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

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Abstract

As of October 2018, the Center for Teaching Profession, Asahi University is in the process of developing a programming curriculum outlined in the educational guidelines for the next course of study in elementary schools. It was done at the request of the Mizuho Board of Education as part of a project to aid digitization of education in Mizuho city that started in 2017. This report introduces teaching materials in line with two different organizational principles (system-oriented and experience-oriented) that were conceived in this endeavor. It also examines some tools for a desirable elementary school programming education.

Keywords:

Mizuho city, Gifu prefecture, public elementary school, programming education, curriculum development

Introduction

The Center for Teaching Profession, Asahi University (CTP) started a project to aid the digitization of information as one of its projects included in a December 2013 comprehensive partnership agreement with Mizuho city in Gifu Prefecture. Initially, the project was launched with six people, Tetsuaki Hattori, Rentaro Yamashita, Ken Kameda, Nobuyuki Ogawa, Akihiro Fujita and Atsushi Adachi; four more people, Takashi Izumo, Kiyoshi Hayashi, Miyuki Kamegai, and Fumihito Mushiga, joined later. Hattori, Mushiga, Yamashita, Ogawa, Fujita and Adachi belong to the CTP; Kamegai, Izumo, and Kameda are on the university's Department of Law faculty; and Hayashi is part of the Gifu Commercial and Business High School. This paper reports the current state of development of a curriculum for programming education in public elementary schools in Mizuho city, promoted as part of this project as of October 2018.

As is well known, the educational guidelines for the next course of study in elementary schools, announced in March 2017, targets "classroom reform" to realize "subjective, interactive, and significant learning." When subjects are taught, students are required to make use of information tools such as computers, information communication networks, and experience programming.[1] In response to this, the board of education in each region is currently

promoting the preparations for full implementation in 2020.[2]

On the other hand, the Ministry of Education, Culture, Sports, Science, and Technology released its "Elementary School Programming Education Handbook (First Edition)" in March 2018, which presents striking examples on how to advance programming education at elementary school and how to collaborate with related organizations.[3] In addition, in-service teachers and educational researchers are rapidly accumulating lessons using information devices and practical examples of programming education.

Viewed from a macroscopic perspective, the efforts reported in this paper will also be ranked among the aforementioned nationwide trends. In the future, it will be necessary to develop curriculum and teaching materials while effectively utilizing the educational resources available in each municipality and at each school in order to promote programming education in public elementary schools appropriately.

This paper presents the background of curriculum development in programming education in elementary schools in cooperation with the Mizuho Board of Education promoted by the CTP, and the assumptions and agreement formed during the process. Next, we discuss the relationship between two different curriculum organization principles, system-oriented and experience-oriented, that form the basis of the two teaching methods being developed. While the remaining issues are still to be sorted out, future projects are also eagerly anticipated.

I. History and Prerequisites of Development

1. History of Development

As part of the project to aid digitization of education in Mizuho city, efforts were initiated to conduct a questionnaire survey aimed at clarifying the status of how information devices are used during public elementary and junior high school lessons, and the difficulties faced by teachers. The survey was conducted with assistance from the Mizuho Board of Education as a primary work to provide specific supportive measures in 2017.[4] When the work was being promoted in early September, Hiroaki Kano, Director of Education, had collaborative discussions on the development of curricula for programming education in elementary schools, and steps were taken in the CTP to consider the feasibility of these efforts. Takashi Izumo also joined.

Then, Atsushi Adachi attended a seminar on information education in elementary and junior high schools held at Mizuho Hozumikita Junior High School on January 12, 2018. Adachi exchanged views on programming education with Yutaka Matsui, a teacher at Sunami Junior High School who works as an information education assistant teacher, and agreed to cooperate for curriculum development. Also, Matsui was invited to Asahi University on February 6 to formulate a common understanding regarding the prerequisites of curriculum development. Kiyoshi Hayashi and Miyuki Kamegai also participated as technical collaborators at that meeting.

Based on the meeting with Matsui, various

ideas were taken to the CTP and a review was conducted on March 20 and 30. As a result, there was a consensus on aiming for the development of two curricula according to two different organization principles (sys-tem-oriented and experience-oriented), which will be described later.

