Playing with Turtle Blocks

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Turtle Blocks is an Open Digital Canvas, especially designed for children. Here they can explore mathematical concepts through play. It functions as a digital playground where children can connect naturally with mathematics and perhaps even begin to appreciate what they have studied in their mathematics textbooks. Turtle Blocks has been developed on the lines of Logo Programming which was created at MIT Media Lab way back in the 1960s. It can be accessed on different devices such as desktop computers, laptops, tablets and smartphones.

One cannot talk about Logo programming without mentioning the name of Seymour Papert, to whom we owe the term *computational thinking*[1] and who had truly propounded the constructionist theory of learning. Papert had worked closely with Jean Piaget and had developed what we know today as *constructionism*, a learning theory based on Piaget's constructivism. According to Ackerman [1], the thrust of the constructionist theory is on learning by doing with one's own hands and helps us understand "how ideas get formed and transformed when expressed through different media, when actualized in particular contexts, when worked out by individual minds."

At MIT Media Lab, Papert had created Logo Programming with a physical turtle robot whose movement could be controlled through a given set of instructions. He had envisioned an open space where children could experience mathematics and he decided to call it Mathland [3]. Mathland can, in fact, be any space, not necessarily virtual, where learners can play with objects and experience mathematics in a natural setting. However, the digital space affords many possibilities which may be difficult to experience in the finite analogue world.

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In this manner, Turtle and Logo programming was simulated digitally and now we can see it in the form of Turtle Programming Software [5]. In this software, there are virtual programming blocks (similar to Lego blocks in the tangible mode) which can be arranged as a set of instructions to guide the movement of the turtle on the computer screen. Thus, if the user wishes the turtle to move in a straight line or in a circle, the programming blocks can be arranged accordingly. When the turtle moves, it traces out its path in a color (chosen by the user) thus creating a shape. In this manner, one can draw many shapes and patterns by giving suitable instructions. The very process of articulating the instructions to create a specific shape with certain properties elicits mathematical thinking. Figure 1 illustrates the four main programming blocks which make the turtle move in a specific direction. Each block has a number associated with it which regulates the movement of the block in a specific direction and by a certain distance.

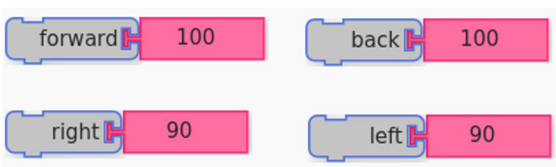
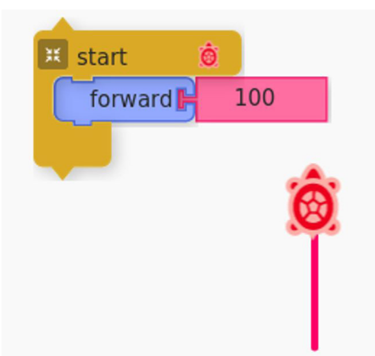


Figure 1. The Turtle Programming Blocks

The forward and backward commands are used to move the turtle in a straight line. Thus forward 100 means that the turtle will move 100 steps forward and backward 100 means it will move 100 steps backward. Similarly the right and left commands will rotate the turtle right or left on its axis. Hence, right 90 means the turtle will turn right through 90 degrees and left 90 will mean the turtle will turn left through 90 degrees.



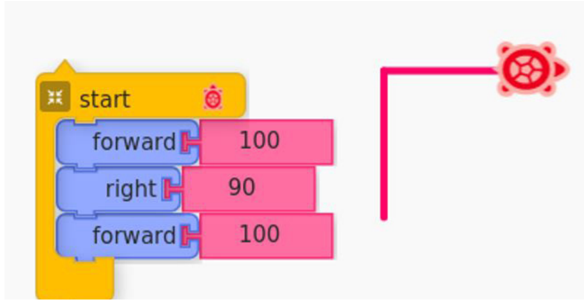


Figure 2. The movement of the turtle specified by the turtle programming blocks.

Why mathematical thinking?

Let us see how a rectangle can be drawn using the programming blocks. First, we may instruct the turtle to move in a straight line for a specified distance (say 100 units), then turn 90 degrees to the right. This will be followed by the turtle moving again in a straight line for a specified distance (say 50), followed by making a right turn. This is repeated until the turtle reaches the starting point. In this manner, one can create many shapes and experience their mathematical properties as well.

