

## **Development of Teaching Materials and Teaching and Evaluation Methods for Programming Education During the Period for Integrated Studies**

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### **Summary**

The Center for Teaching Profession, Asahi University received a request from the Mizuho City Board of Education as part of a project to aid digitization of education in Mizuho city that began in 2017, and has been working on the development of a curriculum for programming courses that builds over six years of elementary school and the possibility of developing content for learning at junior high schools. This report considers the outline of the teaching material “Kakirin Quest,” which is being developed as of September 2019 as an experimental lesson during the period for integrated studies, the ideal way of teaching and evaluation methods.

### **Keywords**

Mizuho City, Gifu Prefecture, public elementary school, period for integrated studies, programming course materials, teaching method, evaluation method, development

### **Introduction**

This is a report on the background and results of a project to aid digitization of education in Mizuho city (hereinafter referred to as the project) that began in 2017 at the Center for Teaching Profession, Asahi University (hereinafter referred to as the CTP). The project is part of a comprehensive partnership agreement between Asahi University and Mizuho City in Gifu Prefecture.<sup>1</sup> This project was initially established by six people: HATTORI Tetsuaki, YAMASHITA Rentaro, KAMEDA Ken, OGAWA Nobuyuki, FUJITA Akihiro, and ADACHI Atsushi. Later, five other members joined: IZUMO Takashi, HAYASHI Kiyoshi,

KAMEGAI Miyuki, MUSHIGA Fumihito, and TAKAHASHI Kohei. Hattori, Mushiga, Takahashi, Yamashita, Ogawa, Fujita, and Adachi are from the CTP. Kamegai, Izumo, and Kameda are from the School of Law, and Hayashi is from Gifu Commercial and Business High School. This paper is a report on the current status of curriculum development for programming courses at public elementary schools in Mizuho City, which has been promoted as part of this effort.

In the educational guidelines for the next course of study which were announced in March 2017, to improve lessons to achieve what is called “subjective, interactive, and significant learning,” the introduction of programming

experience is required.<sup>2</sup> Currently, regional school boards are making various preparations for full implementation in 2020.<sup>3</sup> Additionally, the Ministry of Education, Culture, Sports, Science and Technology has published an *Elementary School Programming Education Handbook*<sup>4</sup> and introduced pioneering examples of how to advance programming courses in elementary schools and how to cooperate with related organizations. Furthermore, in-service teachers and educational researchers are rapidly accumulating practical examples of classes and programming education using information devices.

The initiatives reported in this paper will also be positioned in the above-mentioned national trends when viewed macroscopically. Initially, the curriculum was developed in coordination with the Mizuho City Board of Education. After an experimental class at the Hozumi Elementary School, as of September 2019, teaching materials, in addition to teaching and evaluation methods for programming education during the period for integrated studies (hereinafter referred to as the integrated studies) are being developed through a collaboration between the university, elementary school, and the Board of Education.

Therefore, in the following, we will explain the process leading up to the development of the above-mentioned teaching materials and teaching and evaluation methods, as well as the agreements and assumptions that have been formed. Next, we will introduce the outline of the teaching materials currently under development and consider the desirable way of teaching

and evaluation methods. Finally, we will categorize the remaining issues and look at the future direction of the project.

## **I. Background of the Development and Assumptions**

### **1. Background of the Development**

As mentioned at the beginning, the process of curriculum development for elementary school programming courses from the start up to October 2018 has been reported in a separate paper.<sup>5</sup> To explain briefly, using Scratch<sup>6</sup>, a visual programming language widely used online, two plans for teaching materials were created according to different organizational principles of systematic orientation and experience orientation. The first plan is educational material called “Let's Make an Animation with Kakirin!” that aims to help children acquire the basic concepts of computer operation and programming step-by-step through the production of animation based on Mizuho City's mascot character, Kakirin.<sup>7</sup> The latter is a teaching material called “Let's Make Chimes Together!” which is aimed at giving students a sense that programming is useful for improving their school life through creating chimes together.

These were proposed to the Mizuho City Board of Education and the city's computerized education support staff, MATSUI Yutaka and in early September 2018, the Education Board selected the Hozumi Elementary School as a model school. In response to this, we visited the school on the 21st of the same month, explaining

the purpose to the principal, ITO Masao, and other computerized education personnel. It was agreed that we could continue to work on the trial and improvement of the teaching materials for the fifth graders after November.

Afterwards, members of the project from Asahi University participated in a workshop for the head of computerized education, which was held at the Honden Elementary School on October 4th, observing how information devices were used in lessons, further deepening the exchange relationship.

