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A PROGRAMMING LEARNING SYSTEM USING VIDEO

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Abstract. *We have developed a system with the goal of increasing the number of people who can continuously engage in programming learning. In recent years, as society has shifted to IoT, a shortage of IT human resources has become an issue. Against the background of mandatory programming in elementary schools, we decided to conduct this research because we believe that continuous programming learning is necessary for fostering IT personnel. In the current situation where there is a shortage of IT personnel, we created a programming learning system that enables continuous learning by using videos that young people are interested in as the subject matter. The system provides a right/wrong judgment on the answers to actual coding problems, and offers advice when the answers are incorrect, so that even beginners can learn in an easy-to-understand manner. The learning system is designed to allow users to learn from basic to advanced content in a step-by-step manner, making it easy to continue and acquire practical knowledge. As a result of the evaluation, the system received a high evaluation in terms of usability, confirming the validity of the system.*
Keywords: Learning system, Video, Programming, Programming learning

1. **Introduction.** According to the Ministry of Economy, Trade and Industry, the latest trends, and future estimates of IT human resources [1] predict that the IT human resource shortage will peak in 2019. It estimates that this will result in a shortage of at least approximately 410,000 IT personnel in 2030. This is thought to be due to the rapid development of IoT throughout society in recent years. In addition, there are approximately 21.37 million IT professionals in 92 countries worldwide, and Japan ranks fourth in the world with 1.09 million IT engineers [2]. On the other hand, the growth rate of the number of IT engineers in Japan ranks 27th, indicating that the new increase in human resources is insufficient and that there will continue to be a shortage of IT engineers at this rate. Japan has made elementary school programming education mandatory starting in 2020. However, programming learning has unique difficulties [3], making it difficult to continue learning. Now that there are more opportunities to be exposed to programming, the development of a learning system that encourages continuous programming learning is desired. A system using a gamification framework [4] exists as a learning system that encourages continuous learning, and it has been shown to be effective in promoting continuous learning. There are also systems that introduce a function that offers advice for wrong answers and a function that allows the user to write and execute programming [5,6]. However, these systems are almost equal to general materials in terms of learning subject matter, and it is difficult to say that they are effective in sustaining programming learning, even for those who do not want to learn or are new to it. To solve the problem,

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the system must be one that beginners want to continue learning. There is also a programming learning system for children [7], but while this system is easy to understand and enables continuous learning, it has the problem that it does not allow developmental learning. The use of interactive artificial intelligence GPT in education is also limited because program bug resolution using GPT is limited [8].

For continuous programming learning, it is important that the learning materials attract interest. When we examined the advantages and disadvantages of conventional programming learning systems, we found that they are problematic in that they do not allow students to learn advanced content, and that they do not keep learners motivated to learn with explanations full of text. Therefore, we incorporated video learning, which was one of the advantages of the existing system, to keep learners motivated to learn. In addition, by using images, which have become more familiar in recent years, as the subject matter for learning problems, we were able to achieve even more continuous learning. To cultivate practical skills, we have made descriptive learning questions. Evaluation experiments showed that the system did not receive the highest evaluation for the clarity of the video images, which is the key element of the system. On the other hand, the system received a high evaluation on average, and the convenience of the system was also highly evaluated, confirming the validity of the system.

Chapter 2 describes the existing systems and their problems, Chapter 3 describes the solution method, Chapter 4 details the learning procedure and the correct/incorrect judgment system, Chapter 5 describes the contents and results of the evaluation experiment, Chapter 6 describes the future issues of this system based on the results of the evaluation experiment, and Chapter 7 concludes this study.