In the following fiscal year, Fumihito Mushiga, who had just joined the CTP, also became a member of the project. The second review meeting was held on April 9. On the 11th, the school superintendent officially issued a letter requesting the development of curricula for programming education covering all grades of elementary school.[5] On the 16th, Matsui was welcomed again to discuss the concept of the curriculum. After that, it was decided to proceed with the development of the proposal made during the Mizuho conference related to the promotion and regulation of information education in the entire city. A project review was conducted on May 9 and May 15. Finally, a consultative body was established on June 12 between Matsui and the Mizuho Board of Education Secretariat, Hori Takatsugu and Mika Ando. In addition, a prototype of the teaching material was developed with a focus on Hayashi and Adachi, in tandem with interactions in Mizuho city.

The results of the work described above were reported during the Information Education Promotion Conference held at Mizuho City General Center on July 11 (see **Fig. 1**). Hattori, Yamashita, Kameda, Izumo, and Adachi at-tended on behalf of Asahi University. A broad framework of the curriculum plan and materials under development were mostly approved, and the municipal board of education decided to select

Fig. 1: A Glimpse of the Information Education Promotion Conference

Fig. 2: Meeting-in-progress at Hozumi Elementary School

model schools for the trial.

The municipal board of education reported in early September that Mizuho Hozumi Elementary School had been selected as the model school. Hattori, Kameda, and Adachi visited the school on September 21 to explain the purpose to those involved in information education, including Masao Ito, the school principal (see **Fig. 2**). While writing this report in October 2018, a schedule was charted out to work together with a group of teachers from the school, with the testing and improvement of teaching materials under development to begin toward the end of November.

2. Prerequisites of Development

The CTP has worked on curriculum development based on several agreements and prerequisites in deepening ties with stakeholders from Mizuho city. Among them, it is necessary to explain some important matters before taking a specific look at the contents of teaching materials under development in the next chapter.

First, a basic policy was adopted to focus on the upper grades for the time being, while looking at the systematic nature of programming education during the six years of elementary school and considering the possibilities of learning in junior high schools, in order to fully implement the educational guidelines for the next phase. There is speculation that some want to concentrate the department's extremely limited resources on the development and trial of teaching materials on high school students at this time, while all the members involved are still trying to find their way.

The second step is to develop teaching materials that can fit within three to four hours a term, nine to twelve hours a year. The educational guidelines for the next term in school do not include any specific time for programming education. Therefore, programming education has to be positioned with related subjects and areas in accordance with the circumstances of each school. By doing so, it is aimed at organizing and harmoniously incorporating learning activities without putting pressure on the existing curriculum as much as possible by scheduling it within the number of hours as mentioned above.

The third step is to focus on the current level of knowledge and skills of children in Mizuho city regarding the operation of various kinds of information devices, including computers. While some of them may be familiar with the operation of information devices on a daily basis in their family life, others may not even know the basic terms or how to operate the devices. Most of the children who are not familiar with the basic operations even find it difficult to type letters on a keyboard. In view of these circumstances, it is necessary to prepare teaching materials that can tackle learning activities with only two skills, namely, basic mouse operation and numeric keypad input.

The fourth step is to organize the qualities and abilities that are to be taught to all children through programming education. The educational guidelines for the next step is to equip children with the "logical thinking skills necessary to make the computer do what you want."[6] Further, the *Elementary School Programming Education Handbook (First Edition)* also sets forth the "qualities and abilities nurtured through programming education in elementary school."[7] In addition to these, it is also necessary to clarify the minimum knowledge and skills required to experience programming in the first place.

The fifth step is to evaluate the learning outcomes of children through programming education, and develop curricula and teaching materials by incorporating specific methods. In other words, a framework needs to be proposed that can record the process and results of the learning activity of each child, and objectively analyze how well the above-mentioned abilities and

qualities have been acquired.

The sixth step is to use visual programming language. At present, a number of educational visual programming languages are being developed, some of which are popular all over the world. The Mizuho city team suggested making use of Scratch, a classic example of this language, to develop the curriculum. Scratch is provided free of charge by the Massachusetts Institute of Technology, and it is possible to have a well-rounded experience of programming by simply using mouse and keyboard operations.

The CTP has been working on the development of curricula and teaching materials for programming education that satisfies the six agreements and prerequisites mentioned above. The next chapter shall describe these contents in detail.