On January 9th of the following year, we visited Hozumi Elementary again, and we explained the purpose of the teaching materials to a group of teachers in the computer classroom and gave a hands-on lecture on Scratch. Furthermore, in the principal's office, we listened to requests from the principal, vice-principal, curriculum coordinator, the head of computerized education, and senior staff for the fifth grade (Fig. 1). We then coordinated the schedule of the parties concerned for conducting experimental classes. As a result, an agreement was reached to

**Fig. 1: Listening to requests at Hozumi Elementary School**



conduct an experimental lesson as part of the integrated studies from February 4th, using reconfigured exploration-based teaching material called “Let's Make an Animation with Kakirin!”

On the 16th and the 19th of the same month, Matsui was invited to Asahi University. We reorganized the teaching material for the experimental class. The details will be described later. Additionally, a meeting was held and it was decided that experimental classes would be held for all four classes of fifth graders for which Matsui would conduct the first class on February 4th, with each of the teachers in charge of a class conducting the subsequent classes.

On the first day of the experimental class, eight people from the project, HATTORI Tetsuaki, MUSHIGA Fumihito, YAMASHITA Rentaro, KAMEDA Ken, IZUOMO Takashi, KAMEGAI Miyuki, HAYASHI Kiyoshi, and ADACHI Atsushi participated. Five students from Asahi University who are student teachers also visited. Attendees from Mizuho City included the Hozumi Elementary School teachers, the Board of Education, and Mizuho City Council members. It was the first time that most of the students experienced programming, but under the guidance of Matsui they were able to happily converse with each other and tackle learning tasks through trial and error.

At the end of the experimental class, there was an opportunity to exchange opinions on plans and policies, the methodology for effectively promoting programming education, instructional conditions, and issues necessary for the group of teachers from Hozumi Elementary to work on

**Fig. 2: Exchanging Opinions After the Experimental Class**



and the development of teaching materials for use in the following year (**Fig. 2**).

On February 12th and 13th, the teachers for the remaining classes held the first lesson, and the second round was held on the 20th and 26th of the same month. The third round was held on the 28th and 1st of March. Project members and the Asahi University students also participated in these classes as assistants and after the class was over and the students had left the computer classroom, everyone gathered and there were discussions about how to improve teaching materials and teaching methods.

Based on the above series of experimental classes, the project system and policy for the next year were confirmed on March 14th. The following day, specific work tasks were organized and confirmed. April 17th marked the start of a new school year. TAKAHASHI Kohei joined as a new member of the project, and the results and issues of the previous projects were reconfirmed, overall.

After that, we worked on the development of teaching materials while reporting our progress

to the Board of Education. On June 20th, the School Education Division of the Board of Education conducted a survey for requests regarding the content of the summer training program. As more than 100 teachers in the city cited programming courses, it was decided that a hands-on workshop would be held using the teaching materials that had been developed, and thus we were contacted.

Therefore, on July 18th, we had a meeting with Matsui at Asahi University and held a detailed discussion about the schedule and content. Matsui served as a lecturer and assistants were also dispatched from the project to the meeting venue four times. Matsui held lectures and hands-on workshops on programming courses on July 22nd at the Hozumi Elementary School, July 24th at the Minami Elementary School, on August 1st at the Ushimaki Elementary School, and on August 5th at the Honden Elementary School (**Fig. 3**).

As of September 2019, when this paper was written, teaching materials and methods were improved to overcome the issues and problems

**Fig. 3: Hands-on workshop at Honden Elementary School**



that have been revealed and raised through the experimental classes, exchange of opinions, and hands-on lectures for teachers. The next experimental class is scheduled to start in December at the earliest and in January 2020 at the latest.

## **2. Assumptions for Development**

So far, curriculum development for programming courses has gone ahead based on agreements and assumptions between the project and Mizuho City.<sup>8</sup> The six points are: (1) Focus on the upper grades for the time being while looking ahead to systematic education through the six years of elementary school and the development of learning content in junior high school. (2) To envisage an amount of teaching material that will fit in 3-4 hours per semester and 9-12 hours per year. (3) To be aware of the current level of knowledge and skills of children in Mizuho City regarding the operation of information devices. (4) Organize the content of qualities and abilities that all students should acquire through programming courses. (5) Construct teaching materials, including how to evaluate students' learning outcomes, including their specific methodologies. (6) Use a visual programming language.

These were created based on the two teaching material plans, which were in line with the different organizational principles mentioned earlier. Later, after discussions with the faculty of the Hozumi Elementary School and experimental classes, the following changes and additions were made to the agreements and assumptions in the development of teaching material.

First, in response to (1), it was decided that the results of the 2018 school year will be received, and in the experimental classes scheduled for the 2019 school year, the scope will be expanded from third to fifth graders and will be implemented using the teaching materials currently under development. There is an intention to determine whether children's learning activities can be effectively developed even at lower grades.

