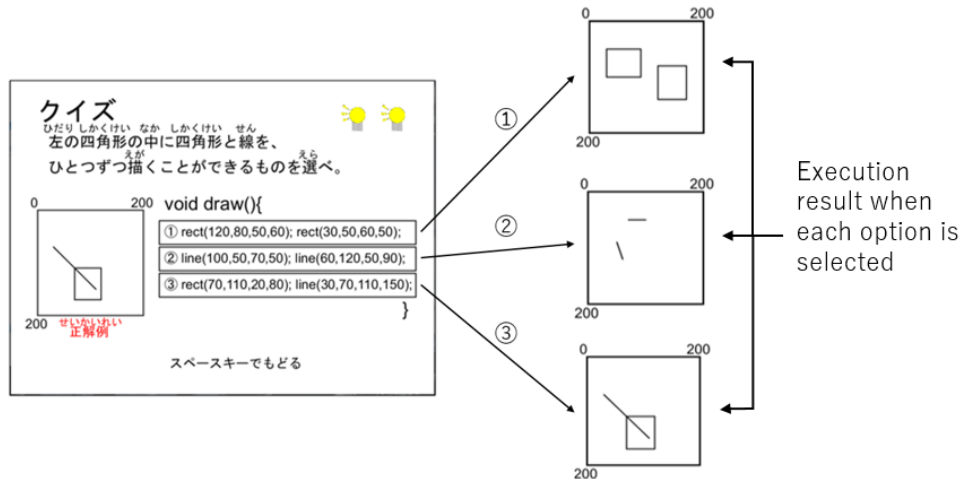
FIGURE 10. An example of quiz function

4. **Evaluation Experiment.** An evaluation experiment with university students has been conducted as first evaluation experiment to find out to what extent this system achieved the original goal of "developing a programming learning system for children". Ideally, an evaluation experiment should be conducted for elementary school students, but since it became difficult to ask elementary school students for their cooperation due to the influence of the coronavirus, 27 university students who belong to the same laboratory as us have been asked to cooperate. The people who cooperated in the questionnaire have been asked to operate this system, and it has been evaluated how they felt about this system using a score formula of 1 to 4 points. The contents evaluated were 6 items about the contents of the learning step, which are easy to see, easy to understand, the contents of the commentary, which are easy to see, easy to understand, whether children are interested, and the contents of the quiz. Regarding the questionnaire, the respondents have been asked to answer as much as possible from children perspective. The results are shown in Table 1 and Figure 11.

TABLE 1. Results of evaluation experiment of this system

Questionnaire items		Evaluation (27 persons, 1 to 4 points evaluation)
Contents of learning steps	Easy to see	2.9
	Easy to understand	2.8
Content of commentary	Easy to see	2.9
	Easy to understand	2.9
Other	Interest	2.4
	Contents of the quiz	2.7

5. **Consideration.** From the results of the questionnaire, the ease of viewing the learning steps for learning programming and the ease of understanding the explanation of program functions were evaluated sufficiently. It can be considered that the goals set in the development of this system have been almost achieved. However, there is still room for the improvement of the system.

On the other hand, the item of ease of yinterest was not evaluated sufficiently. The reason for this is that the optical illusion that was introduced to attract interest appears later in the learning step, and that the background does not change even if the screen changes. Due to these causes, the learning system became a little less interesting for children, so it
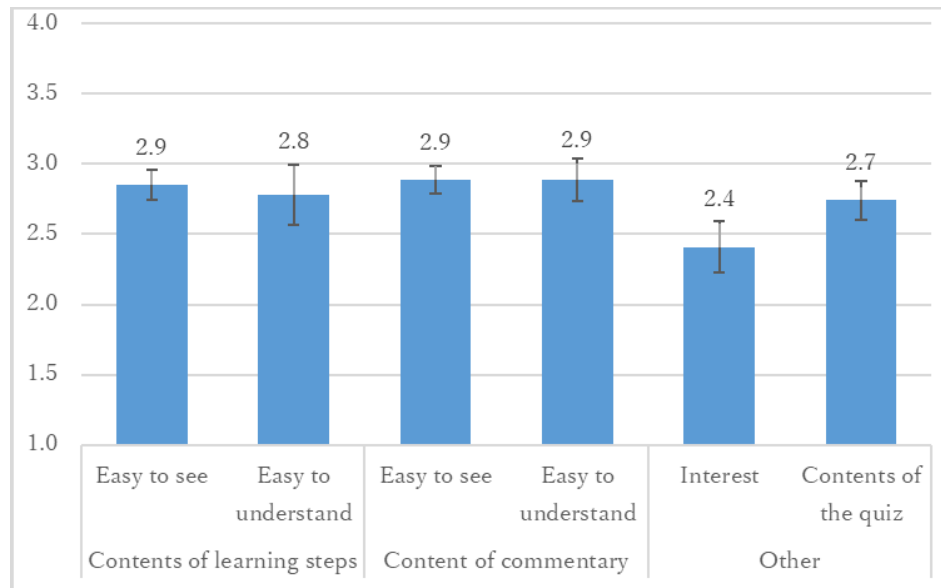
FIGURE 11. Results of evaluation experiment of this system

can no longer be said that "a system that easily attracts children's interest" was created. In order to develop a system that is more suitable for the purpose, it is necessary to improve the factors mentioned above and devise ways to make it more interesting for children.

6. **Conclusion.** We have developed the system so that children who are interested in programming can enjoy learning programming. The results were somewhat satisfactory for the readability and comprehension of the learning steps and commentary content. In addition to making it easier to get interested by using optical illusions as a theme, in the explanation of the function, while explaining with letters, visual explanation using colors, figures, and animation is also given, and the content of the confirmation test is easy for each answer. We were able to make it easier for children to understand by making the explanations easy. In the future, it will be necessary to conduct the evaluation experiment with elementary school students to make the results more accurate and objective. Furthermore, it will be suitable to make improvements of the system such as implementing more detailed advice functions.

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