Effect of STEAM Education Program Using Flexible Display

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***Abstract*—The need for STEAM education has increased as an educational law of Mathematics, Science and Information Education was promulgated in April 2018, and applied to the revised curriculum of 2015 in Korea.**

Development of a STEAM program using flexible display expected to be a suitable tool for mathematics, science and software classes. In this research, we developed Flexible Display Programming tool based on scratch 2.0. Based on that software we designed STEAM educational program for elementary, middle school students.

Satisfaction measurement of this program shows that there is enhancement of the attitude to science and mathematics. Moreover, qualitative measurement confirms the possibility of the suggested method of education in Science, Technology, Engineering, Arts and Mathematics.

***Index Terms*—STEAM education, flexible display, software, arduinoscratch, mathematics, scaffolding.**

I. Introduction

Visual information can deliver a large amount of information to the human brain. Flexible display is called "dream display device". It is considered the third-generation display device following the first-generation CRT and second-generation flat display devices. It can be used in a variety of situations, such as next-generation smart phones and wearable computing. Therefore, the experience of solving real-life problems using this flexible display is important in understanding the world to come.

In April 2018, Korean Government published the law which promotes Mathematics, Science and Software Education [1]. The law aims to foster creative talent through convergence of two or more subjects. STEAM education is recognized as a converged problem-solving method. It is also considered as a way to develop creative problem-solving skills in the future. People believe that STEAM education showed the possibility to develop creative problem-solving skills through a convergence of mathematics, science, and software education programs. The study revealed that elementary school teachers' level of STEAM awareness was low in 600 elementary schools. Moreover only one percent of teachers has experience of STEAM classes. Regarding the result, the teachers' statements showed that it is because of the burden of preparing the class and the barriers to teachers and students' technology and related educational tools.

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Therefore, this study aims to develop the programming environment based on scratch 2.0which provides scaffolding for Flexible Display programming. So, programming novice can program the Flexible Display.

II. Theoretical Background

A. STEAM Education

STEM is the term first used by the National Science Foundation (NSF) as an abbreviation for Science, Technology, Engineering and Mathematics. STEM has occupied important position in reforming science education worldwide today since it frequently appears in educational policy and educational research. John [2] (2000) noted that STEM education neglected the area of cognitive science related to creativity, and arts [3]. Maes(2010) also stated that arts and humanities must be included in order for the results of the convergence of science, technology, engineering and mathematics to realize individual creativity [4]. So, the STEAM education added Art to STEM.

STEAM education was proposed as an important educational policy direction for solving the low motivation for science learning and the phenomenon of avoiding science and engineering [5]. Regarding teaching and learning methods for STEAM education, Sanders (2009) emphasized the importance of an integrated approach based on mutual communication and cooperation among subjects, not on individual education in science, technology, engineering and mathematics [6].

The "Learning By Design" educational program, developed by the American Society of Engineering Educators and supported by NASA and the US National Science Foundation, is a practical problem-oriented science and mathematics application program centered on content and problem solving processes in technology and engineering [7].

B. Flexible Display

Flexible Display allows to be used in a bendable form. WS2812 and SK6812, commonly used as LED driver chips in Flexible Display. It has the following features.

- It is possible to be controlled with 4 pins.
- The price is very cheap.
- Various libraries have been developed.
- Refresh rate is not high.

This research is based on flexible displays based on WS2812 and SK6812 chip, which is inexpensive and it has 4 connection pins.

C. Flexible Display Programming Environment

Flexible Display using Open hardware can be programmed

using C++. Fig. 1 shows the Flexible Display programming screen.

Fig. 1. Text based flexible display programming.

However, it is not suitable for programming beginners. Therefore, in this research, we develop a block-type programming interface for open hardware.

III. Research Method

A. Research Subjects and Evaluation Methods

The subjects of this study are 790 elementary and junior high school students.

Table I shows the study subjects and the application period of the developed education program. STEAM standard attitude change evaluation is applied before and after evaluation method. The evaluation period is from May to June, and the post evaluation is conducted within one month after the program is applied.

TABLE I: Research Subjects and When to Apply the Training Program

division	Applicable grade	Number of people	Application date
elementary Grades 1 and 2	1 Grade	90	September to November
elementary Grades 3 and 4	4 Grade	240	
elementary Grades 5 and 6	Grades 5 and 6	120	
middle School	1 Grade	340	
Sum		790	

B. Education Program

STEAM program using Flexible Display is shown on Table II. This table show the details. It contains main activities of the grade group. The learning activity take 3 hours.

Learning activities emphasize the creativity of students. Students make and create with flexible display. According their purpose, they should code the flexible display.