Secondly, as for (2), we decided to organize teaching materials by learning activities, not by time. In the future, in the Mizuho City elementary schools, it is highly likely that comprehensive learning will be spent on programming courses. How many hours are actually spent on this depends on the circumstances of each school. Therefore, the teaching material itself needs to be flexible enough to be deployed within a limited time.

As described above, in response to the request from the group of teachers at the Hozumi Elementary, we decided to reorganize the teaching materials for the creation of Kakirin animations into exploration-based materials. Along with this, by making it possible to learn the basic operation of Scratch using a step-by-step method in the process of learning activities, this would meet (3), and even more so, (4) and (5), by making it possible to evaluate learning results on the extension of learning activities.

## II. Teaching Materials, Teaching and Evaluation Methods Under Development

### 1. Overview of “Kakirin Quest”

In this section, after briefly explaining the teaching material “Kakirin Quest” that is currently under development, we would like to consider the ideal teaching and evaluation methods for programming courses in the integrated studies.

The goal of the learning activities in “Kakirin Quest” is very simple. Simply put, an instruction (code block) is given to Kakirin on the screen to go to school. The entire teaching material is composed of three quests. Each quest is composed of two learning activities. Students will understand the basic operation of Scratch by working on learning activities that combine various pre-defined blocks, such as “walk to the right” and “wave your right hand.” The expectation is that they will be able to freely create stories in which Kakirin attends school. An

explanation of the purpose of each learning activity follows.

Fig. 4 and 5 are from the stage area and code area of learning activities Q1-1 and Q1-2, which make up the first quest. The aim here is to make students understand the goal of learning activities and the basic operation of Scratch and to raise interest in learning activities themselves.

In Q1-1, first the students are told that the goal is for Kakirin to go to school. Next, the “walk to the right” block already placed in the code area is moved and combined with “when the flag is pressed,” and closed by “stop this script.” Finally, the students press the flag button to see how it works.

Then, Kakirin walks to the right, but walks past the school and goes off the screen. Many of the children who thought Kakirin would stop at school cry out in disappointment. Here, after the students think about what kind of order can be given to stop Kakirin at the school, we move to Q1-2.

In Q1-2, the children make sure that three new

Fig. 4: Kakirin Quest (Q1-1)

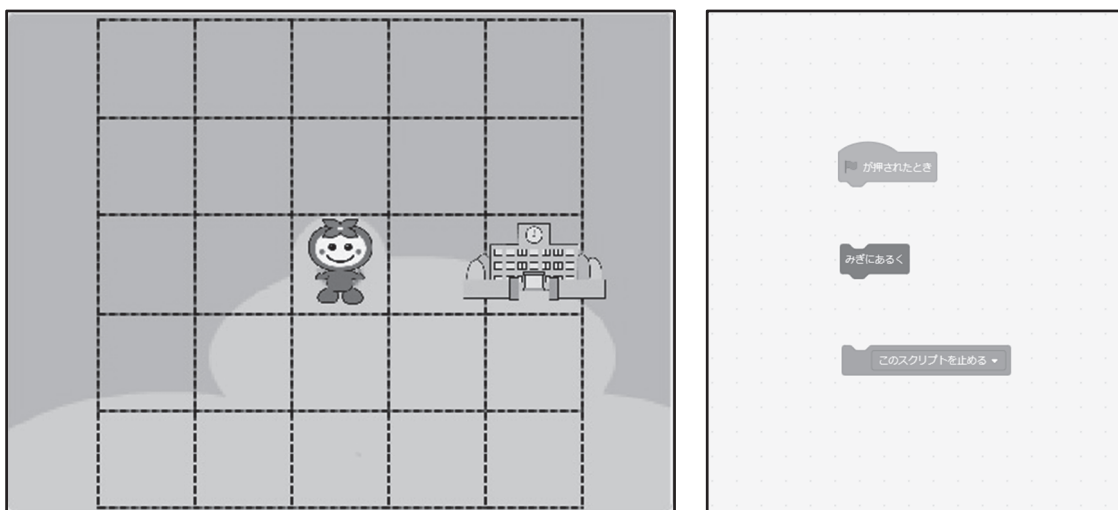
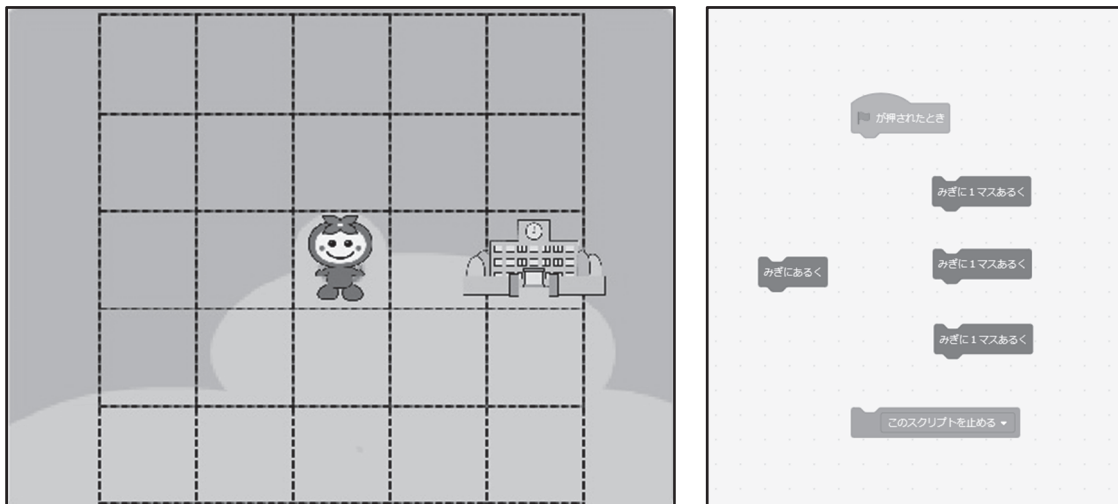


