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Design and Implementation of Scratch-based Science Learning Environment Using Non-formal Learning Experience

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Abstract

In this paper, we use scratch to design and develop non-formal learning experiences that are linked with contents of secondary science textbook to educational programs. The goal of this paper is to develop a convenient and interesting program for non-formal learning in a learning environment using various smart device. Theoretical approaches to mobile education, such as smartphones, and smart education support policies continue to lead to various research efforts. Although most of the smart education systems developed for students who have difficulty in academic performance are utilized, they are limited to general students. To solve the problem, the learning environment was implanted by combining the scratch, which is an educational programming that can be easily written. The science education program proposed in this paper shows the result of process of programming using ICT device using scratch programming. In the evaluation stage, we were able to display the creations and evaluate each other, so that we could refine them more by sharing the completed ideas.

1. INTRODUCTION

The various social and cultural changes in the 21st century and discussions on the talent award require various changes in the educational environment including the educational purpose. As core competencies such as creativity, problem solving ability, communication ability, artistic thinking and technology literacy required by the future society are emphasized, the demand of school education incentives to cultivate this is increasing [1]. On the other hand, the existing learning viewpoint has been developed as a reconstruction of personal experience through social relations and the development of various information and communication technology (ICT) has expanded the field of human experience. In other words, through non-formal activities outside the school, such as museums, amusement parks and exhibition halls, where students can experience informal and unstructured experiences beyond a school environment that provides formal and structured education as an environment in which individuals can experience new things the human experience can be

expanded [2-3]. Learning is an intrinsic process of change in an organism, not a direct observation, but a performance. Education is a series of artificial processes that control or assist in the development of mental and physical development of man by any ideal, purpose, or value standard. Natural growth or accidental learning is excluded from the strictly educational sense. Education implies at least the intention of the person or society that plans and drives it. Since the publication of the report 'Learning to be: The World of Education Today and Tomorrow' by UNESCO, most of the details are different, but most of them are formal learning, non-formal learning, Formal, non-formal, and informal learning is a representative classification of the diversity of lifelong learning. Formal learning is an intentionally, systematically planned, and systematic way in which a person who teaches and a person learns at a certain place through well-organized education contents. Formal learning defines activities that are clearly learned in a structured context, and as a result of learning, certain qualifications, including education, are given, including regular school education and vocational education and training [4]. Non-formal learning is an organized learning activity, but it means that qualification or certification does not follow the result of learning, and various short-term courses are included. Non-formal education has a form between formal education and non-formal education, including consumer education and broadcasting communication education. Non-formal education refers to learning activities that take place in a non-formal environment such as a school without a teacher who systematically supports specific learning objectives and learning. Informal learning refers to learning that happens through everyday life, without organized lectures or programs, and through learning through work-related activities, housework, and leisure activities [5-6]. Formal learning is usually supported by the organization, is lecture-based, and well structured. However, experience in non-formal situations is scattered meaninglessly, so there is a limit to linking to meaningful experiences. Therefore, it is necessary to organically link the advantages of formal education provided by the school with the advantages of the non-formal learning experiences available outside the school. In general, non-formal learning refers to learning activities that occur in a non-formal environment such as a school, without a teacher who systematically supports specific learning objectives and learning. For example, on-the-job learning, zoo, museum, amusement park experience, and information acquisition through online material search are classified as non-formal learning separately from classroom instruction. Non-formal learning has the following characteristics. First, non-formal learning is the most natural and important learning method for humans, and Combs and Ahmed [6] research that the first experience of human beings is the non-formal learning environment, which is much more and longer than formal education like school. Second, individuals experience more interest through experience in non-formal situations, and experience the opportunity to integrate perception, personality, and emotion. In everyday life, which is mostly non-formal situation, individuals feed and become aware before conceptual recognition of phenomenon or problem. In this process, person experiences emotional and personality in organic process. Third, the non-formal learning experience provides concrete and practical contexts and provides specific examples of how organized contents such as concepts, principles, and rules in formal education, including schools, are applied and utilized in daily life [7]. However, since non-formal learning is not organized because there is no intention in advance, there is a need for non-formal learning to be linked to the advantages of formal education such as school education. Table 1 summarized the characteristics of non-formal learning for each researcher.