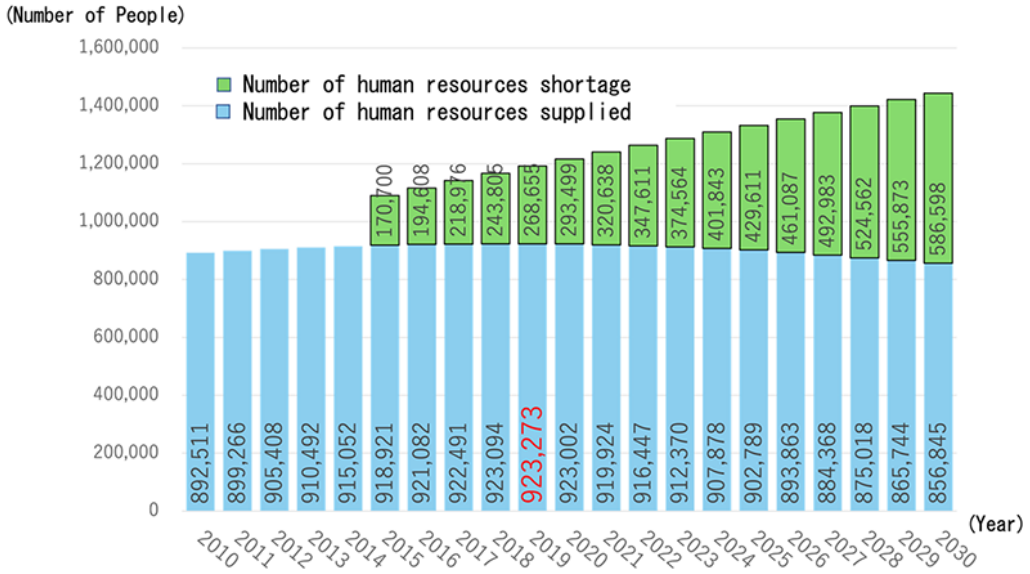

FIGURE 1. Supply and shortage of IT personnel [1]

2. **Problems of Conventional Systems.** An existing system for learning programming is the visual code programming learning system for children [7], which allows children to learn basic descriptions in a way that even they can understand. The system has the advantage of using visual illusions to make learning visually enjoyable, and the learning content allows even young people to learn programming without damaging their motivation to learn. On the other hand, the program is basic and does not allow for learning advanced content, and there are too many words in the explanations, which may cause a decline in motivation as the learners get older. Another system that allows descriptive execution and presents advice for incorrect answers is the programming learning system

that provides advice for typical wrong answers [5]. This system is unique in that it offers advice for short answer questions, making it easy for beginners to understand. On the other hand, it is difficult to maintain the desire to learn when learning the initial knowledge of programming because the basic learning is done through many letters and multiple-choice questions, and the questions are simple. The object-oriented programming learning system using color as a theme [6] is another learning system that introduces a system for executing descriptions and presenting advice. This system allows users to learn step-by-step from the basics to development through the theme of color. Although this system is close to what is needed today, it has the problem that not everyone can learn because the basic learning is explained by text and a certain level of knowledge of colors is required. In addition, there is a programming learning system called paiza learning [9] that utilizes video. While the video learning method is easy to understand, the images and learning content are not interesting, and it is difficult to continue learning. In summary, it is difficult to maintain the motivation to continue learning due to the large amount of text and lack of interest in the learning content, as well as the inability to accumulate advanced knowledge.

3. **Solution in This System.** The problem of difficulty in sustaining learning was addressed by incorporating basic learning through video, which was an advantage of the conventional system. In addition, we also considered that learners would be more interested in learning by using content that is of interest to them as the subject matter for learning.

Figure 2 shows the number of monthly active users [10] of major social networking services (SNS) in Japan and abroad. YouTube, an application related to video posting, has approximately 2.56 billion users, and TikTok has approximately 1 billion users. Since the development of media content using video has been remarkable and the number of users continues to increase, we considered that the learning content could be video playback and editing, which would allow for continuous learning of programming.