II. Two Curriculum Organization Principles and Teaching Materials

1. Teaching Materials that Conform to the System-Oriented Organization Principle

As mentioned earlier, CTP members brought their own curriculum plans to the discussion table, and categorized and consolidated the ideas into system-oriented and experience-oriented organizational principles. Let us take a look at each in turn.

The main purpose of this paper is not to explain the specifications and operations of Scratch. There are many excellent websites and books that discuss Scratch, so please refer to them for more details.[8]

The first project, "Let's Animate Kakirin!" is based on the system-oriented organization principle. It aims at helping children learn the fundamental concepts of operating a computer through animations based on Kakirin,[9] the mascot character of Mizuho city (see **Table 1**).

At present, this teaching material is supposed to be completed in a total of eleven hours (three hours in the first term, four hours in the second term, and four hours in third term). As shown in **Fig. 3**, it is possible to move Kakirin around the screen continuously by creating in advance a large number of blocks under "Others" in the script, which defines actions such as thinking, waving the right hand, flashing, bowing, etc., and combining these actions.

In this curriculum plan, the emphasis is placed on learning activities to create more suitable scripts by dividing children into groups to make Kakirin animations that are in harmony with the stories conceived by their group as well as the settings and conditions given by the teacher. The children will learn through trial and error, and will also learn about ingenuity and success from one another. In addition, by presenting animations produced by each group, it is also important to deepen the understanding of methodologies for efficiently and effectively creating scripts.

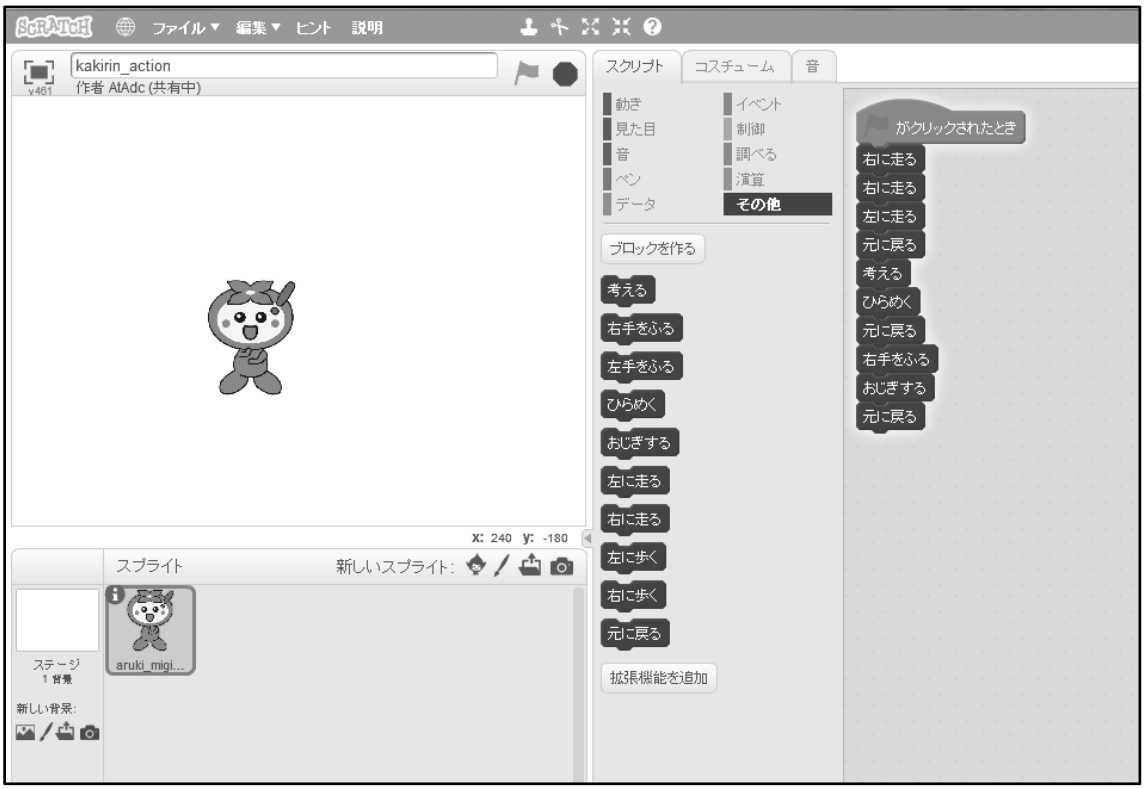
These learning activities aim to teach the basic concepts of programming and computer operations to children in a methodical way by allowing the children to handle simple to complicated tasks through their learning activities, and providing necessary the knowledge and skills in phases to achieve them.