Table 1. Classification and characteristics of non-formal learning

Researcher	Separation factors of non-formal learning	Characteristics of non-formal learning
Clark [7]	- Intentional, Accidental	Formal and informal learning can involve both intentional and accidental learning

Eshach [8]	- Motivation, Interest, and Social context - Evaluation	Apply to all situations of life The learner determines the path for acquisition of internal motivation and the desired knowledge, skills and abilities.
Hill, Domizi [4]	-The degree of learner's choice for learning objectives, activities, tools, and resources - Interaction and design	Learners design their own learning activities Choose voluntarily
National research council [9]	- Formality - Non-formability	The learner develops his own goals and chooses path Results from untrained learning experiences and deliverables
Rossett & Hoffman [10]	- Output - Experience - Origin of learning - Role of learners - Role of instructor - Location	Almost no goal or artifact assessment, and the learner's voluntary activity Professors
Savenye [11]	- Timing - Structure - Control - Leading - Contents	Frequent occurrences in museums, after-school clubs, botanical gardens, zoos, and science museums

The non-formal learning environment structured the learner to use artifacts, media, and signals to guide the learner's experience, but it is up to the learner to interact with the learner, In other words, learners prefer to participate in the designed non-formal learning environment by personal choice or adult choice such as parent or teacher, and the learners give attention and attention to the exhibit that suits their interests. In this research, we developed a program that presents the problem of secondary science simply by using quiz problem design and scratch of science subject to be developed. In the future, it will be necessary to study the improved science learning program as a future research project by adding quizzes by the unit of science, correcting wrong answers and adding other additional menus. Therefore, we designed and applied scratch-based program learning as a learning method to organically link education in school and informal experience outside school. The rest of the paper is organized as follows. Section 2 surveys related work. It also describes the elements and scratches of the educational programming language. Section 3 presents the design method. In order to apply the education program that integrates the formal education with the non-formal learning using scratch, the appropriate learning state was designed and the teaching and learning stages of the science education and the technical education were analyzed and summarized, and we conclude in Section 4.

2. RELATED WORKS

Research to integrate school-based formal education and informal experiences outside the school is continuing with the development of advanced technology. For example, Sandberg studied how his colleagues and students use mobile devices to learn language in schools, public places, and homes. Although most of these studies effectively show the educational applicability of mobile devices and the learning process in non-

formal situations, there is a limit to linking experiences in formal situations to experiences in non-formal situations. Research on the effects of language learning using mobile devices such as smart phones, and the possibility of constructing creative knowledge in field learning. However, since these studies are often limited to formal education or experience in non-formal situations, educational efforts are needed to link the experiences of both studies.

Table 2. Design examples based on analytical framework

Analysis element / Design examples	Subject	Design goal	Foundation theory	Applied technology	Learning activity/stage
Hung et al. [3]	Middle (14-15age) geography	Non-formal reinforcement in de-contextualized curriculum by linking actuality to school learning	Social constructivist	SecondLife Collaborative learning platform that leads to peers and thinking and messing around	Six Learning Curricular Sale of land by group Become a professional geographer
Jones, Scanlon[11]	Middle (12-16age) geography	Supporting the learner's personal inquiry		nQuire (web-based / mobile)	Group composition based on learner's choice
Marty et al.[13]	Grades 4 and 5 Science	Provide scientific inquiry opportunities within formal and informal learning environments Possibility of mobile learning		Mobile device Project website	Observation Raising scientific questions Background check Designing the Quest
song, wong [14]	Grades 3 and 4 Science	Learning in formal / non-formal environments 1 : 1 technology possibility search	Kolb's Experience Learning	In-house development mobile Learning environment	Culturalization Observation Reflection Data collection Experiment Recodification / evaluation

Table 2 shows typical examples of design examples based on the analysis framework. The subject of the design was mainly the subject emphasizing learning in everyday life such as science and geography. The technology applied to the design cases is commonly applied to mobile technology and devices. The use of the term 'seamless learning' in mobile technology is emphasizing the fact that learners support the maintenance of connectivity with other learners and teachers regardless of their time and location. Problem space representation or conceptual modeling, comparisons between knowledge and experience, and virtual space, game-based learning platforms provide a learning process. Currently, educational applications such as smart phones in Korea are directly related to the interest in smart education. In Korea, various research efforts have

been carried out on theoretical review of smart education, development of smart education support policy and finding a practical plan. Kwon Mi-kyung [15] has developed a smart education system for students who have difficulty in performing their studies. Other than that, the main focus is the development of a smart education model linked to STEAM. Therefore, this research project designed and implemented a method of direct learning by linking education in school and informal experience outside school. Educational programming languages differ from general-purpose programming languages. General-purpose programming languages are used in the practice of industry and are used for commercial purposes by people who have received specialized training. These general-purpose languages have complicated contents of grammar, a large amount thereof, and various packaged applications exist. Educational programming languages, however, need to be easy and easy to learn without the need for complexity or ambience. Therefore, this paper designed and implemented a method of direct learning by linking education in school and informal experience outside school.

