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Geometry Learning Through Batik Reconstruction

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ABSTRACT

In this world, the shapes of objects, including Batik motifs in Indonesia, are regular and irregular. One of the regular Batik motifs is Surya Kawung Batik from Mojokerto. The purpose of this research is to observe the ability of the Electrical Engineering Department students in Maranatha Christian University to study and reconstruct the geometric shapes of Surya Kawung Batik. In the making of the Batik motifs, the research methods employed are survey, observation, exploration, testing, and improvement, while in the learning process, the method applied is descriptive qualitative, in which the researchers check the data credibility. Turtle graphics algorithm and mathematical calculations are used to form Batik geometric motifs. The result of this research shows an increase in the students' ability to learn the geometric shapes and to reconstruct digital Batik motifs which resemble the original Batik motifs and which can be stored using a smaller memory. If the memory for storing motifs is small, the required storage space will be more efficient.

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A. INTRODUCTION

Batik is a handicraft product from Indonesia which has artistic value and meaning in each motif. Batik as one of the local wisdoms in Indonesia has been recognized by the world. One of the characteristics of batik is its repetitive geometric shapes. The concept of geometry in Mojokerto Surya Kawung Batik motifs have been taught to elementary school students in the form of point exploration, straight lines, curved lines, zigzag lines, parallel lines, acute angles, obtuse angles, right angles, triangles, squares, rectangles, trapezoid, circle, oval, and folding symmetry. Providing education and literacy of the local culture can become an interesting source of learning (Islam & Mariana, 2021).

This research is in line with C. Kemmis and Mc. Taggart's two-cycle study, which shows improvement in the mastery of geometry concepts and measurement of Mathematics for fourth grade elementary school students carried out in Classroom Action Research (CAR). 25 fourth graders became the subject of the research. The instruments used were teacher's and students' observation sheets, along with the mastery of the concepts. The research results revealed that there was a gradual increase in the percentage of the students' achievement in their concept mastery. In the pre-cycle the percentage was 12%, and in the first cycle it became 40%, which then increased further into 84% in the second cycle. Thus, the expected mastery of the concept has reached the achievement indicators and it can be concluded that the application of Bruner's learning theory can improve the mastery of geometry and measurement concepts (Enggaringtyas et al., 2019).

The research conducted by Yusri and Arifin (2018) aims to design learning, especially the tools applied in the cooperative learning model in Bruner's theory on the subject of cubes and blocks. The design procedure itself used Mc. Kenney's cycle and it was combined with Dick & Carey's model, which includes 3 stages, namely the preliminary design, prototyping phase, and assessment phase. The designed cooperative learning tools based on Bruner's theory have been validated and revised three times so that they are feasible to use. The result of the limited trial shows that Bruner's tools and design prove to be effective and practical. Besides, the result of the cooperative learning design based on Bruner's theory is highly qualified.

According to a journal article written by (Bilai et al., 2019), early Mathematics education is the basic foundation of academic achievements in Mathematics for higher education. Digital technology can support the learning of children's mathematical concepts by exploring and manipulating concrete representations, so that digital activities provide opportunities for children to be engaged in experimental mathematics. This research studied the effects of digital learning tools on early childhood learning about geometric shapes. It also aimed to investigate children's progress in digital learning activities in terms of recognition and discrimination of basic geometric shapes. The results of this study indicate that the series of activities that was carried out helped children to achieve a higher cognitive ability, namely increasing their understanding through digital activities.

