International Journal of Learning Technologies and Environments
International Institute of Applied Informatics
2021, Vol. 4, No. 1, 43 – 56

Examination of Remote Support by University Students for Programming-Related Lessons in Elementary Schools

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Abstract

In Japan, programming education was introduced into the elementary curriculum from FY2020 onward. We analyzed a case in which university students became remote support teachers for 10 programming classes in four elementary schools by the use of a Web conference system. The results show that teaching-related self-confidence increases when university students provide remote support. Additionally, facilitating the exchange of cooperative guidance between university students and teachers is important, along with the positive evaluations of student's work, thus providing guidelines for improving university students' remote support.

Keywords: Programming education, Information education, Distance education, School support, Web conference

1 Introduction

Japanese schools tend to organize their curriculums based on national guidelines. The latest version of these guidelines introduced programming education at the elementary school level. In addition, programming tools can now be incorporated into elementary school mathematics and science classes [1].

However, the information and communication technology (ICT) field and its educational use are currently insufficient; it is therefore necessary to improve the skills of programming teachers that. According to the survey results of Kuroda and Moriyama [2], teachers feel they lack sufficient knowledge about and understanding of programming education, meaning teacher training is necessary. However, it is not easy for schools to secure training time, which makes it important to increase the efforts to improve skills while also receiving support for ongoing classes.

As a result, the are several studies on this issue. For instance, Krauss and Prottsman proposed specific teaching methods and teaching materials for computing [3]. Sentance and Csizmadia showed that the curriculum plays an important role in teachers' attempts to develop programming education and also suggested it is important for teachers and university students to learn

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various teaching methods to develop good-quality curriculums [4]. The Computer Science Teachers Association (CSTA) determines standards and teaching plans for computer science and also provides measures of teacher training [5]. These cases provide useful content for facilitating teacher training; furthermore, through high-quality teacher training, elementary schools' programming education can be further developed.

However, it is not easy to secure time slots for teacher training in Japanese schools. At present, teachers are unable to find the time to attend the teacher training programs conducted by the Board of Education. As such, teachers at the elementary level must improve their programming education skills by the assistance of outside teachers. In this context, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) [6] has shown that cooperation with companies, organizations, and regions could prove effective in enhancing programming education.

Kanezuka, Yamamoto, and Motomura [7] and Yamamoto and Yamauchi [8] described the university students visiting elementary schools and teaching face-to-face classes, along with the results obtained. However, university students may find it difficult to personally visit multiple schools; as, beside providing support through visits, there is another channel that students can utilize to remotely support programming education—distance learning. In addition, due to the effects of the new coronavirus infection, it became difficult for university students to go to school and support classes. In order to continue to take measures against infectious diseases, it is necessary to reduce contact in the classroom and support lessons remotely. And, in Japan, face-to-face support can be seen, but no research on remote support can be seen.

Japanese schools have implemented distance learning for elementary and junior high students in various situations. In this way, opportunities can be established not only for the exchanges between schools, but also for collaborative learning with specialized institutions and experts. Uchida presents a case in which university professors remotely supported elementary programming teaching [8], showing that, along with that of university teachers, the participation of university students can offer more detailed assistance.

In Japan, many elementary school teachers acquire their teaching licenses from teacher training universities. These universities should thus make efforts to help university students acquire the necessary leadership skills for teaching programming education classes. However, there are few cases where elementary school programming education is dealt with in university classes in the teacher training course. University students are required to have the opportunity to learn elementary school programming education practically while they are still in school.

Therefore, this study analyzes how a university student can become an instructor and provide remote support for elementary-level programming classes by using a web conference system. We also analyze attitude surveys, class records, and class videos and examined how best to support elementary school programming education classes.

2 Ease of Use

2.1 Implementation target

Remote support was implemented for 10 classes held at four elementary schools. The elementary school students who participated were in the 5th and 6th grades, and participated in the comprehensive study time and class activities. Elementary school students learn programming such as Scratch and micro:bit for the first time. While the faculty member in charge of the class did not have any previous experience in programming education, the assisting university students acquired visual programming operation skills (e.g., Scratch and micro:bit) in the course of the class. We selected university students on a voluntary basis. Ten university students participated in the remote support activities. There were 10 students in the 4th year of university, 3 boys and 7 girls, all aiming to become teachers in the Faculty of Education. They learned programming such as Scratch and micro:bit in class.