2.1 Educational programming language

Educational programming languages differ from general-purpose programming languages. General-purpose programming languages are used in the practice of industry and are used for commercial purposes by people who have received specialized training. These general-purpose languages have complicated contents of grammar, a large amount thereof, and various packaged applications exist. Educational programming languages, however, need to be easy and easy to learn without the need for complexity or ambience. Materson [16] is an element of the educational programming language. First, for simplicity, educational programming languages should be easy to learn and be able to solve simple problems. Second, it must be able to solve complicated problems easily and easily with robustness. Third, compatibility must be easily transferable to other areas such as word processing, statistical packages, and other programming languages. Fourth, language should be rich in imagination, free expression, variety of application, and extensibility. Cho Han-hyeok [17] emphasizes that it should be a friendly language for conversation as an element of educational programming, and should be able to use Hangul freely in a programming environment. An interpreter language is suitable for a conversational environment. Something must be provided to communicate between the computer and the student, but a graphical environment is needed to learn such as mathematics. Thus, scratches are well-suited for educational programming languages.
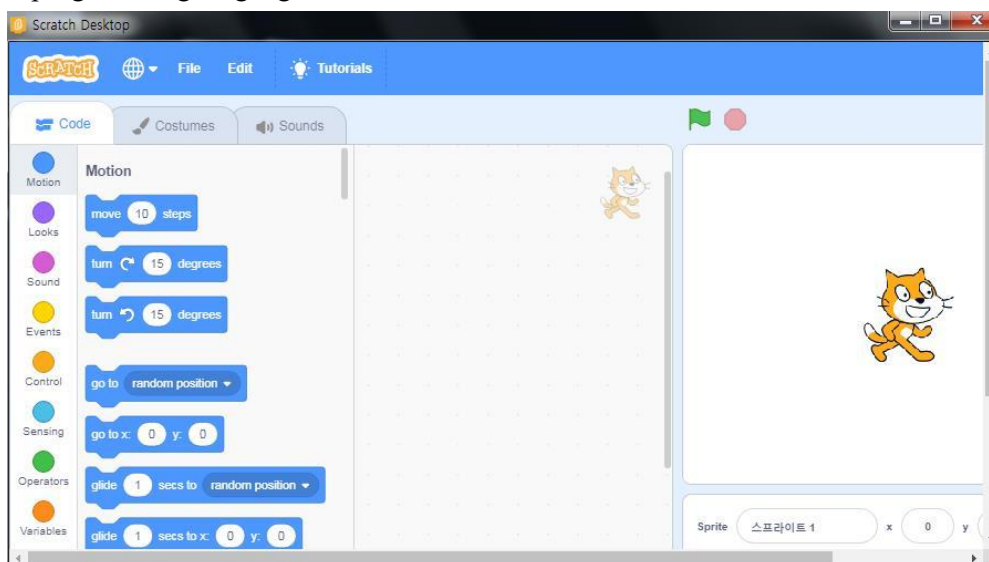