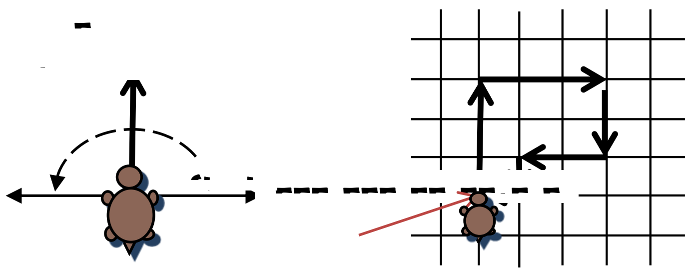
Furthermore, (Novita et al., 2018) stated that understanding Geometry and spatial reasoning is an important area of learning Mathematics. In addition, Geometry and spatial reasoning serve as the basis for most learning of Mathematics and other subjects, especially for students of early childhood. This research aims to design learning activities that can guide students in understanding Geometry and spatial reasoning, by doing several activities related to shapes. The results of teaching experiments unfold the fact that the developed learning trajectory has the potential to make a significant difference in early-childhood Geometry learning. It will also help children to relate their experiences of different shapes encountered in their lives to Mathematical knowledge (i.e., Geometry and spatial reasoning). This will enable them to rediscover and reinforce the concept of Geometry.

Furthermore, an article written by (Clements & Sarama, 2011) informs that understanding Geometry and spatial concepts is important for learning Mathematics at an early age, and it will support arithmetic skills as well as number concepts. The model proposed is TRIAD (Technology-enhanced, Research-based, Instruction, Assessment, and Professional Development). Biza (2011) conducted research on students' perspectives on the tangent to the function graph, especially in the transition from Geometry to analysis. In this study, an example of the function space uses the Dynamic Geometry software with Graph Tool Functions. The analysis of the data collected during the experiment focused on the evolution of students' understanding, especially the understanding of the tangent line to the function graph. The evolution of the students' understanding shows a non-linear result. This makes the researchers feel the need to improve the ability of engineering students in Maranatha

Christian University to develop their abstraction skills through a combination of learning from Mathematics, programming algorithms and arts as outlined in Batik motifs, which is a local wisdom and special feature of Indonesia.

B. METHODS

The methods used when making Batik motifs are survey, observation, exploration, testing, and improvement, whereas at the time of learning process, the method used is descriptive qualitative to check the credibility of the data (Annati, 2001; Goldman et al., 2013; Happonen, 2015). The method for digitalization used in the implementation are turtle and mathematics graphics (Goldman et al., 2013; Lindenmayer, 2004; Ratnadewi et al., 2021). Turtle charts are used for arbitrary Batik motifs and Mathematical graphs are used for Batik motifs that can be formulated using Mathematical equations (Chan, 2014; Dobashi et al., 2019; Fan et al., 2019; Hu et al., 2021; Widodo, 2020). Before drawing a graph turtle, the Batik motif is sketched first on paper and then the graph equation is formulated. The basic idea of turtle interpretation is given below. For example, in Figure 1(b), the turtle first faces upward and then it moves three steps forward. The turtle rotates 90° to the right and moves 3 steps forward, rotates 90° right, two steps forward and spin right 90° forward two steps, spin left 90°, go forward one step, spin right 90° forward one step. This command can be abbreviated as FFF-FFF-FF-FF + F-F, as shown in Figure 1.



(a) (b)

Figure 1. (a) Turtle interpretation of the string symbol F, +, -. (b) Interpretation of a string. Increased angle δ equals 90◦. Initially the turtle faces upwards.

Some simple Turtle Graphics commands are as follows:

1. Forward (10) is to move the Turtle (arrow) forward by 10 pixels.
2. Backward (5) is to move the Turtle (arrow) back by 5 pixels.
3. Right (35) is to move the Turtle (arrow) clockwise at an angle of 35 degrees.
4. Left (55) is to move the Turtle (arrow) counterclockwise at an angle of 55 degrees.
5. Goto(x,y) is to move the Turtle (arrow) to position x,y
6. Penup () is to disable the pen so that when there is movement of the Turtle (arrow) it does not create a graph.
7. Pendown () is to activate the pen so that when there is movement of the Turtle (arrow) it will create a graph.

C. RESULT AND DISCUSSION

1. Students' Ability in Learning Geometric Shape

The research begins with tutorials to the students concerning the theory of turtle graphics and the basics of programming. Furthermore, the students were asked to survey the Batik motifs that they would make. Then the results obtained were observed and compared with the Batik cloth/photo. The questionnaires were distributed and interviews were conducted to students of Engineering in order to receive inputs regarding the Batik motif making by using the turtle graphics algorithm.

