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Classroom practices of low-cost STEM education using scratch

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Abstract

Aim: The purpose of this study is to demonstrate the potential of Scratch for STEM instruction. Drones and mobile robots can be navigated using Scratch. Mobile robots and inexpensive drones are also available. The author suggests a budget-friendly STEM education. Scratch is a great way to introduce kids to computer programming. The STEM disciplines can also be taught with Scratch. The research here suggests using Scratch as a low-cost tool for STEM education.
Method: The current investigation employs a qualitative descriptive strategy. The Scratch app was developed and used with kids to achieve the results. **Findings:** The results demonstrate that STEM education through Scratch can be provided at a lower cost. Learning occurs in a group of 6 or 7 students when a teacher assigns a task in which robots must move forward while dodging obstacles built from LEGO bricks. Each student can focus on the assignment at hand with the help of a low-cost mobile robot, should the instructor choose. If the instructor decides to use Scratch exclusively, students can engage in activities requiring them to think critically about the problem.
Implications/Novel Contribution: Creativity training is at the heart of STEM curricula. Many Japanese cities host annual robot competitions. A robot-building competition is a fun way to encourage original thought. As a result, more students would benefit from learning to code. Inexpensive mobile robots and drones that can be piloted with Scratch are becoming increasingly popular. Less expensive teaching materials are necessary if we force each student to engage with the issue.

Keywords: Classroom, Low cost, STEM education

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INTRODUCTION

Japan's STEM education lags behind that of other developed nations, according to a 2016 comparative study cited in (Omori, Isobe, & Yamazaki, 2016). By 2020, the Japanese Ministry of Education expects all pre-university institutions in the country to offer computer programming courses to their students. This already-existing subject is supposed to incorporate a certain way of thinking about programming. In contrast, elementary school educators are presently in a bind. In particular, educators in the liberal arts have little experience teaching computer science.

That's why I've been retaking elementary school courses numerous times over the past few years. Scratch and JavaScript are used in these lessons. Scratch is an accessible visual programming language for primary school students. Drones and mobile robots can be controlled with Scratch because the programming language supports reading expanded blocks. In my opinion, Scratch can be used in science, technology, engineering, and math classes.

This paper demonstrates the application of Scratch to STEM instruction.

STEM EDUCATION USING MOBILE ROBOTS

Old Style

From what I've seen, a LEGO robot is the most well-known mobile robot. Market share for LEGO MINDSTORMS Education EV3 is high. However, the price is rather steep. The price of the starter kit in Japan is 57780 yen (USD 547). The cost of 1 unit per student is prohibitively expensive for classroom use. In my classroom, I distribute one unit for every seven students. The presence of children who do not actively seek physical contact during group activities is problematic.

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Following the heavy black line is a common assignment given in class practice. Going from the black zone into the white zone causes the LEGO robot to make a right turn while going from the white zone into the black zone causes it to make a left turn. Following the white and black lines, the LEGO robot zigzags. The following step is to advance past the zone delimited by the blue and red lines. When crossing from white to blue, the LEGO robot makes a right turn, and when crossing from white to red, it makes a left turn. The LEGO robot will continue forward, avoiding the barrier you just placed between the blue and red lines. Children can learn much from these tasks, encouraging them to learn through trial and error.

New Suggested Style

LEGO robots are expensive, so I suggest cheaper robots. PROTCH (Yamazaki, 2019), which is created by Yamazaki Corporation (http://www.yamazaki-kk.com), is a cheaper robot. The robot image is shown in Figure 1. It is sold in Japanese yen at 3500 yen (USD 33). It has two touch sensors, two light sensors, two (Light Emitting Diods) LEDs, one buzzer and two motors. Arduino board is included in PROTCH. ProtchEditor can program the movement of RPOTCH. Its display image is shown in Figure 2. Protch Editor was created by Massachusetts Institute of Technology (MIT) and is based on the Scratch 2.0 Offline Editor. It uses Adobe AIR and Arduino IDE.