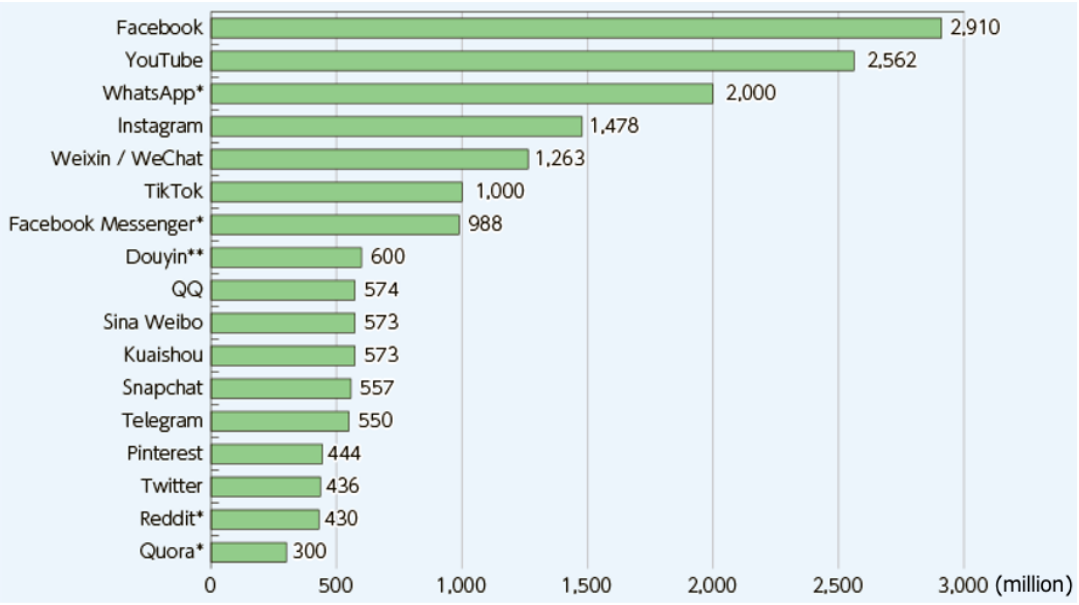

FIGURE 2. Number of monthly active users of major SNS in Japan and abroad [10]

This system was designed to enhance programming knowledge by allowing students to learn what programs are running in the background of video playback and how to utilize functions in video playback through programming. In addition, to make the videos for

learning interesting and to keep the learning process going, we decided to incorporate video editing techniques such as YouTube and TikTok, which have become popular and can be viewed in a fun way. The video playback time was shortened to less than two minutes to facilitate continuous learning.

To solve the problem of not being able to accumulate advanced knowledge, we have made the learning content progressively more difficult, so that programming beginners can gradually build up their skills to a level where they can use and apply the published programming.

4. **Configuration of This System.** The programming language used for learning was Processing, a simplified version of Java. This allows students to learn object-oriented programming in a simplified manner. We decided to use Processing because it is easy for beginners to learn, and we believe that understanding a language, even if it is a simplified language, is important for deepening programming knowledge.

The flow of learning in this system is shown in Figure 3. After input through video learning, students acquire knowledge through output by solving fill-in-the-blank type questions. This process is carried out over several units to learn programming knowledge from the basics to application.

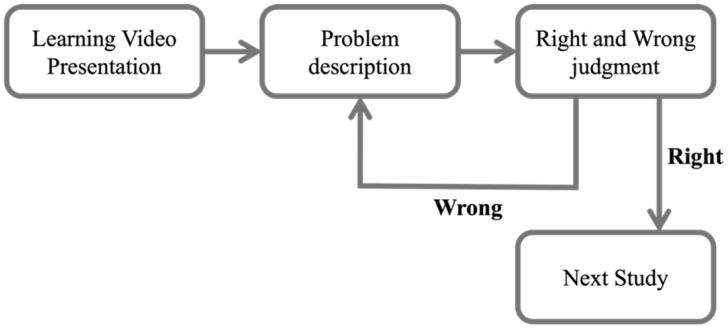

FIGURE 3. Learning flow

This system was designed to motivate learners to learn programming through video viewing and by using video as the subject matter for learning. This approach can solve the problem of the learning system using the gamification framework [4] in that the subject matter is equal to general learning materials, making it difficult for beginners to continue learning. In addition, the problem of not being able to learn developmental content, which was a problem of the programming learning system for children [7], can be solved by learning through video viewing, which makes it possible to learn higher-order problems in a shorter period.

In the system there are different difficulty levels and contents for each unit, and the learning method is to progress through the unit step by step from low difficulty to high difficulty.