At first, the students were given a photo of Surya Kawung Batik motif as well as a reference to the turtle graphics algorithm. Afterwards, they were asked to observe the shapes and sizes that would be made in the Python programming language with the turtle graphics algorithm. The students were given one week to make a Batik Surya Kawung motif. The results of the reconstruction would be collected and compared with the Batik motifs in the photo. The students filled out the questionnaires containing inputs on the students' experiences when doing the assignments. Based on the criteria of the shapes, sizes, and reconstruction, 25% of the students got good grades. On the other hand, 75% of the students were considered less able to express the Batik motif in the program that was made.

In the second stage, the researchers gave a tutorial on how to put the shapes of Batik motifs into the Python programming language. Afterwards, the students were given one week and they had to make Surya Kawung Batik motifs into the program again. The tutorial proved to be very helpful for the students as 90% of them managed to make the Batik motif into the program. From this observation, it can be seen that the students at first felt that the Batik motif was easy to make in the programming language. However, when they tried it themselves, there were some problems when they tried to lay out the lines and curvature of the curves. The same problem occured when estimating how many degrees the turtle had to rotate and how many steps it needed to take. Some students managed to learn by repeating the method for two or three times; yet, many could not figure out how large the steps and angles that needed to be taken. After the tutorial, the students were of the opinion that they gained more insights, which can be seen from the better result in the second chance.

2. Reconstructing Surya Kawung Batik Motif from Mojokerto

Figure 2 below shows Surya Kawung Batik cloth from Mojokerto. This motif is programmed with the turtle graphics algorithm to get a reconstruction of the digital Batik motif, the program will be run. At first, students were asked to observe the geometric shape of this Batik cloth. Then, this geometric shape would be written in the form of programming commands, using the turtle graphics algorithm. The program would be stored, so that the memory required would be smaller. If Batik reconstruction is needed, the program will be run, and the result will be used for Batik-making purposes. According to the questionnaires and interviews from students, the geometric motifs on this Batik have the shape of squares and curves. Moreover, there is a symmetrical feature as well as a 45-degree angle rotation. To shorten the command in the program, looping and distance calculations would be conducted according to the Pythagorean angle; hence, synchronized results would be achieved using the turtle's movement, as shown in Figure 2.

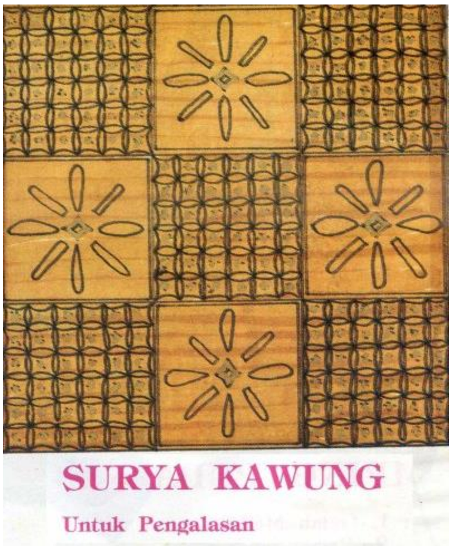


Figure 2. Surya Kawung Batik Motif from Mojokerto
Source: https://grahaBatik.com/motif-Batik-mojokerto-jawa-timur/70-contoh-motif-Batik-mojokerto-jawa-timur-terbaru-2020/

The motif design starts from observing the shape, measuring or scaling, designing motifs, testing program results, repairing, and so on. An example of the Surya Kawung Batik motif here is a square shape, which is made with the following commands:

```
for i in range(4):
  pd()
  fd(s)
  lt(90)
  pu()
```

What is meant by the commands is: Repeat 4 times to perform the command: lower the pen, go forward s steps (s is a constant representing the length of the desired side of the square), rotate it left by 90°, lift the pen. When the program is run, it will produce something as shown in Figure 3.