2.2 Implementation environment

We used web conferencing systems that elementary schools use on a daily basis: Zoom or Skype. The students started to use visual programming tools such as Scratch and micro:bit. When using Zoom and Skype, it is possible to communicate with high image quality and high sound quality using an external camera under a stable optical line. In addition, the screen of the instructor can be shared with the learners. The instructor can share the programming screen on Scratch and micro:bit, and the instructor can explain with annotations. Remote support for the programming classes was advanced through the instructor–classroom and instructor–learner channels (see Table 1).

Under remote support, classroom teachers became the main teacher and provided guidance in the classroom. Then, university students facilitated the teaching activities.

Table 1: Connection Channels

Connection channel	Specific content
① Instructor–Classroom	The instructor and the class are connected
② Instructor–Learner	The instructor and the learners are individually connected
③ Learner–Learner	Learners are connected among them

2.3 Evaluation method

Considering the elementary school context, five question items about programming education were prepared. Table 2 shows the contents of these question items. These included items such as university students' confidence in teaching programming to elementary-level students and their thoughts about whether they had the knowledge and skills required for teaching effectively. The responses were assessed using a four-point Likert scale, ranging from 4 = very applicable to 1 = not applicable at all. Two awareness surveys were conducted in May 2019 and February 2020.

Table 2: Questions for university students

(1) Do you feel confident about teaching programming to elementary-level-students? [Con fidence]
(2) Do you think that you have the knowledge and skills required for teaching programming to elementary-level-students? [Knowledge and skills]
(3) Do you think that using web conferencing is an effective way for university students to teach programming to elementary-level-students? [Effective method]
(4) Do you feel that it is difficult for university students to remotely teach programming to elementary-level-students through web conferencing? [Difficulty]
(5) Do you think that it is useful for university students how to teach programming to ele mentary-level-students through Web conferencing? [Usefulness]

The university students and homeroom teachers were asked to describe their needs, issues, and usefulness of remote support using descriptive answers. Table 3 shows the contents of these answers to predetermined questions. Classification items were set with reference to the report on distance classes [9]. The description contents were classified using these items. The classification items were divided into six items: instructional method, curriculum, equipment and environment, programming instruction, student understanding, and distance teaching skills.

Table 3: Descriptive survey items for university students

(1) What do you think is required for university students to teach programming to elementary-level-students remotely while using web conferencing and what issues need to be addressed in this regard?
(2) What do you think would prove useful for university students when using web conferencing to teach elementary-level programming?

Furthermore, the university students recorded the content of the support they provided and also provided a description of this content. At the end of the course, we interviewed the classroom teachers about the feasibility of programming education. Furthermore, before and after the remote support was provided, we conducted an awareness survey on the students' practical ability of using information. The awareness survey utilized questionnaire items on the practical ability of information utilization from the "Information Utilization Ability Survey," conducted by the Ministry of Education, Culture, Sports, Science and Technology [10]. Table 4 shows the 12 question items. ranked on a four-point Likert scale ranging from 4 = "very applicable" to 1 = "not applicable at all."

Table 4: Descriptive survey items for university students

(1) I am good at inputting characters using a computer keyboard. [Character input]

(2) I am good at searching for necessary information on the Internet. [Information search]

(3) I am good at making tables and graphs using a computer. [Creating tables and graphs]

(4) I am good at making slides and materials for presentations using a computer. [Preparation of presentation materials]

(5) We are good at creating and displaying presentations using computers. [Conducting presentations using ICT]

3 Results of Remote Support

3.1 Remote support practice

Remote support was implemented in three stages to connect the university with the elementary school. Table 5 shows the flow of the remote support.

During Stage 1, a connection was made through the instructor–classroom channel. Specifically, a university student became an instructor and explained the programming operation methods and the game production procedures to elementary-level students. After Stage 1, the programming activities commenced for each group. In Stages 2 and 3, the connection was made through the instructor–learner channel. Stage 2 considered a situation where university students answered the questions that came up during the activities conducted after Stage 1. After Stage 2, the elementary-level students continued the programming activities. During Stage 3, the university students evaluated the programming produced by the elementary-level students.

Table 5: Flow of remote support

Stage	Form	Specific content
Stage 1	① Instructor–Classroom	Explain the programming operation methods and the game production procedures.
Disconnected		In the classroom, create program for each group.
Stage 2	② Instructor–Learner	During the production process, the university students answered the elementary-level students' questions.
Disconnected		In the classroom, create a program for each group.
Stage 3	③ Instructor–Learner	The university students evaluated and provided advice regarding the work of the elementary-level students.

3.2 Instructor-classroom support

Stage 1: Under the instructor–classroom channel, the university students became instructors and explained how to program to all students. Specifically, they explained how to operate the programming application and create games. They were also able to utilize the screen-sharing function and other tools to explain how to program clearly.