Fig. 5: Kakirin Quest (Q1-2)



blocks that say “move 1 block to the right” are added to the code area. The students then think about how to combine these so that Kakirin can get to school.

In this case, of course, it is only necessary to combine “when the flag is pressed” with two “move 1 block to the right” and close it with “stop this script.” When the child presses the flag button and confirms the action, Kakirin

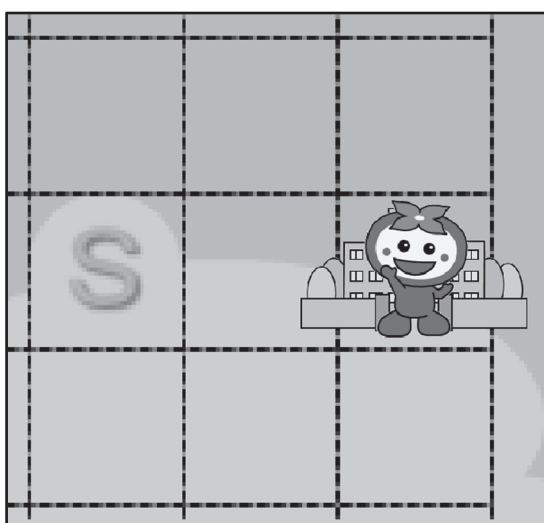
waves his hand after going to school and there is a sound effect to indicate that the goal was achieved (Fig. 6).

Through this series of learning activities, students will be able to understand the goals of learning activities, the basic operations of Scratch, and it may spark further interest in learning activities.

The second quest aims to make the students think logically and learn through trial and error. First, in the code area of Q2-1, there are blocks that allow Kakirin to walk left, right, up, and down one square (Fig. 7). By using the basic operations that have been learned so far, students are able to easily achieve the goals of their learning activities.

Next, in the code area of Q2-2, there are addition blocks that move Kakirin one block to the left, right, up, and down, in addition to blocks that say “repeat X times,” or “wait for X seconds (Fig. 8).” In addition to Kakirin and school, new sprites, such as a dog and some trees are also placed in the stage area. When the

Fig. 6: Kakirin after the goal is achieved



\*The square marked "S" shows Kakirin's starting point.

Fig. 7: Kakirin Quest (Q2-1)