Figure 1. Scratch 2.0 programming

2.2 Scratch

Scratch is a global educational programming language developed by MIT in the United States for students ages 8 to 16. Although existing programming education has received negative recognition from learners and teachers because it takes a lot of effort and time to learn, educational programming languages such as scratch are easy to understand in most ages, easy to learn, and intuitive programming [18] . In addition, since multimedia support is provided and the efforts of various users have made it possible to support almost perfect Korean language recently, it is possible to use it in various fields such as programming education. The characteristics of scratch are as follows. Figure 1 shows the execution screen of Scratch 2.0 used in this research project. First, in Scratch, you can easily and conveniently define multiple objects. You can program these objects in a script area by calling them as sprites and dropping the desired block elements out of the eight color-coded scratch blocks in each sprite. Each block has a groove that can be fitted to each other, and another block can be placed inside, so that there is no syntax error, and the program area in the sprite can be immediately checked through the stage area. Second, the scratch is created by a scratch project that includes various graphics and sounds using a script composed of several code blocks. The fact that scratch is prominent is the intuitiveness of the object and event programming process. Third, it is possible to embed rich media such as pictures and sounds, so that it is possible to learn programming with fun. When you select the Picture tab in Scratch, you can view or edit the picture of the sprite. Scratch supports JPG, BMP, PNG, and GIF image formats. You can also edit the sound of the sprite using the Sound tab. You can read MP3 files and uncompressed WAV, AIF, AU files, share your productions with others in programming with great sharing, and share them on all types of devices like desktop, mobile, tablet. Fourth, it can support various languages to enhance sharing and ease of use. Since the version of Scratch 1.3 that was released in September 2008, Hangul is supported, so it is easier for elementary school students who are used to English language to use the scratch without programming difficulties. Scratch can be used to create various results by using objects called sprites, and it is intuitive to see the result of programming through sprites. Therefore, it satisfies the creativity and friendly dialogue language that is the element of educational programming language Giving. Students will learn how to select, create, and manage various types of media, such as images and animations, while creating research tasks using scratch. And creating and designing a project through scratch is a process of creating something unfamiliar to the learner, which improves the problem solving ability of the learner.

3. DESING AND DEVELOPMENT OF SCIENCE EDUCATION PROGRAM

3.1 Learning stage design

In non-formal learning, learners cross learning environments in and out of school, and there are multiple environments, so learning is done in consideration of multiple interactions. Table 3 summarizes the teaching and learning stages of science education and technical education for designing the learning stage for applying the integrated education program and the non-formal integrated education program using scratch [17].

Table 3. Science inquiry and engineering stage

Science inquiry phase	Engineering stage
Present selected issues	Define the problem
Prior research related to problems	Prior research related to problems

Set various hypotheses and then select a solution	Set various hypotheses and then select a solution
Perform an experiment	Create and test
Modify the hypothesis based on the results	Redesign solution according to test result
Make conclusions and record results	Design and drawing
Submit and evaluate results	Delivering results
Ask a new question	Define a new problem

Figure 2 is a creative and comprehensive design stage presented by introducing the concept of creative integrated design education in Korea Science and Technology Foundation. In order to apply and practice the problem solving in real life with the content of the lessons learned at school, active use should be assumed. In addition, it should be designed so that it can act as a rich experience of the learner, and learning should be done as an accelerator for active learning through it.
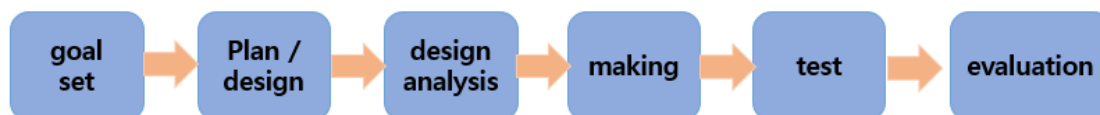

Figure 2. Create design stage

The steps of creative overall design consist of goal setting, planning and design, design analysis, production, testing and evaluation. In this research task, the program was designed by setting four learning steps as shown in Figure 3. As shown in Figure 3, the design stage was applied to the learning design.
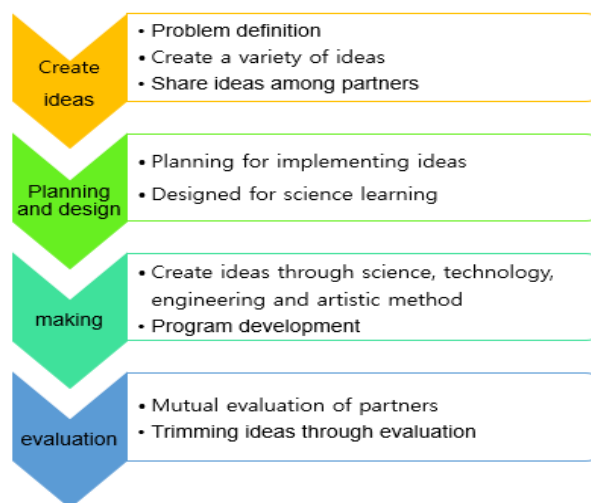

Figure 3. Learning design 4 steps used in this paper

The learning design stage used in this research project consists of 4 steps: idea generation, planning and design, production and evaluation. In the idea generation phase, you can create various ideas and share ideas among cooperators and team members. At the planning and design stage, a plan for the implementation of the idea is established and the learning is designed using the design methods necessary for the science learning.