TABLE II: Education Program

Grade group	Subject	Main activity
elementary Grades 1 and 2	Create a shape with a light point.	• Find ◯, □, △ shapes and understand features. • Looking for ◯, □, △ shapes in your life. • Expressing ◯, □, △ shapes in a grid. - Understand the features of the ◯, □, △ shapes. • Create the ◯, □, △ shapes. • Understand the concept of digital pixel. • Identify the pixel as a bright point. • Draw ◯, □, and △ with light points. • Create various patterns with the ◯, □, △ shapes made of light points. •Decorate your classroom with light points. • Use ◯, □, △ shapes to create a variety of creative shapes. • Enjoy classrooms decorated with ◯, □, △ shapes. • Respect each other's work and give positive feedback.
elementary Grades 3 and 4	Draw shapes on Flexible Display.	•Learn about the features of flexible displays through storytelling •Find out the difference between a bending smartphone and a commonly used smartphone. •Draw Points, Straight Lines, and Diagonals on Flexible Display. •Learn the concept of shapes by looking for regularity and counterclaiming. •Learn about the different rectangular features and draw them on a flexible display. •Learn more about the various pattern designs. •Create beautiful polygon patterns through programming. •Create a work by attaching a flexible display to other objects •Watch other friends' works and find out what shapes they used.
elementary Grades 5 and 6	Find the width of a shape with a Flexible Display.	• Learn what Scratch code Blocks mean. • Draw multiple lines, rectangles with scratch code blocks • Create a Rectangular shape using the Scratch Command Blocks • Find out how to obtain a rectangular width by creating a rectangle on a flexible display. •Create your own creative pedestrian traffic lights by utilizing different types of rectangular shapes using a flexible display. •By applying SCAMPER techniques such as substitution, coupling, application, removal, modification, enlargement, shrinkage and rearrangement, plan and create my own creative pedestrian traffic light. •Evaluate your friends' work to see what's good and what's to be complemented.

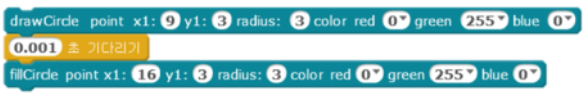
Middle school grade 1	Making works using principles of light synthesis	•Draw shapes (triangle or square, rectangular) on a flexible display and know the scratch code blocks that fills the face with color. •Check each color using the RGB value of the scratch code blocks. •Create a program that is illuminated by a certain value of the sound sensor. •To change the sound sensor reading of the scratch code blocks and to check the LED's on, off •Create LED wearables that respond according to the size of sound by group. •Experiment with principle of light mixing using pixel programming of Flexible Display. •Understand the principle of making color in digital display technology •Experiment with principle of light mixing using pixel programming of Flexible Display. •Understand the principle of making color in digital display technology.
Exam-free semester	Send a message expressing your heart to the board by mobile	• Design various messages to communicate with friends. • Know what Scratch command blocks mean • Click on each of the scratch command blocks to see what happens. • Draw multiple types of lines with scratch command • Draw lines with different colors and positions • Know the block where the scratch command block fills the face with color •Click on the scratch command block to see how the face is filled •Understanding blocks for sending text to mobile devices using Scratch •Try running an example and understand the meaning of the block •Try using Scratch to practice sending text messages to your mobile device •Using a mobile device to send an English message with Scratch programming

C. Flexible Display Programming Tool

The Flexible Display programming tool consists of 22 blocks. Blocks can be classified into four types.

They consist of declaration of flexible display type, drawing figures, writing a sentence and effecting to Flexible Display.

Fig. 2 shows an example of the Flexible Display programming block and the execution result.



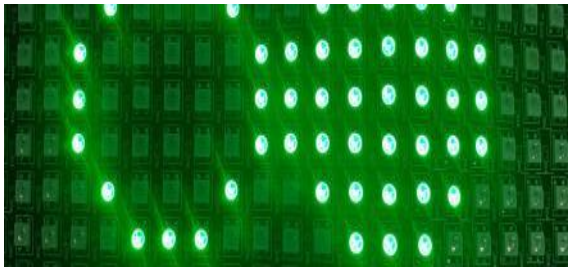


Fig. 2. Block code and execution result.

IV. Conclusion and Discussion

A. Satisfaction Measurement Results [7]

Table III is the result of a paired-test on the pre - and post - examination of attitude changes to science, mathematics through a steam program.

The significance level is [P*<.05].The test showed a significant result in the questions 5,8, 23, 35, 36, and 40. "I like science." and "Knowledge of mathematics is helpful in everyday life." have shown that we have achieved the original purpose of STEAM program.

Especially, we can see the characteristics of the STEAM education program through the results that mathematics and science have improved at the same time.

The results of questions 34 and 40 showed that students did not like mathematics, but they like the mathematics contents of this STEAM education program.