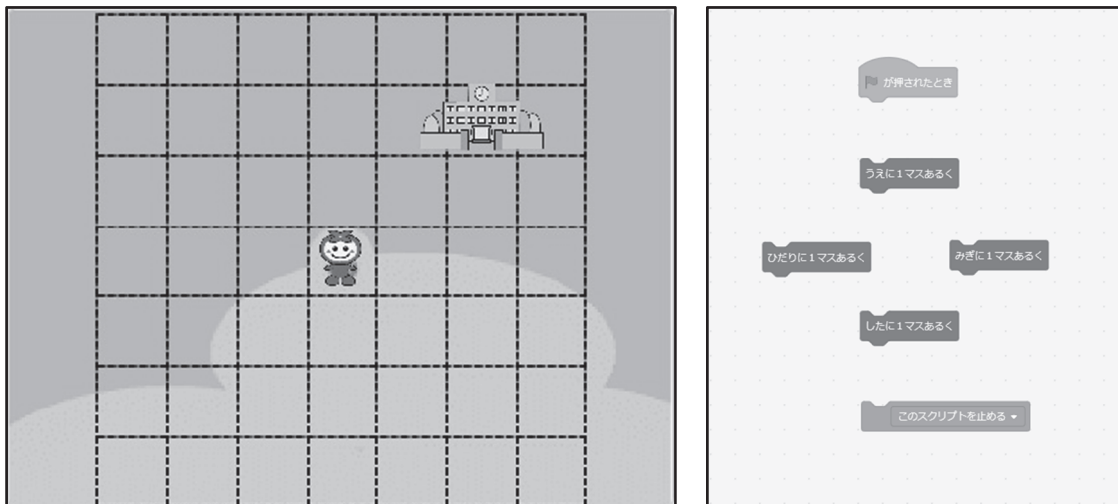
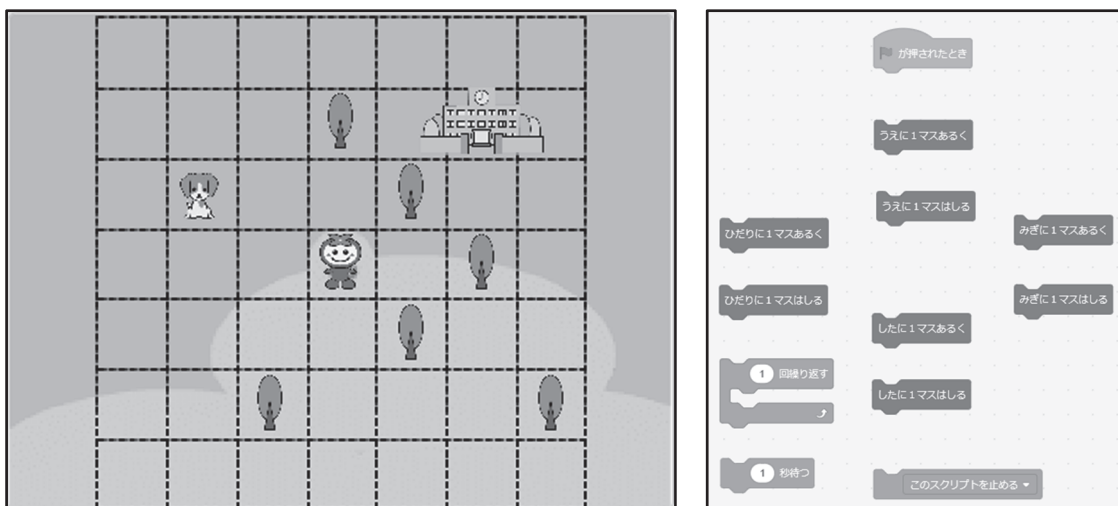


Fig. 8: Kakirin Quest (Q2-2)



flag is pressed, the dog runs back and forth on the screen. Kakirin is surprised when it touches the dog or bumps into a tree and will burst into tears or stop moving. Therefore, for Kakirin to reach the school, the provided blocks must be duplicated or combined, while avoiding the obstacles. It is expected that this will nurture the children's logical thinking skills.

The following is an explanation of the final quest. In Q3-1 and Q3-2, there is an increased degree of the children's freedom in the learning

activities. The only block pre-placed in the code area is “when the flag is pressed (Fig. 9 and 10).” Therefore, children need to select a block from the block pallet area that has the function that suits their intention. There are more diverse items, such as “bow,” “think,” and “be inspired.”

In the previous quests, various scripts were pre-installed in the code area, and when the flag was pressed, all sprites including Kakirin were automatically returned to their initial positions and then the script created by each child would



run. On the other hand, all the sprites except for Kakirin in Q3-1 and all of them in Q3-2 are excluded from the above settings. Furthermore, in Q3-2, the outlines of the squares in the background are no longer visible.

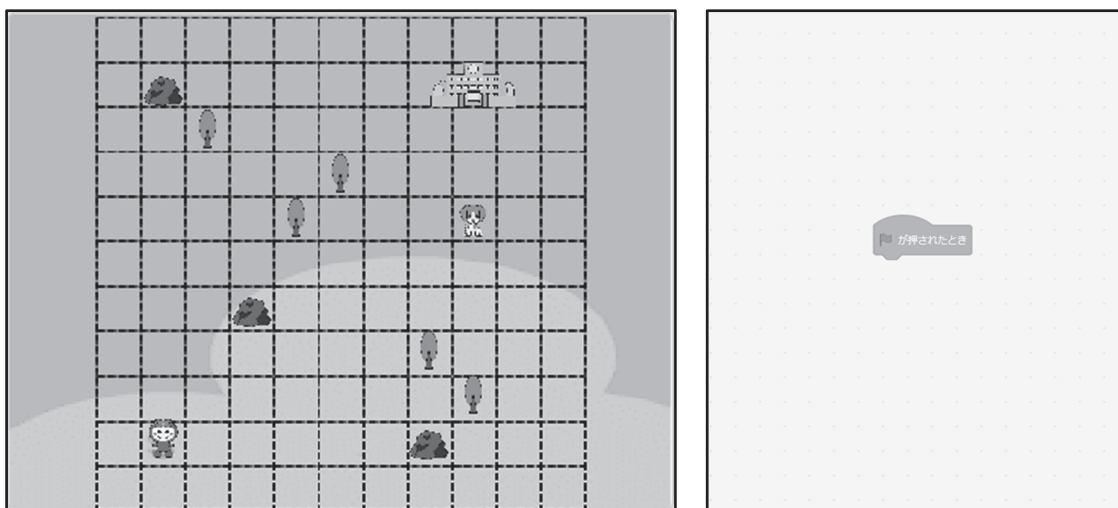
In short, in the third quest, students can create their own story about going to school by freely changing the initial position of the sprite and building a script that suits their ideas.