Table 1: System-Oriented Curriculum Plan : "Let's Animate Kakirin!"

School Term	Number of Hours	Learning Activity	Remarks
1	1	Envision the kind of instructions and sequence Kakirin has to follow in order to achieve the tasks ("make Kakirin walk to the extreme right of the screen") and multiple instructions (such as "walk to the right," "walk to the left") posted on the blackboard by the teacher, and present them. ・The faculty member creates a script on the Scratch screen according to the concept presented by the student and verifies the script by moving Kakirin.	At this time, computers are operated only by faculty members.
	2	Envision the kind of instructions and sequence Kakirin has to follow in order to achieve the tasks and multiple instructions posted on the blackboard by the teacher, and present them. ・Understand and become proficient in launching the Scratch screen.	Increase the tasks' difficulty in phases.
	3	・Understand and familiarize yourself with Scratch operations (learn how to add, arrange, and delete blocks). ・Create scripts on the screen while consulting each member in the group, and verify the script by moving Kakirin.	
2	4	Produce Kakirin the animation while consulting each member in the group in accordance with the settings and conditions presented by the teacher. ・Familiarize yourself with Scratch operation methods. ・Understand and become proficient in storing the generated animation. ・Understand and learn how to appreciate the work produced by other groups.	
	5		
	6		
	7	Present the animation generated, and share each other's ingenuity and success.	
3	8	Make collaborative efforts to create Kakirin animations in line with the story created by each group. ・Familiarize yourself with Scratch operation methods. ・Learn how to store the generated animation. ・Learn how to appreciate work produced by other groups. ・Understand and learn how to refer to work produced by other groups.	
	9	Think about rules when referring to work produced by other groups. ・Imagine and present how you would feel if another group uses part of	

		your work without permission. ・Think about rules and how to name files referring to works of other groups.	
	10	Produce animations while referring to works produced by other groups.	
	11	Present the animation produced and share each other's ingenuity and success. ・Based on the presentation, vote for the animation you think is the best.	

Fig. 3: Kakirin Animation



2. Teaching Materials that Conform to the Experience-Oriented Organization Principle

Next, let us take a look at the teaching materials that conform to experience-oriented organization principles. This project is called "Let's Make a Chime!" This helps children realize that programming is useful for improving their school life by working together to produce chimes (See **Table 2**).

Learning activities consist of a total of ten hours: three hours in the first term, four hours in the second term, and three hours in the third term. Moreover, the assumption is that the children will actually use the chimes produced in a single school day. As shown in **Fig. 4**, a typical script needs to be prepared beforehand so that chimes

Table 2: Experience-Oriented Curriculum Plan : "Let's Make a Chime!"

School Term	Number of Hours	Learning Activity	Remarks
1	1	Think about the meaning of school chimes. ・How many seconds will the chimes sound? (When it is too long/too short?) ・What kind of impression does the melody give? (Fun/sad/no feelings) ・What does the chime ring for? (What is it notifying people about?)	
	2	Understand the mechanism that is used to ring school chimes. ・Observe the facilities and equipment used in school broadcasts. ・Understand the mechanism and chime program corresponding to the timetable.	
	3	Listen and compare the chimes of various schools and think about the meaning of the melody. ・Listen and compare the chimes prepared by teachers in other schools with the chimes of your own school. ・Think and present the effect of different melodies on people.	
2	4	Envision and produce an ideal chime. ・Understand and become proficient in launching Scratch. ・Understand and familiarize yourself with Scratch operations (how to add, arrange, and delete blocks, and how to change the scales and length of beats). ・Create scripts to ring the chimes while consulting each member in the group. ・Understand and become proficient in storing the generated animation. ・Understand and learn how to appreciate work produced by other groups.	
	5		
	6		
	7	Present the chime produced and share each other's ingenuity and success.	
3	8	Think about rules when referring to work produced by other groups. ・Imagine and present how you would feel if another group used part of your work without permission. ・Think about rules and how to name files referring to works of other groups.	
	9	Produce chimes while referring to works produced by other groups.	
	10	Present the chime produced and share each other's ingenuity and success.	