TABLE III: Paired t-Test Result (Paired Difference of Pre-post)

n	Question	Paired t-test			
		Mean	Standard Deviation	t	p-value
1	I like the contents of science class.	-0.17	0.98	-1.97	0.051
2	I am confident that I can understand the contents of math.	-0.04	1.18	-0.37	0.712
3	I like math activities (such as math experience activities, solving math quiz questions, or reading math-related books).	-0.16	1.33	-1.38	0.170
4	It's great to have a science-related job.	-0.12	1.06	-1.24	0.217
5	I enjoy studying science.	-0.21	1.05	-2.25	**0.026***
6	I am confident that I can understand the contents of science.	-0.08	1.02	-0.86	0.390
7	I enjoy finding and reading information or books about science.	-0.12	1.38	-1.02	0.310
8	I like science.	-0.22	1.12	-2.19	**0.03***
9	I am interested in a job related to mathematics.	-0.07	1.44	-0.55	0.584
10	I enjoy science-related activities (visit science museums, participate in scientific events, and read science-related books).	-0.06	1.21	-0.58	0.562
11	I share my science experiment tool with other friends.	-0.08	0.84	-1.04	0.299
12	It is important to share ideas with your friends when you are gathering in science class.	-0.08	0.87	-1.01	0.314
13	Studying science will help you study in middle and high schools in the future.	-0.15	0.93	-1.89	0.061
14	I like the contents of math class.	-0.14	1.30	-1.22	0.226
15	I listen carefully to my friend's presentation in math class.	-0.07	1.20	-0.66	0.513
16	I enjoy finding and reading information or books about math.	-0.22	1.48	-1.72	0.088
17	Math helps to study other subjects.	0.11	1.23	1.00	0.322

18	I respect the opinion of my friend who has different opinions in math class.	-0.12	1.06	-1.33	0.187
19	It's wonderful to have a job in math.	0.02	1.31	0.20	0.841
20	I also take a deep look at other friends' positions when I make an opinion in science class.	-0.12	0.93	-1.51	0.135
21	I enjoy studying math.	0.04	1.48	0.30	0.768
22	I actively share my opinions with my friends in math class.	-0.01	1.26	-0.07	0.945
23	I actively share my opinions with my friends in science class.	-0.23	1.16	-2.27	**0.025***
24	I think science is easy.	0.02	1.37	0.19	0.848
25	I actively express my thoughts in math class.	-0.05	1.34	-0.46	0.647
26	I listen carefully to my friend's presentation in science class.	-0.09	0.99	-1.06	0.291
27	I am confident that I can solve math problems well.	-0.10	1.39	-0.82	0.414
28	I have a quick understanding of the math content.	-0.10	1.39	-0.82	0.414
29	Science helps you study other subjects.	-0.02	1.07	-0.25	0.806
30	I have a quick grasp of the contents of science.	-0.06	1.19	-0.59	0.555
31	Knowledge of science is helpful in everyday life.	-0.05	1.09	-0.56	0.573
32	It is important to share ideas with your friends when you are gathering in math class.	-0.01	1.15	-0.08	0.939
33	Studying math will help you study in middle and high school in the future.	0.05	1.18	0.52	0.603
34	I like math.	0.01	1.60	0.06	0.956
35	I am confident that I can solve science problems well.	-0.23	1.20	-2.19	**0.031***
36	I am interested in a career in science	-0.28	1.31	-2.41	**0.018***
37	I actively express my thoughts in science class.	-0.17	1.20	-1.61	0.109
38	I think math is easy.	0.11	1.52	0.81	0.421
39	I also take a deep look at other friends' positions when I make an opinion in math class.	-0.05	1.16	-0.45	0.651
40	Knowledge of mathematics is helpful in everyday life.	-0.38	1.35	-3.24	**0.002***

*P**<.05

B. Discussion

After applying the program, the students were interviewed as follows.

"Combining a science and software class was interesting experiences, so we became interested in Flexible Display."

"Although I had a hard time at the class since it was the first time. After I had experienced it, I felt like growing up."

"It's fun to actually experience the technology we've only seen in movies, and I'm interested in programming."

"It was amazing for me to code Flexible Display myself. It was challenging task for me, but it was good time when the work was completed."

"I was amazed to see the Flexible LED."

"When I am coding myself, it was fun to see a variety of lights from the Flexible Display."

By the students' interview, we conclude that students extend their understanding of Flexible Display and confirm that they accepted it as a new way of learning.

The results of statistical analysis and qualitative measurement show that Flexible Display have an impact on STEAM. However, further studies are needed on the effects of long-term classroom application, gender differences.

C. Teacher's Opinions after Applying Steam Program

After applying the program, the teachers were interviewed as follows.

"It was half-believing at first to learn using a new method that was not previously available, but as a result of its actual application, innovative methods of learning could be found to be possible if applied to the school."

"There should be an easy way to purchase the necessary tools for learning."

"Through the program, students were able to connect science and coding and also improve their ability to think in a more integrated way. And it was an opportunity to pay attention to the career path involved."

"I was able to conduct a really fun class by watching them succeed and help out with their desired works by directly controlling and creating the technological field that can be enjoyed by the development of science, instead of only exploring simple principles."

"As a teacher, I also enjoyed turning on the lights as much as I wanted to on the Flexible display, and the process of controlling with a smartphone was really new."

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