The above was an explanation summarizing the “Kakirin Quest,” which is under develop-

ment.<sup>9</sup> To summarize the section, “Kakirin Quest” gives students the clear goal of Kakirin going to school, and then the students master basic Scratch operations through learning activities. At the same time, it focuses on a programming experience that demonstrates logical thinking and creativity in the process of creating a story.

Now, what is the preferred teaching method for programming courses in comprehensive learning using these teaching materials? In the

**Fig. 9: Kakirin Quest (Q3-1)**



**Fig. 10: Kakirin Quest (Q3-2)**



next section, we would like to consider this issue, based on the knowledge that has been clarified from previous experimental classes.

## 2. The Preferred Teaching Method

When we first began developing this curriculum in response to a request from the Mizuho City Board of Education, it was unclear even how the proposed teaching materials would be positioned in the curriculum. However, as we proceeded with the project, which was also a learning process for us, we came to realize that programming courses were likely to be introduced as part of the integrated studies at elementary schools in Mizuho City.

As already mentioned, “Kakirin Quest,” which was introduced in the previous section, was originally designed as system-oriented teaching material. However, in response to a request from the group of teachers at the Hozumi Elementary School, it was restructured as exploration-based teaching material. However, whether “exploratory learning,”<sup>10</sup> which is positioned at the core of the integrated studies will be developed by using these teaching materials will depend on the teaching methods adopted by individual teachers in the future.

In accordance with the principle of “exploration-based learning,”<sup>11</sup> teachers are required to guide comprehensive learning without adhering to pre-developed learning plans and evaluation frameworks, promoting an attitude that allows students to flexibly engage in learning activities and be interested in the activities. Further, in line with individual and specific

learning activities, it is thought that this provides each child with the ability to interpret the activities in various ways to value and verbalize what was learned and form a common understanding.

Even in the previously mentioned experimental class at the Hozumi Elementary School, for students whose teacher had a habit of reprimanding those who tried to deviate from the detailed instructions given prior to learning activities, it was our impression that these learning activities were generally monotonous and slow. In contrast, teachers who honestly expressed that this was also their first experience with programming, only briefly explained the basic operations. They then encouraged the children to approach the learning activities freely. Those who shared unexpected results among all the students were clearly successful in bringing out an ambitious attitude in the children.

In the latter class, students were frequently seen actively combining new blocks and trying out the unknown features of Scratch. We also found that when children did not understand or

**Fig. 11: The Children Learn Through Trial and Error**



learned something, they shared information with each other and would look at each other's screens or become focused on practicing through trial and error (Fig. 11).

This seems to suggest that programming courses are a desirable learning activity in the integrated studies. However, one of the important concerns that the project must continue to pursue is how can teachers with the attitudes and abilities described above be successful in achieving “exploration-based learning” for children?

### 3. Tentative Plan for the Evaluation of Learning Outcomes

If the teaching materials currently being developed are to be used in the integrated studies, then naturally the process and results of the children's learning activities will be evaluated based on the teacher's findings.<sup>12</sup> On the other hand, what is expected of programming courses in the next elementary school course guidelines

is the development of children's logical thinking ability. If so, there is a concern about how and to what extent a student's logical thinking ability can be evaluated.

As mentioned above, the project assumes that the teaching materials, including the specific methodology should be structured in consideration of how the children's learning outcomes will be evaluated in the ongoing collaboration with Mizuho City. Fig. 12 and Fig. 13 show a tentative evaluation method that is currently under investigation to satisfy this condition.

Kakirin starts in the square labeled “S” in Fig. 12. A script is already set in the code area and when the flag is pressed, Kakirin bumps into a rock on the way to school and falls. Here, the students are asked to reassemble the script so that Kakirin can safely get to school.