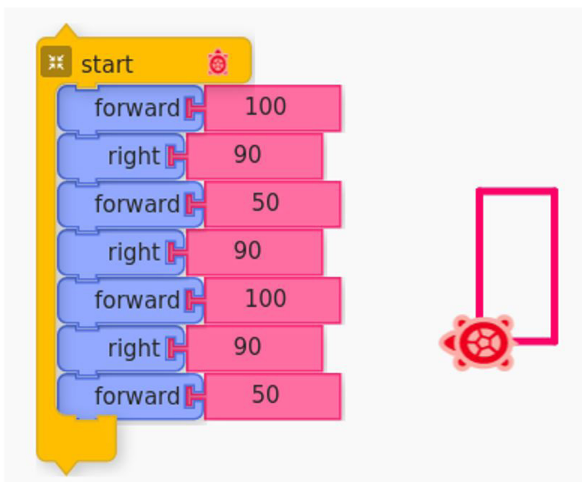


Figure 3. Instructions to the turtle block to trace out a rectangle.

Turtle Blocks may be explored from a pedagogical perspective. I had an opportunity of exploring the potential of this tool when I introduced it to my eight year old daughter. In fact, Turtle Blocks can be introduced to very young children. My daughter thoroughly enjoyed seeing the turtle 'follow' her instructions.