The production stage and the evaluation stage are stages of completing the idea creation through the production and modification work from time to time, and there should be mutual evaluation and feedback, and the feedback is used to refine the idea.

3.2 Learning program design

The science education program proposed in this study shows the result of the process of programming using ICT device using scratch programming and was developed by setting the following basic directions.

3.2.1 Curriculum analysis

Scratch is very easy to implement a program that represents motion and state changes, such as games and animations. In the 3 units that corresponded to the "abstention and our life" of the 2-1 textbooks of middle school science, problems were extracted and used for education that utilized scratch. Table 3 categorizes them into sub-sciences.

Table 4. Secondary science 2-1 3unit, abstention and our life

stage	question
Science	Q1. There are many gases that are part of atmosphere. Four of the gases in the example are the main gases that make up our atmosphere, but one doesn't include in this. Choose the one that is not part of the main gases in the atmosphere.
	Q2. There are two kinds of pressure: high and low. Choose the answer that explains about low pressure system correctly.
	Q3. The types of clouds are determined based on how high they are located. Which one is included in mid-level clouds?
	Q4. Precipitation is form of H_2O that falls from clouds. Name all 6 types of precipitation.
	Q5. A weather front forms when cold and warm air masses meet. Name 4 fronts and talk about each of weather.

3.2.2 Goal of development

Using the design method shown in Figure 3, the learning activities were designed and developed according to the steps, and they were modified several times. The science education program proposed in this research project, was developed by using the smart device that can use scratch as follows. First, the education program selects the experiences in the non - formal situations related to the content of the science class at the school and develops it by integrating with the class activities. Second, it provides learning tasks linked with science textbooks, and allows them to interact with other people, including friends, and to reconstruct individual experiences. Third, we provide diverse knowledge to effectively support learning activities. It also supports self-development through guidance materials that explain the program, questions that support the student's learning process, and incorrect answers. Fourth, provide various ICTs and programs for students to utilize the tools in activities such as information retrieval, sharing, and reconstruction of knowledge, communication, and production.

3.3 Development of educational programs

Table 4 shows the flow of learning activities and categorized science problems. In particular, scratch was used to think that scratch is easy to make a program, and that a variety of artistic activities are involved in program production. In order to develop this research project, we have supplemented the existing open source program.

Table 5. 3 unit of secondary Science 2-1, abstention and reconstruction of life

Step	Subject	Using scratch
Create ideas	Fun story composition	Create a free story
Plan design	Abstention	Creating a storyboard
	Water in the atmosphere	- Story scene picture
	Weather and change	- Write description
	Pressure and wind	- Writing science problems
		- Thinking about algorithms for implementation
Making	Scratch program completion	Completing the program
		- Writing the manual
		- Completion on storyboard
Evaluation	Run scratch program	Sharing completed programs
		- Mutual evaluation between partners
		- Share your completed ideas

At the idea creation stage, I thought about the programs that I wanted to freely make and thought about as many ideas as possible. During the planning stage, students were asked to write based on the various scientific problems presented in the textbooks. Each question can be written and freely written.

Table 5 shows that the learner designed the problem by choosing one of his studies. In the production stage, the problem was created by using scratch directly using the storyboard created in the meantime.

3.3.1 Learning environment

The program used for the learning program is the offline version of scratch 2.0. The scratch 2.0 can be programmed on the web unlike the existing scratch 1.4. However, because of the difficulty of using the Internet depending on the educational environment, I took advantage of the offline editor of scratch 2.0 [18] that can be programmed offline. The program production platform used PC of Windows 10 OS environment.