By giving the students this type of challenge, it may be possible to evaluate the learning results as an extension of the learning activities they have been working on. In doing so, it may be necessary to give each student a different task to

Fig. 12: Tentative Plan for the Evaluation of Learning Outcomes (1)

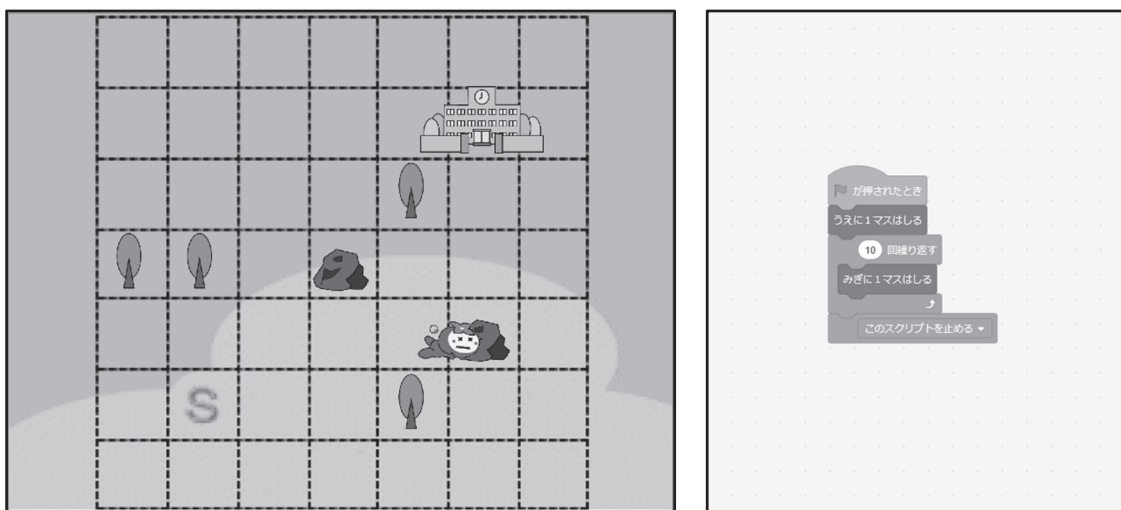
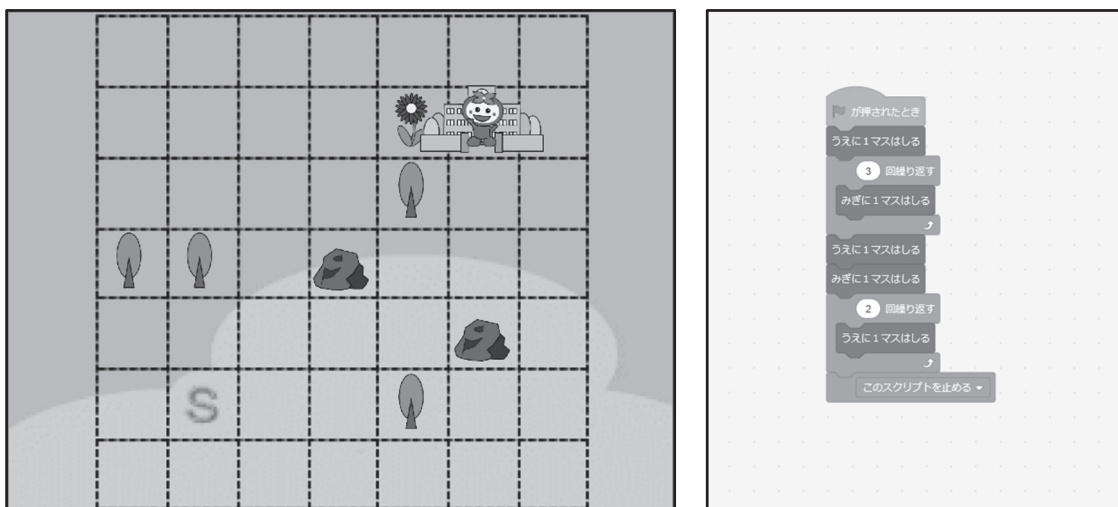


Fig. 13: Tentative Plan for the Evaluation of Learning Outcomes (2)



be able to verify the increase in individual logical thinking skills in a computer classroom with other students nearby. For example, when Kakirin arrives at school, different colors of flowers are placed in different positions for each task and the child must answer questions about the position and color (Fig. 13), or by changing the position of the obstacles between Kakirin and the school, the student must think about the correct path each time.

However, the concept described above is only a tentative plan and there may be various issues that must be solved for the plan to be implemented at each elementary school. In the future, it will be necessary to proceed with close discussions and cooperation with the Hozumi Elementary School and Mizuho City Board of Education.