		・Based on the presentation, vote whichever chime you think is the best.	
		Spend one day in school using the most voted chime. ・Voice your thoughts on how it felt to experience the chimes that you created.	

can be created just by changing the scales and length of beats using a mouse and numeric keypad.

In this teaching material, children think about the meaning and function that the chime has in the first place, and compare it with the chimes of other schools to review it at their school. In addition, discussions will be held on the kinds of chimes that can be created to have a better school life. Next, the children will come up with an ideal chime by consulting each member in the group and referring to the work of other groups, then produce and present their results. The best chime is selected by voting. Then the children will mutually voice their thoughts and feelings on how they felt on using the chime that got the most votes in a single school day.

This teaching material does not place much importance on the systematic learning of operation methods and basic concepts, as in the case of the animation production seen earlier. Instead, the emphasis is placed on motivating children to bring out their sensitivity and creativity with an intention of improving their school life with friends, and encourage each child to feel how useful programming is, while attaching meaning to their own experience.

Fig. 4: Example of Chime Script

Conclusion

The above is an overview of the relationship between the teaching materials being developed for programming education in elementary schools and the underlying organization principles of curriculum. However, it goes without saying that both approaches need some minimal systematic knowledge and skills to undertake the learning activities. It also makes sense that this is more or less associated with reconstruction and attaching a meaning to the experience gained. In this sense, the distinction between both is merely relative.

Nevertheless, the fact that those who develop these curricula are aware of the organizational principles will be significant to advance future programming education constructively. This is because the vast majority of teachers must now research new teaching materials and prepare new lessons, so it will be helpful to establish a guidance policy by clearly indicating the aim and priority areas of teaching materials in advance.

This paper has focused on the learning activities for children with regard to two curricula in their planning stage. In the future, the modalities of teaching can take shape by proceeding with trials and improvements of teaching materials by consulting the collaborative efforts of the group of teachers from Mizuho Hozumi Elementary School, which was selected as the model school. In addition to organizing the qualities and abilities that children must learn through programming education, appropriate evaluation methods and mechanisms must also be developed.

End Note

1) See *Educational Guidelines of Elementary School,* Ministry of Education, Culture, Sports, Science and Technology, March 2017.
2) However, according to the announcement made by the Ministry of Education, Culture, Sports, Science and Technology in June 2018, a response was given as of February 2018 stating that "no particular measures have been taken" for introducing programming education, but the responses increased to 501 out of 722 members (69%) of the boards of education in the municipalities who participated in the questionnaire survey (*Efforts related to Elementary School Programming Education in the Board of Education*, Institute for Policy Studies, March 2018, p. 6, http://www.mext.go.jp/a_menu/shotou/zyouhou/dtail/__icsFiles/afield file/2018/06/22/1370024_1.pdf, retrieved September 26, 2018). From here, it is easy to imagine that the progress of preparation for programming education toward full implementation of educational guidelines for the next term in elementary school for 2020 is still quite different depending on the educational committees of each region.
3) See *Elementary School Programming Education Handbook (First Edition)* by the Ministry of Education, Culture, Sports, Science and Technology (March, 2018).
4) For results, refer to "Some Thoughts Concerning the Issues and Status of Utilization of Information Devices in Lessons in Public Elementary and Junior High School : From the Results of Questionnaire Survey in Mizuho city, Gifu Prefecture" by Ken Kameda, Rentaro Yamashita, Atsushi Adachi, Tetsuaki Hattori, Fumihito Mushiga, and Michio Tatsumi. (*Bulletin of the Center for Teaching Profession, Asahi University*, No. 20, the Center for Teaching Profession, Asahi University, March 2018).
5) Hiroaki Kano, "Preparing teaching materials for programming education in elementary schools (request)," Mizuho City Board of Education, April 11, 2018.
6) *Educational Guidelines of Elementary School*, op. cit., p. 22.
7) *Elementary School Programming Education*

Handbook (First Edition), op. cit., pp. 10-14.

8) Please refer to the following website to have an overview of Scratch and how to operate the Scratch screen (https://scratch.mit.edu/about).

9) For the time being, please refer to the following website to know about Kakirin (http://www.city.mizuho.lg.jp/kakirin/).