For every unit, there are study videos and questions based on the videos, each with approximately 3 questions. It is also possible to start learning from a unit in the middle of a unit, allowing students to choose the unit they wish to study according to their ability.

The content up to library utilization 2 in Figure 4 is basic, allowing students to learn the knowledge required to use Processing, variable declarations, if statements, and other basic content frequently encountered in programming. After acquiring playback time, the content is more advanced, and students will learn techniques to utilize multiple basic skills, for statements, and use of existing systems while creating systems that respond to mouse movements and video editing systems. All the questions are written, allowing students to learn in a practical way through actual coding.

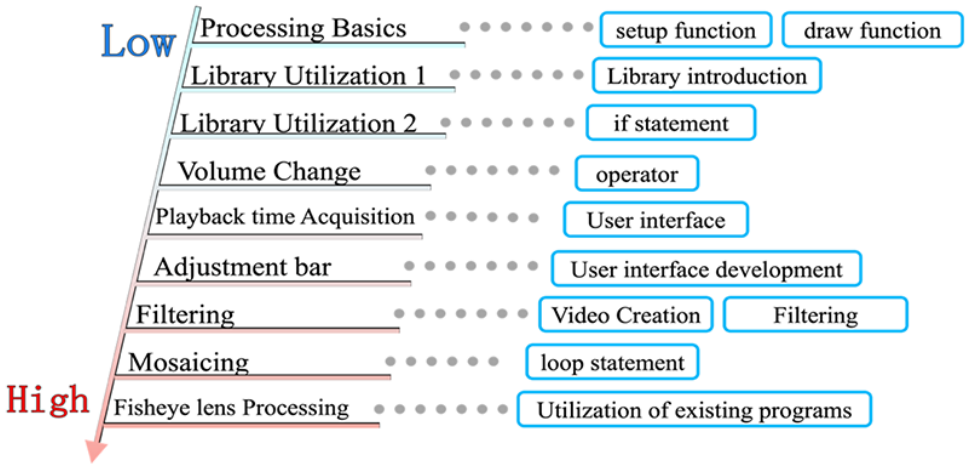

FIGURE 4. Learning content of this system

The correctness of this system is determined by utilizing the method of the existing system [5]. The learner's output result is saved as a 500×500 pixel image and is compared pixel by pixel with the image of the correct output result to determine correctness. In this case, the system did not use a perfect match as the correct answer, but rather a 99.8% match as the correct answer. This system uses video images for learning, but since there is a problem that these frames may differ depending on the PC specifications, we decided to use a method in which the correct answer is given even if 0.2% of the frames do not match. The output results of typical errors are also prepared as images, so that even if a learner makes an incorrect statement, the system will offer advice for each of them according to the input program. This function also follows the method of existing systems [5,6], so that the system can be used for learning system even when the learner does not know what kind of description will be made.

Figure 5 shows an example of a study screen. The left side of the screen is used to display the question text and the program in different colors, and the user considers the appropriate description for it and writes the answer in the area on the right side of the screen where written answers can be written. The results of correct or incorrect answers

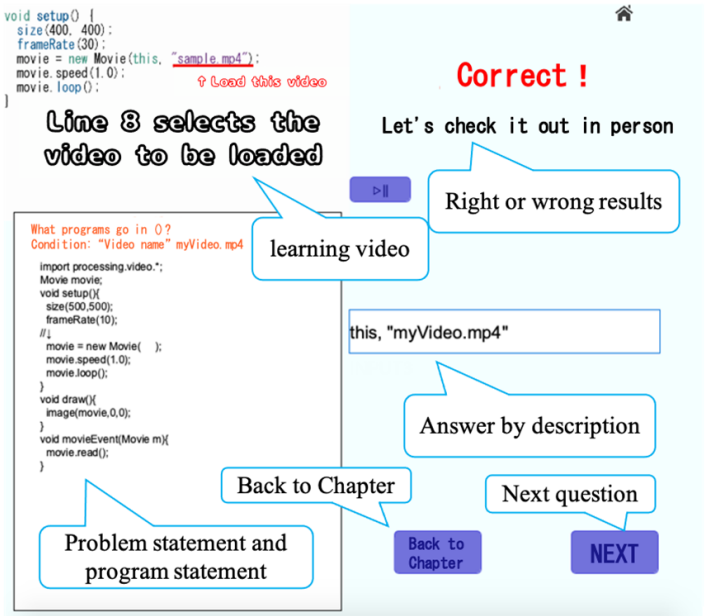

FIGURE 5. Answer screen (translated)