**Conclusion**

In conclusion, we would like to review the discussion to this point, categorize the remaining

issues, and to look ahead to the future direction of the project.

the CTP has been working on curriculum development for elementary school programming courses since 2017 was trialed in experimental class for 5th grade students at the Hozumi Elementary School in 2018. Currently, this has expanded to the development of teaching materials and teaching and evaluation methods in the integrated studies. The teaching material “Kakirin Quest” is aimed at demonstrating logical thinking and developing one's imagination by creating a story about Kakirin going to school. In the future, the target grades will be expanded from third to fifth graders for the 2019 school year, and experimental classes will be held again at the Hozumi Elementary School for further improvement.

The principle of “exploration-based learning,” which is positioned at the core of the integrated studies is used in programming courses, and while clarifying the level of teaching ability that can be achieved, it will be necessary to verify the

plan to turn this into a specific teaching method. We must also carefully examine how and to what extent the students' logical thinking ability expected in programming courses can be evaluated in cooperation with the Hozumi Elementary School and Mizuho City Board of Education. In the future, we plan to support elementary school programming courses in Mizuho City through initiatives that address these issues.

#### End Note

- 1) For more details, see Tetsuaki Hattori, Rentaro Yamashita, Ken Kameda, Nobuyuki Ogawa, Akihiro Fujita, Takashi Izumo, Kiyoshi Hayashi, Miyuki Kamegai, Fumihito Mushiga, Atsushi Adachi, *Efforts to Develop a Curriculum for Programming Education in Public Elementary School as Part of a Project to Aid the Digitization of Education in Mizuho City, Gifu Prefecture*, *Bulletin of the Center for Teaching Profession, Asahi University*, No.21, the Center for Teaching Profession, Asahi University, March 2019.
- 2) See *Educational Guidelines of Elementary School*, Ministry of Education, Culture, Sports, Science and Technology, March 2017.
- 3) However, according to a statement released by the Ministry of Education, Culture, Sports, Science and Technology in June 2018, as of February of the same year, of the 722 municipalities that participated in the questionnaire survey, 501 (69%) answered that they were not making any efforts toward the introduction of programming courses. (Ministry of Education, Culture, Sports, Science and Technology, *Situation on Elementary School Programming Courses by the Board of Education, etc.* (National Institute for Policy Studies, March 2018, p.6, [http://www.mext.go.jp/a\\_menu/shotou/zyouhou/detail/icsFiles/afieldfile/2018/06/22/1370024\\_1.pdf](http://www.mext.go.jp/a_menu/shotou/zyouhou/detail/icsFiles/afieldfile/2018/06/22/1370024_1.pdf)), last viewed on September 26th, 2018). It is not difficult to imagine that the progress for programming courses for the full implementation in the next educational guidelines in 2020 will still vary by local school boards.
- 4) The first edition was announced in March 2018 and the second edition in November of the same year.
- 5) See the previously referenced *Efforts to Develop a Curriculum for Programming Education in Public Elementary School as Part of a Project to Aid the Digitization of Education in Mizuho City, Gifu Prefecture*.
- 6) For an overview on Scratch, refer to the following website (<https://scratch.mit.edu/about>). Scratch officially migrated from version 2.0 to 3.0 in January 2019. The descriptions in this paper use version 3.0.
- 7) To learn more about Kakirin, please refer to the following website (<http://www.city.mizuho.lg.jp/kakirin/>).
- 8) For details, refer to the previously referenced *Efforts to Develop a Curriculum for Programming Education in Public Elementary School as Part of a Project to Aid the Digitization of Education in Mizuho City, Gifu Prefecture*.
- 9) As of September 2019, refer to the following website for an overview on “Kakirin Quest” ([http://aalaboratory.michikusa.jp/project/mizuho/mizuho\\_index.html](http://aalaboratory.michikusa.jp/project/mizuho/mizuho_index.html)).

- 10) In the educational guidelines of elementary school curriculum, the goal of the integrated studies is “to cultivate qualities and abilities to solve problems better and think about one's life through lateral and comprehensive learning through the use of exploration-based views and ideas.” (See the previously referenced *Educational Guidelines of Elementary School*, p.179).
- 11) Regarding this point, refer to ADACHI Atsushi, Issues in Teacher Training Education in Forming Comprehensive Teaching Capabilities for the Period for Integrated Studies, *Bulletin of the Center for Teaching Profession, Asahi University*, No.22, Asahi University Teacher Training Center, March 2020.
- 12) Regarding this point, refer to *Educational Guidelines of Elementary School, Integrated Studies Edition*, Ministry of Education, Culture, Sports, Science and Technology, July 2017.