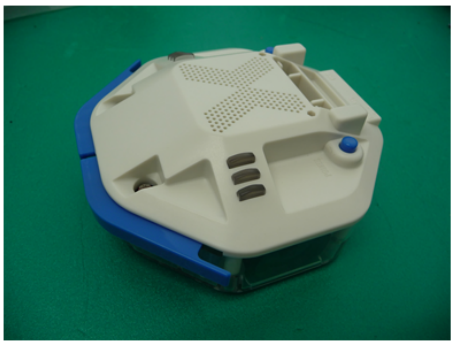

Figure 1. An image of PROTCH

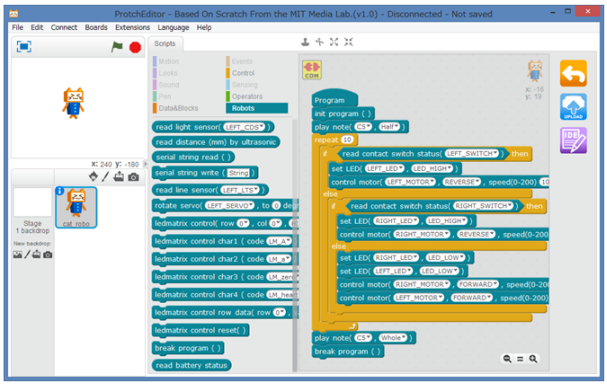

Figure 2. A display image of protch editor

STEM EDUCATION USING ONLY SCRATCH

Teaching Materials

A movement similar to a mobile robot can be realized using Scratch. However, the sensors that can be used are limited. It can be used as a sensor when certain events occur. The events are when the Sprite touches the specified color, when a Sprite touches another Sprite and when a Sprite approaches the specified distance for another Sprite.

Figure 3. A display image of scratch appli

Therefore, I made a Scratch application. The display image is shown in Figure 3. A child insect travels from left to right on the road surrounded by blue and red lines. I let elementary school students program the child insect to reach the parent insect. First, the children receive an explanation of the program when the road is straight. In that case, the program is completed by repeating the forward block. Next, children tackle the problem of scenes with curved roads. In that scene, the program needs to add a conditional statement that a child insect turns when it touches a blue or red line. Next, children tackle the problem of scenes that a frog appears in the center of the road. The frog eats the child insect, so the child insect must avoid getting close to the frog. In that scene, the program needs to add a conditional statement that a child insect turns when it approaches the specified distance for a frog. In Figure 3, Green button straightens the road. The orange button turns the road into a curve. Purple button puts two frogs on the road. If the user clicks on a frog, the frog moves off the road.

Figure 4. A scene where two frogs appeared

Classroom Practices

In June 2019, I practiced Scratch programming lessons for sixth graders in Kurima Elementary School. First, I gave a correct program when the road is straight. Next, I taught how to write conditional statements. After I taught how to bend when a child insect touches the red line, I let the children create a program of bending when a child insect touches the blue line. Next, After I taught how to avoid when a child insect approaches the specified distance for a frog, I let the children create a program of avoiding two frogs. The two frogs scene is shown in Figure 4.

With Scratch alone, children can program similar movements as when using a mobile robot. However, there is a difference in using a mobile robot. Scratch cannot assume physical troubles that occur during the operation of a mobile robot. Scratch Sprite works logically. Mobile robots are likely to move in trouble in the real world. Mobile robot slides on wheels when travel distance is less than planned. In STEM education, it is important to deal with real-world troubles. However, I think that ideal programming is enough for the beginning of STEM education. I think it will be useful for Scratch alone.

There is a problem when moving with Scratch. Judgment is made in the entire Sprite area to touch the specified color. Therefore, it happens that Sprite cannot get out of touching the specified color. The scene is shown in Figure 5. Depending on the parameters of the program that touches blue and then goes down and rotates to the right, it causes a movement to continue drawing a circle. Sprite draws a circle while backing behind. When using a mobile robot, this phenomenon does not occur because the sensor position is one point. Sprite's touch sensor is a whole aspect of Sprite, so it takes a technique to get out of sensing.

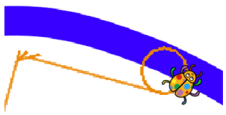

Figure 5. An example of trouble scene

The above troubles are likely to occur if the position of the frog is changed freely. Therefore in classroom practice, the position of the frog was not changed freely.

STEM EDUCATION USING DRONES

A Combination of Drone and Scratch

In recent years, children have become very interested in drones. People are more likely to get drones and see them more often. Therefore, using drones for STEM education can make children more attractive. I think that it will become STEM education if it is programmed and controlled rather than simply flying the drone.