However, as the university students required a considerable amount of time to check on all elementary-level students, the classroom teachers taught along with the university students and also helped the elementary-level students. Therefore, it is necessary to grasp the overall progress of the elementary-level students and cooperate with the teacher in charge. Figure 1 shows t classroom situation through the instructor–classroom channel. In Figure 1, a university student explains how to use a programming tool to all students within the classroom of an elementary school.

Table 6 shows the contents when creating a programming work using micro:bit. Since it is created with a visual programming tool, it is created by combining blocks, not code. These are programming games that children in the lower grades can play. (1) Displaying and blinking the mark is a simple matter. (1) is a repetitive program that uses about three blocks. (2) The stop-watch game is a program that measures the elapsed time by pressing a button. (2) is a conditional branch when the button is pressed, and is a program that uses about 6 blocks with time as a variable. (3) Measure the angle (4) Rock-paper-scissors game is a program that uses an accel-eration sensor. (5) The compass is a program that uses a directional sensor. The programs from (3) to (5) are advanced programs using sensors. Based on the variables obtained from the sensor, we used about 7 blocks in a program that branches according to conditions.

Figure 1: State of the instructor-classroom channel

Table 6: Contents of works using micro:bit

Contents of works	Specific production content
(1) Mark display and blinking	Specific production content Mark display blinking Save the program Data transfer
(2) Stopwatch game	Measure elapsed time Press the button the first time to start measuring the time, and press the button the second time to display the measured time. Save the program, Data transfer

(3) Measure the angle	Works using accelerometers Shows the tilt of the micro:bit Save the program, Data transfer
(4) Rock-paper-scissors game	Measurement of the angle around you Works using accelerometers When shaken, one of Goo, Choki, and Par is displayed. Save the program, Data transfer
(5) Compass (compass)	Works using magnetic sensors Show orientation Save the program, Data transfer

The content of the program to be produced is the content that the university students researched and considered in advance. Before remote support, we consulted with each other and examined it. As a programming method, we have made it possible to learn the concepts of conditional branching and variables. For example, a conditional branch is provided when a button is pressed. In addition, the variables obtained from the sensor are displayed. Table 7 shows the contents considered from the implementation records and class videos of university students in the connection form of Form ① “Instructor-Classroom”.

Table 7: Contents considered from the implementation records and class videos

[From the implementation record of university students]
・ I was able to explain in an easy-to-understand manner by explaining using screen sharing.
・ I felt that remote support could close the gap between regions.
・ I was able to give advice on the basic contents of programming operations.
・ Because the time was short, there were some scenes that were difficult to convey.
・ Voice was disturbed due to communication conditions, so I was conscious of speaking clearly.
[From the recording of the lesson video]
・ There were many cases where the homeroom teacher gave guidance between desks.
・ It was seen that the homeroom teacher re-transmitted the explanation of the university students.
・ It was seen that university students proceeded while confirming, such as asking for a raised hand.

3.3 Instructor-learner support

Stages 2 and 3 (instructor–learner): The university students and the groups of elementary-level students connected to each other one-on-one, the former providing individual support. In Stage 2, the university students answered questions and explained how to program by screen sharing. Depending on the content of the question, some were able to provide responses after searching the Internet or manual.

In Stage2, university students answered questions from elementary school students through a web conference. Table 8 shows some of the questions from elementary school students and the answers from university students.

In response to a question from an elementary school student, a university student explained using the screen sharing function of a web conference. The university students explained the contents that could not be displayed on the screen, such as the connection of the USB cable, while contacting the teacher in charge.

In Stage 3, the university students evaluated the elementary-level students' work positively. Since the university students saw the work for the first time, there were some instances where the corrected responses could not be provided immediately. Figure 2 shows a class using the instructor–learner channel. Multiple university students responded to each group, with one university student answering questions from four students.

Table 8: the questions from elementary school students and the answers from university students

Questions from elementary school students	University student answers
The created program does not work. Why?	Share the screen and explain.
	Check the parts that do not work and explain how to work.
Please tell me where to put the block out.	Share the screen and explain.
	I will explain how to put out blocks.
I want to create a more difficult game. Please tell me how to do it.	Share the screen and explain.
	I will explain the difficult method while carefully instructing it.
I want to create another program, but what should I do with the program I created immediately before?	Share the screen and explain.
	We will explain how to save the program created immediately before and how to create it after deleting it.
I would like to use other blocks, but what kind of blocks are there?	Share the screen and explain.
	We will explain repeating blocks and variable blocks that you can create new blocks by yourself.
The program is not transferred. Why?	Understand the situation and encourage them to try another connection code.
Why does the mark change when shaken?	Point to the part where the accelerometer is located and bring it closer to the front of the camera.
	The acceleration sensor will be explained.
Why is the micro:bit on the left moving?	Explained that the program can be confirmed and recreated by performing a simulation before transferring the data.