3.3 2 Science quiz program

The developed science quiz program stores the quiz problem, quiz view, quiz answer on the list, and the moderator introduces the quiz. The quiz writer will explain the quiz problem and the example, and the student will see the quiz and run the quiz.
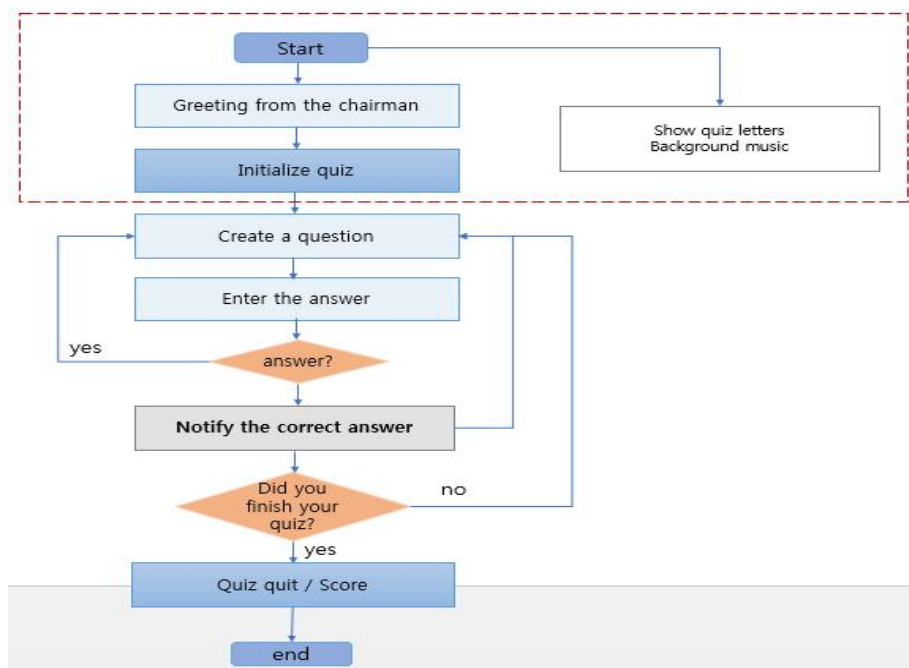
Figure 4. Algorithm of science quiz program

Algorithm of science quiz program

Figure 4 shows a flowchart showing the algorithm of the science quiz program. In the flowchart shown in Figure 4, when the quiz is executed, the part indicated by the red dotted line introduces the quiz in the greeting by the moderator, shows the letter QUIZ and plays the background music. You can also initialize greetings, quizzes, quizzes, and quizzes, respectively. If you answer the quiz question and view the answer and answer is correct, explain to the student, and then proceed to the next quiz question. If it is not correct answer, it informs the student that the answer is incorrect and gives the correct answer to the student. When the prepared quiz is solved, the quiz ends after the moderator informs the end of the quiz and the score. Since the developed program is executed as a moving picture, this paper explains using the picture file capturing the situation according to each menu. Table 6 shows the variable names and list names generated by the developed program.

Table 6. Variables and lists to generate

Variable name to create	List name to create
X coordinate	Greetings
Number of characters	Quiz problem
Issue number	Show quiz
Greeting count	Quiz answers
score	Wrong answer notebook

Figure 5. Problem input scratch script

Figure 6. Create correct and incorrect scratch scripts

Figure 5 and 6 show the created scratch source for inputting Korean and English science quiz questions. After connecting the blocks, create and select the <Correct> message, and create and select the <Correct Answer> message below. First, we concatenate the blocks, select <problem number>, and enter the value. The developed science quiz program stores the quiz problem, quiz view, quiz answer on the list, and the moderator introduces the quiz. The quizzer will explain the quiz problem and the example, and the student will see the quiz and run the quiz.

In the evaluation stage, we solved the problems we created and enjoyed the events, displayed the creations, and made the evaluation possible so that we could refine them more finely by sharing the completed ideas.

4. Conclusion

This study designed a scratch-based science learning program using non-formal learning experiences and developed a learning program using scratches according to design methods. Since it is very easy to implement a program that expresses the movement and the state change such as game or animation, this study used the problem of the science textbook and used it for the education using the scratch. And categorized them into the same subject for the subdivision of science. This study designed and implemented a method of user's learning by using ICT device in school and informal experience outside school. In this paper, we can learn how to create and manage various media by using scratch, and creating and designing a project can improve problem solving ability and interest to learners. There is also an additional need for research to analyze the impact that this program can have on science by providing it to students. Also, it is necessary to study the satisfaction of the experiment group and the comparative group by using the program, and to conduct the objective test after applying the educational program using scratch.

Acknowledgement

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