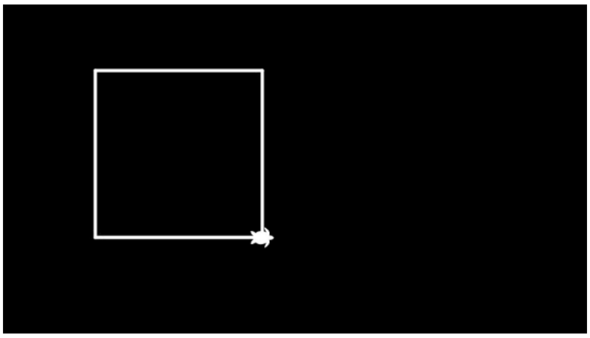


Figure 3. A square
Source: (Ratnadewi, 2022)

From the bottom right corner, the turtle will be moved to the center of the square by calculating half the slope distance of the square from bottom right to top left, the command is:

```
fd(s*math.sqrt(2)/2)
```

If the side of the square is s, then the diagonal of the square using the Pythagorean formula is:

$$diagonal = \sqrt{s^2 + s^2} = \sqrt{2s^2} = s\sqrt{2} \tag{1}$$

To calculate the half-diagonal distance, if s=200 is:

$$distance = \frac{s \times \sqrt{2}}{2} = \frac{200 \times \sqrt{2}}{2} = 141.4$$

What the command means is that the turtle moves forward 141.4 steps as shown in Figure 4.

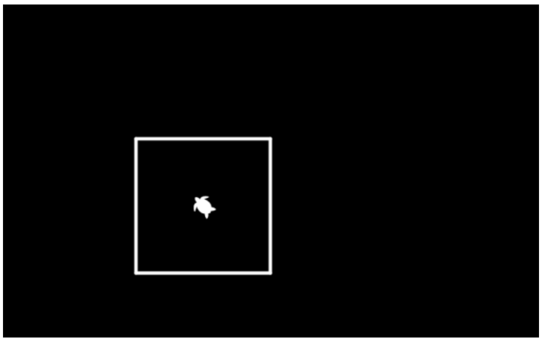


Figure 4. Turtle moves to the center of the square
Source: (Ratnadewi, 2022)

From the center of the square, the turtle will move to make the petals of Surya Kawung circle with a distance of 45° between each petal. The final result will look like Figure 5.

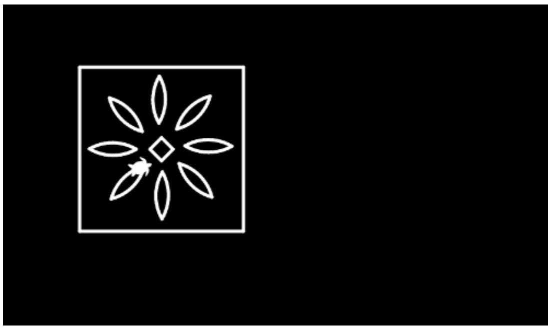


Figure 5. Turtle moves to produce a 45 degree shape between the petals
Source: (Ratnadewi, 2022)

The cloth motif is repeated to form a tiered rope as shown in Figure 5, with the following commands:

```
for i in range(7):
    strip()
    rt(90)
    fd(s/5.8)
    lt(91)
```

This command is executed for the horizontal and vertical sections so that there will be a rope as shown in Figure 6.

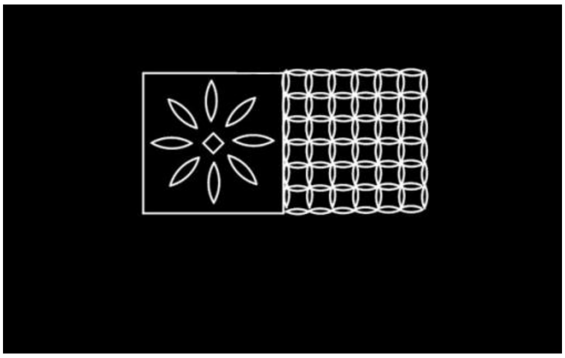


Figure 6. Surya Kawung Motif from turtle graphics
Source: (Ratnadewi, 2022)

After the basic motif is obtained (Figure 6), the repetition process can be carried out to make a reconstruction of the solar kawung Mojokerto batik as shown in Figure 7. Then this batik motif can be colored as shown in Figure 8.