Figure 2: State of the instructor-learner channel

Table 9: Descriptive survey items for the university students

[From the implementation record of university students]
・ I was able to convey not only advice but also impressions of the work.
・ I was able to share the screen and answer the students' questions well.
・ I couldn't answer the simple questions of the students well, probably because I lacked programming knowledge and skills.
・ At first glance, it was not possible to identify what was wrong with the student's work (program).
・ It was necessary to think about where to teach while giving instructions and what to make students think.
[From the recording of the lesson video]
・ University students were seen complimenting the work and its process.
・ By having the students raise their hands, it was observed that the university students were proceeding while checking their understanding and progress.
・ It seemed that it took time for university students to point out the corrections.

4 Analysis Results

4.1 Results of the attitude survey for the university students

We analyzed the results of the attitude surveys administered to the university students in May 2019 and February 2020. The percentage of positive responses was analyzed using the $\chi 2$ test. Table 10 shows the results. For the five items, the results were as follows. For confidence, a significant difference was observed (χ^2 (1) = 4.54, p <0.05). However, there were no major changes in the four items of knowledge/skills, effective method, difficulty, usefulness did not show significant differences.

Table 10: Descriptive survey items for the university students

	2019.5	2020.2
(1) [Confidence]	11.1% (1/9)	66.7% (7/9)
(2) [Knowledge/Skills]	33.3% (3/9)	77.8% (7/9)
(3) [Effective method]	88.9% (8/9)	88.9% (8/9)
(4) [Difficulty]	88.9% (8/9)	88.9% (8/9)
(5) [Usefulness]	100.0% (9/9)	100.0% (9/9)

4.2 Analysis results for description contents

The contents that the university students and teachers produced after the practice were classified into six items: (1) instructional methods, (2) curriculum, (3) equipment and environment, (4) programming skills, (5) elementary-level students' understanding, and (6) distance teaching skills. For example, a description such as "selection of words according to the development stage and speech style according to the development stage" was judged to belong to the instructional methods category; descriptions such as "curriculum ideas and positioning of annual guidance plans" were judged to belong to the curriculum category; descriptions such as "maintenance of equipment and communication lines" were judged to belong to the equipment and environment category; descriptions such as "knowledge and skills of programming tools used" were judged to belong to programming instruction; descriptions such as "communication, grasping the actual situation" were judged to belong to elementary-level students' understanding; and descriptions such as the "ability to explain using the screen sharing function" were judged to belong to the distance teaching skills category. Table 11 summarizes the tools, skills, and processes necessary for remotely teaching programming to elementary-level students and the issues that should be addressed. Table 12 summarizes useful content for university students. According to Tables 11 and 12, both the instructional method and curriculum were frequently referred to.

Table 11: Classification of necessary items and issues to be addressed

	Classroom teachers	University students	Total
(1) Instructional methods	16	7	23
(2) Curriculum	16	4	20
(3) Equipment and environment	7	5	12
(4) Programming instruction	3	4	7
(5) Elementary-level students' understanding	3	3	6
(6) Distance teaching skills	2	3	5

Table 12: Classification of content useful for university students

	Classroom teachers	University students	Total
(1) Instructional methods	9	3	12
(2) Curriculum	6	4	10
(3) Programming instruction	2	3	5
(4) Distance teaching skills	2	3	5

4.2 Analytical results regarding practical information use

A total of 38 elementary-level students responded to a questionnaire survey on the practical use of information. Using a *t*-test, we compared the average of the answers before and after support being received from the university students. Table 13 shows the analysis results. For the presentation using ICT, the post-practice result was significantly higher (at the 1% significance level) than that for the pre-practice. Additionally, for creating tables and graphs and presentation material, the post-practice results were significantly higher (at the 5% significance level) than for the pre-practice. There were no significant differences between character input and information retrieval.