Ryze Tello Powered by DJI (Tello, 2019) is one of the drones that Scratch programs can control (See Figure 6). It is sold in Japanese yen at 11664 yen (USD 110). An example of Tello programming in Scratch is shown in Figure 7. An example of a block that controls Tello is shown in Figure 8. As shown in Figure 7, Tello can be controlled by the Scratch program. The "Wait ○ secs" block in Figure 7 is absolutely necessary. If it doesn't exist, Tello will not be able to recognize the next block command. The waiting block is needed to be ready to accept the next command.

Figure 6. An image of tello

Figure 7. An example of tello programming

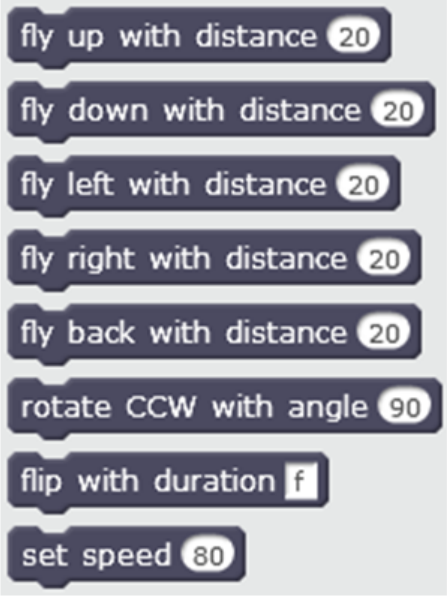

Figure 8. An example of tello blocks in scratch

A drone is difficult to fly manually. Training is required to control with the controller at hand. However, it is not so difficult to navigate with the Scratch program. In Figure 7, the drone takes off about 1m, moves forward 50 cm, rotates clockwise 180 degrees, moves forward 50 cm, and moves to land. This behavior is easy even for elementary school students.

The problem is that the drone is easy to drop and fragile. And there is no sensor in the drone. As shown in Figure 8, there are various movement blocks. However, because there are no blocks to detect some event, it is difficult to create conditional branch programs. A drone can attract children, but difficult to tackle difficult tasks.

Using Only Scratch

There is drone simulation software. If a program can be created with Scratch, it will show the simulation of the flying drone on the screen. (Discovery of Wheels, 2019a) is one of the simulation software that uses Scratch. The display image is shown in Figure 8. DroneSimulator2 works with the Scratch 2.0 offline editor.

DroneSimulator2 is free software developed by Rediscover of the wheel Inc., in Osaka.

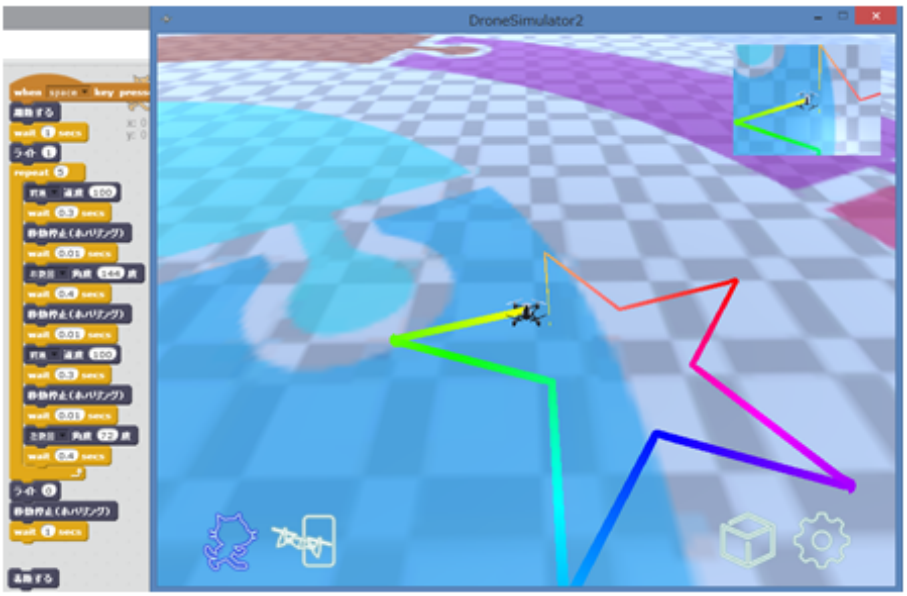

Figure 9. A display image of drone simulator2

If the File menu in the Scratch 2.0 offline editor while pressing the shift key is clicked, the Import experimental HTTP extension menu appears. Then, after selecting the Import experimental HTTP extension menu, it is necessary to load ScratchDrone_1.4.s2e file which can be downloaded from the DroneSimulator2 site. By using ScratchDrone_1.4.s2e file, the operation block of drone appears in Scratch. The simulation screen is displayed by executing the DroneSimulator2.exe file which can be downloaded from the same site.