are displayed in the upper right corner of the screen, with correct answers displayed in red and incorrect answers displayed in large blue letters. In the upper left corner of the screen, a study video continues to play, allowing the user to review the contents of the unit at any time. By pressing the buttons at the bottom of the screen, the user can move to the next study or unit selection screen.

5. **Evaluation Experiments and Results.** This system was surveyed with 17 students. The procedure was as follows. First, the system overview and mechanism were explained, and the students were asked to view a demonstration of the system by utilizing the screen sharing function of the video call application. The students were then asked to rate the system on a 5-point scale from 1 to 5, with 5 being the highest rating. The system demonstration was conducted using a method whereby the students completed the unit on Processing Basics. In addition, several questions from other units were also displayed so that the students could check the difficulty level, etc. Ideally, we would have asked each student to experience the system and then evaluate it to enhance the validity of the evaluation. However, due to the time required and the difficulty of having a face-to-face demonstration due to an epidemic, we adopted the method of conducting the questionnaire survey all together.

TABLE 1. Summary of survey results

No.	Contents	Property	Average
Q1	Were the operating instructions easy to understand?	Convenience	4.3
Q2	Was the screen layout easy to read?	Visibility	4.3
Q3	Was the video study easy to understand?	Clarity of video	4.1
Q4	Is video learning useful?	Usefulness of video	4.2
Q5	Was the difficulty level of the study questions appropriate?	Appropriateness of difficulty level	4.0
Q6	Are you interested in programming?	Interest	3.9
Q7	Would you use this system again?	Reusability	3.9

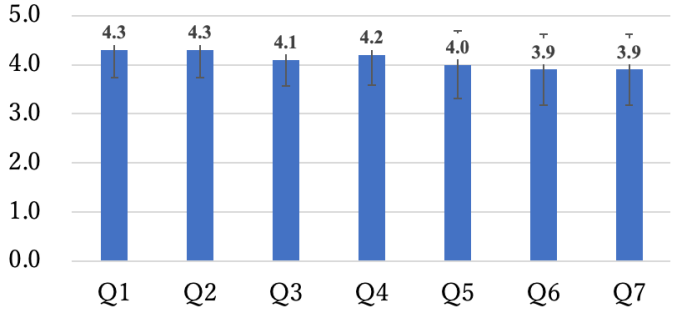

FIGURE 6. Questionnaire results

6. **Consideration.** The low level of interest and reusability about the program was particularly noticeable. The low scores for the appropriateness of the difficulty level of the problems also suggest that the problems themselves were not very interesting to the learners. However, since only the easiest basic problems of each unit were shown during the demonstration, it is thought that this may have made the students feel that the contents of the problems were boring.

As a countermeasure, if the introduction could have been changed to more interesting problems, or if a video could have been prepared prior to the start of the study to further

motivate the students to learn, it might have been possible to increase the motivation to learn until the difficulty level of the problems increased.

In addition, the evaluation of the video for learning, which is the main feature of this system, was not the highest. This may have been because the video was only shown in the upper left corner of the quiz question screen, without any time set aside for the students to view only the study video. Since the highest scores had been recorded in the survey questionnaires prior to this one, it was thought that, overall, there may have been a problem with the demonstration method.

However, it is also true that the overall score was high, and the fact that the learning method was easy to understand is commendable, as well as the fact that the design was user-friendly with clear coloring.

7. **Conclusion.** In this study, a programming learning system was created for students who are learning programming from the basics, using a single theme, video, to motivate them to learn. The system allows students to learn programming from basic to advanced levels by solving quiz questions after video learning. The system's learning videos are designed to be easily accepted by young people. While the system received a high evaluation in the evaluation experiment, many of the questions were simple, and the challenge is to motivate students to start learning in the early stages of the program.

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