Table 13: Analytical results regarding practical information use

Item	Before support	After support	*t*, *p*
(1) Character input	2.77 (0.91)	3.03 (0.91)	t=1.19 *n.s.*
(2) Information search	3.03 (0.82)	3.29 (0.77)	t=1.40 *n.s.*
(3) Creating tables and graphs	1.89 (0.96)	2.50 (1.06)	t=2.59 p<0.05
(4) Presentation material creation	2.26 (0.98)	2.74 (0.95)	t=2.12 p<0.05
(5) Presentation using ICT	2.43 (0.95)	3.03 (0.88)	t=2.79 p<0.01

t: *t*-test value; *p*: significance; *n.s.*: not significant

5 Discussion

Analysis of the attitude survey administered to university students showed that they improved their confidence with regard to programming education. In addition, the university students' records showed responses such as "I felt that remote support can bridge the gap between regions" or "I was able to provide advice about the basic content of programming operations." Therefore, university students' confidence increased.

However, the implementation records also showed communication problems. There were responses such as "Some situations were difficult to convey due to the short time available" or "Communication was disrupted, but I proceeded and continued to speak clearly." Communication posed problems when multiple students and individuals or groups were connected.

In addition, the recorded videos showed that many teachers were active in the classroom, some of them repeating the university student's explanation when needed. These problems are often seen in non-face-to-face remote classes, as it is not easy to grasp the progress of the classroom and of the learning process, thus requiring improvement. In response to this, the university students continued to verify the understanding of the classroom, for example by asking for a show of hands. It is necessary to collaboratively devise remote explanations and instructions with the teacher in the classroom. When we interviewed three faculty members who participated, they answered that remote support for university students was very effective.

In our study, the university students not only provided remote guidance for the entire classroom but also supported groups of learners individually. The video recording of the lessons showed that the university students praised the work of learners, which led to a positive evaluation of the programming they worked on.

However, there were also cases where the university students could not provide clear advice to the elementary-level students or answer their questions due to a lack of programming knowledge and skills that did not allow them to identify problems at the first glance. As such, in some, cases, it took some time for the university students to point out errors and offer corrections. These facts show that some issues should be solved so that individual support can be provided to the elementary-level students. In particular, it is necessary for university students to grasp the level of the elementary-level students and also consider what advice they can offer in advance.

An analysis of the content written by the university students and teachers after the practice showed that most content was related to the instructional methods and curriculum. This shows that the university students and teachers required the same teaching skills during the remote programming lessons as those required for face-to-face lessons. Therefore, it is important for university students in teacher training programs to improve their teaching skills and enhance their curriculum learning.

In the survey for the elementary-level students, we analyzed the changes in consciousness with regard to information use. The items that improved included those related to expressiveness, such as presentation and material creation. The study results suggest that enriching the programming education-related classroom practice through remote support may improve the elementary-level students' expressiveness.

In this study, we implemented two forms of remote support, instructor–classroom and instructor–learner, and analyzed their contents. The learner–learner channel was not implemented. Moore [11] categorizes the interactions in distance education into the following categories: learners and learning content, learners and professors, and learners and learners. That is, in some cases, learners may work together to complete a programming task. It is conceivable that university students could provide support for situations where learners share programming work remotely and provide advice to each other. As such, future research should clarify how university students can support the remote interactions between learners.

During the period from March to May 2020, Japanese elementary schools were closed due to measures against the new coronavirus infection, and elementary school students began to live at home. In order to support home learning, university students have made it possible to remotely support home learning for elementary school students. In the future, it will be necessary to consider supporting programming learning by university students as home study when not attending school.

In order to enhance remote support by university students, it is conceivable to enhance the classes dealing with elementary school programming education at teacher training universities and improve the teaching skills of university students who support remotely. Maruyama et al. [13] (2019) reported that they tried STEM education classes for university students at a teacher training university and that the university students who took the classes increased their confidence in STEM education. In addition, in order to set courses at many teacher training universities in Japan, it is necessary to set the criteria for computational thinking (NETS-T) [14] set by the International Society for Technology in Education (ISTE) in Japan.

6 Conclusions

In this study, some university students remotely supported a programming class by using a Web conference system. The study results showed that teaching-related self-confidence increased when the university students participated in remote support. The implementation records and interviews preserved over the course of the research showed that elementary school teachers could solve elementary-level students programming anxiety while conducting lessons.

In addition, in order to enhance remote support, it is necessary for university students to not only teach programming skills to elementary-level students but also enhance university students' positive evaluations of elementary-level students' works. In particular, this study showed that it is necessary to devise teaching methods and curriculums, such as explanations, instructions, and the questions of university students, rather than simply understand programming and remote system tools. A remote university student is required to cooperate with the teacher in the classroom and devise remote explanations and instructions.

As previously mentioned, in the future, we will examine how to develop remote support for connecting learners with learners.

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