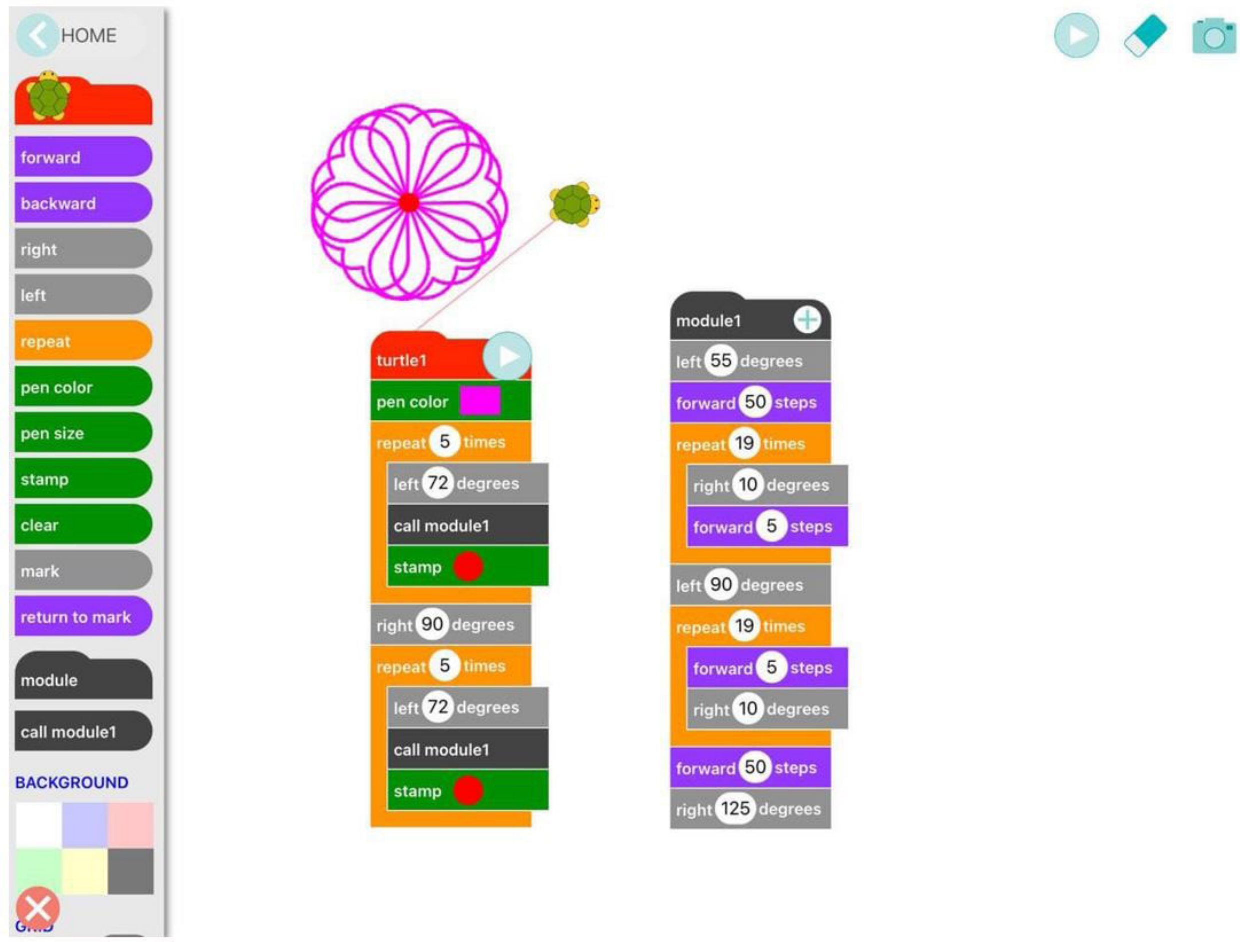


Figure 4. Complex patterns created using the Turtle Blocks.

Programming the turtle to make it draw a pattern of her choice gave her a sense of control and also fueled her imagination to create more shapes and patterns. It also motivated her to think about the shapes and patterns mathematically.

Open Digital Canvas or Playground

Unlike most digital games and platforms, Turtle Blocks is like a blank notebook where the child can put her imagination to work. She can decide on the shape or pattern she wishes to create and then use her mathematical thinking to program the blocks to trace out the required shape. The tool is open ended in the sense that it functions as a playground with certain objects which the child can use to play with. This leads her to engage creatively with the tool rather than play with ready made objects.

After the initial stage of playing with the tool, the child creates her own challenges and finds new problems to explore. The experience is not only fun filled but also an enriching one. However, initiation into the tool many need some scaffolding.

Problem Solving while playing

While playing with Turtle Blocks a child may begin by creating simple shapes but soon she will be encouraged to delve into more complex shapes and patterns. Figure 6 illustrates some complex designs which may be created using Turtle Blocks.

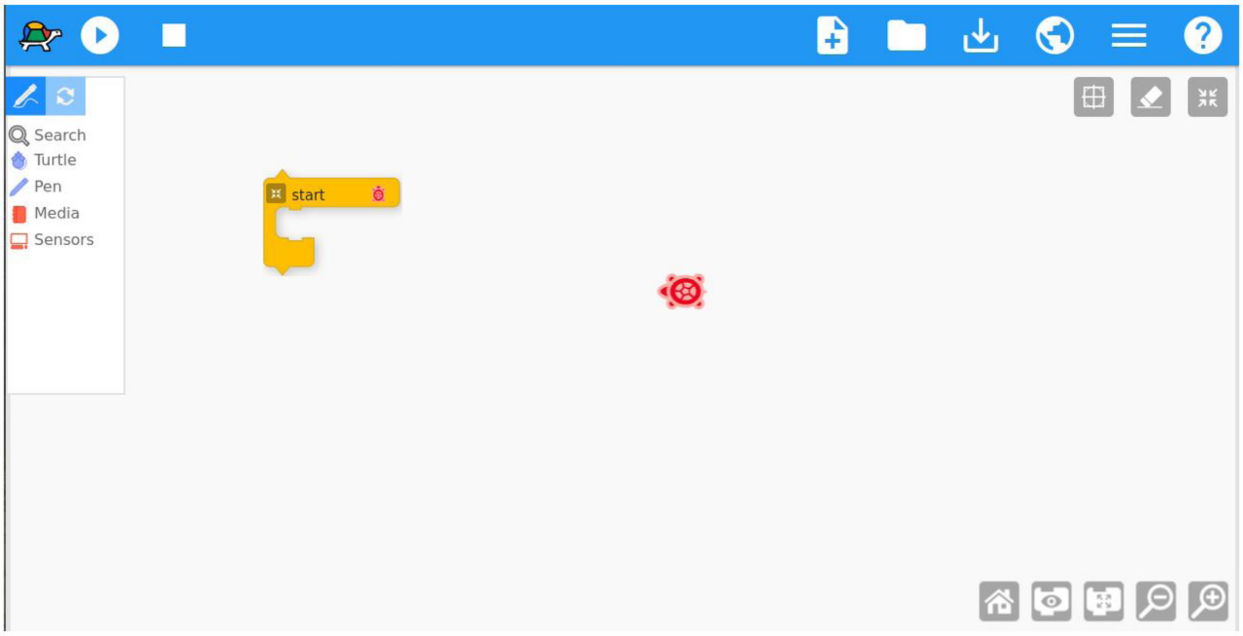


Figure 5. Turtle Blocks when launched will display an open canvas.