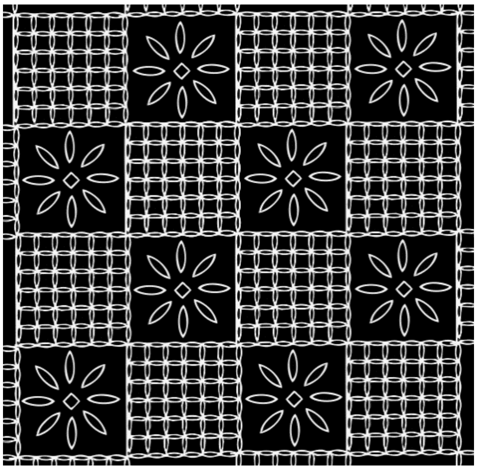


Figure 7. Surya Kawung Motif from turtle graphics reconstruction
Source: (Ratnadewi, 2022)

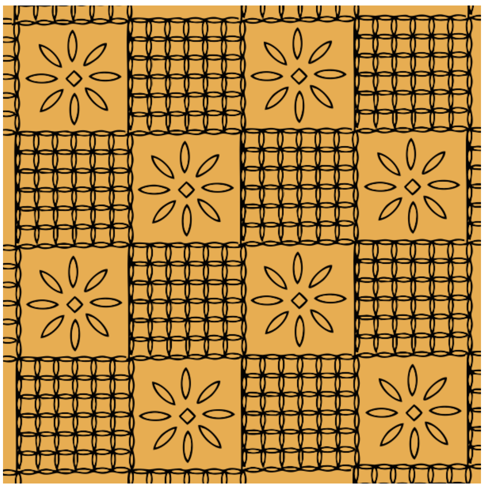


Figure 8. Surya Kawung Motif from turtle graphics reconstruction
Source: (Ratnadewi, 2022)

Through the observations of researchers, the art skills given to engineering students can increase patience, tenacity, willpower, because students need to repeat the process so that the batik motifs produced are in accordance with the original motifs. Geometric perception skills, abstraction skills, and the ability to transform from seeing batik patterns into programs to form mathematical graphs or turtle graphs are also required. Cooperation while studying also seems to foster social character, sincerity in sharing and sincerity in asking questions. Students who are already able to make programs to form batik motifs can provide direction to other students. Male and female students have the same ability to learn it. The batik motifs obtained from the program can be made almost identical to the original motifs. Programming skills will help students learn to observe shapes, sizes, abstraction skills, and programming algorithms. This can be seen from the motifs produced after the student executes the program created and the output of batik motifs is obtained. The memory needed to store the basic solar kawung motif (Figure 6) is 39KB in the form of an image, if it is in the form of turtle graphics reconstruction (Figure 7) 166KB, and in color (Figure 8) 215KB, while in program form (*.py) it only requires memory 2KB. This greatly saves the storage space needed to store batik motifs.

D. CONCLUSION AND SUGGESTIONS

It can be concluded that art skills given to Engineering students can increase patience, tenacity, willpower, geometric perception, abstraction skills, and the ability to transform the Batik patterns into programs to form mathematical or turtle graphics. The students' collaboration is also apparent when studying, which will foster social character, sincerity in sharing and in asking questions. Male and female students have the same ability to learn it. The Batik motifs obtained from the program is almost the same as the original motifs. The ability to make a program will help students learn to observe shapes, sizes, abstraction skills, and programming algorithms. If the memory for storing motifs is small, the required storage space will be more efficient.

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