This simulator can be used to draw figures in 3D space. After all, there is no block to detect events. It is difficult to create conditional branch programs. However, unlike the actual drone machine, there is no worry of hitting somewhere. Drawing figures in 3D space are very confusing. Making complex 3D movements can be difficult even for junior high school students. I think it is difficult to draw 3D donuts and coils in space.

DroneSimulator2 can control real drone (Parrot Mambo, Swing, Airborne Night/Cargo, Rolling Spider, Hydrofoil Orak) combining the Kidsdrone Android application. This information is a description of the website and I have not verified it through experiments. Parrot (2019) is sold in Japanese yen at 9201 yen (USD 86 dollars). I think it's attractive.

The same company also offers DroneSimulator3 (Discovery of Wheels, 2019b). DroneSimulator3 works with Scratch Desktop, which is Scratch3.0 Offline Editor. DroneSimulator3 uses a Web browser. It seems that it is currently under development, but it seems to be able to control Ryze Tello.

CONSIDERATION

The good thing about LEGO is that LEGO can assemble small blocks to solve a given problem. The completed mobile robot has no assembly phase. Because there is only a programming phase, it is not enough for STEM education. In order to have the phase to assemble, the equipment will be expensive and difficult to introduce to elementary school. Expensive equipment is difficult to introduce, and it becomes group learning for 6 or 7 people. It is better to use equipment that can be used by one person. I think it's better to teach programming to each person. I think the equipment proposed in this paper is recommended in that respect.

STEM education focuses on training creativity. Robot contests are often held in Japan. I think the robot contest is a good activity to cultivate creativity. However, robot contest activities are mostly club activities, and there are a few examples of activities in class. Therefore, only some students participate in the activities. I think it is better to use programming education to increase the creativity of more students.

There are various levels of programming using Scratch. The program described above, where insects escape

from frogs, was suitable for sixth graders. I think the program that uses ProtchEditor is suitable for fifth graders. Also, I think that the program that uses DroneSimulator2 to move 3D is suitable for junior high school students. I also had various other lesson practices using Scratch (Yamamori, 2019). For first graders, I had children draw a picture of Scratch Sprite (Yamamori & Yoshihara, 2016; Yoshihara & Yamamori, 2016). Then, after collecting the pictures, I show the moving scene of the picture. First graders can devise a drawing and know what the computer can do. I think that what children need to devise applies to STEM education.

For third graders, I was given the task of creating a program of movement from the entrance to the exit of some maze. They learned sequential and iterative processes and tried to shorten the program. For fourth graders, I was given the task of creating a program of moving around all the points like the traveling salesman problem. For the fifth-graders, I was given the task of creating a program of drawing a geometrical figure (Yoshihara & Yamamori, 2017), a beautiful figure or floor pattern. For sixth graders, I was given the task of creating a game program that answers divisors of integers. Children tried to make a program that works correctly. The key to programming thinking is to try to find the best solution among multiple correct answers. It is better for teachers to raise problems that children can consider multiple answers. The material given to STEM education is important.

CONCLUSION

LEGO is a good teaching material but expensive. STEM education using Scratch is less expensive. When a teacher gives a task that robots progress, avoiding obstacles, using LEGO results in learning by a group of 6 or 7 people. If the teacher chooses to use a cheap mobile robot, each person can work on the task. In addition, if the teacher chooses to use only Scratch, students can work on tasks that make them think more according to the given problem.

When conducting STEM education in class, the class is only 45 minutes. Therefore, many classes are used. STEM education, with work such as assembling small blocks, will take many class lessons. From that point, it is recommended to use only Scratch.

There are cheap mobile robots controlled by Scratch. And there are cheap drones controlled by Scratch. Those materials are very attractive. In order to make each child tackle the problem, it is important to use less expensive teaching materials.

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