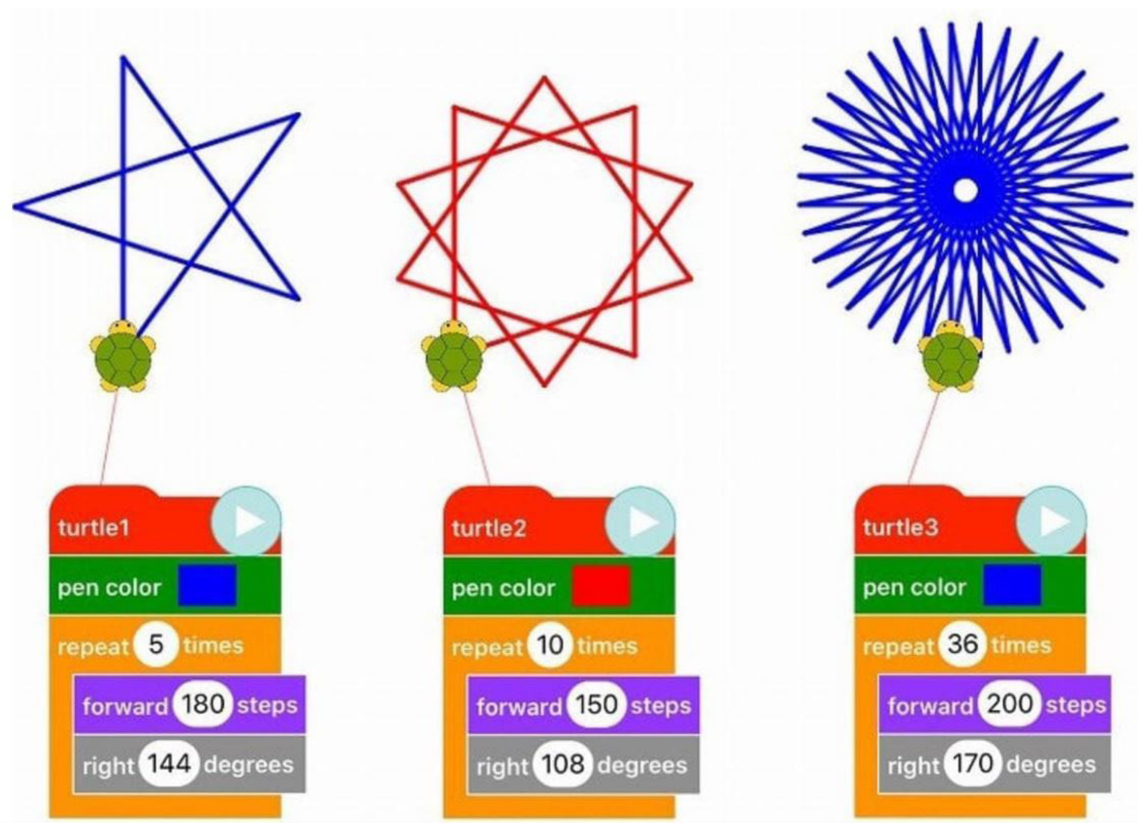


Figure 6. Examples of patterns generated using Turtle Blocks

The software doesn't provide readymade problems to be solved. However, it encourages the user to think about new patterns once they have learnt to create simple shapes. For creating more complex patterns, such as the ones illustrated in Figure 6, the user needs to create a new set of instructions. A method of trial and error which entails refining a set of instuctions to obtain the intended pattern is employed. Being able to accomplish the task of creating a specific shape leads to a sense of achievement. I have seen this in my own daughter as she gradually moved from simple shapes to more interesting and compex shapes. Figure 7 illustrates an example where she first drew a circle and then used the code to create a pattern of intersecting circles.

Figure 7 illustrates how circles have been drawn repeatedly to form a pattern. Each circle comprises four colours as each quarter of the circumference has a different colour. As there are five circles in the above pattern, we can see the module (or subroutine) being called five times in the main program. The module contains the instructions for drawing a circle using four colours. It instructs the turtle to trace one-fourth of the circle in red, another one-fourth in blue and so on. After performing all the steps in the module, one can see a complete circle emerge in four different colors. Once the first circle is drawn, the position of the turtle is shifted to the starting point of the new circle and the subroutine for the circle is repeated. After five repetitions a beautiful pattern of overlapping circles emerges.

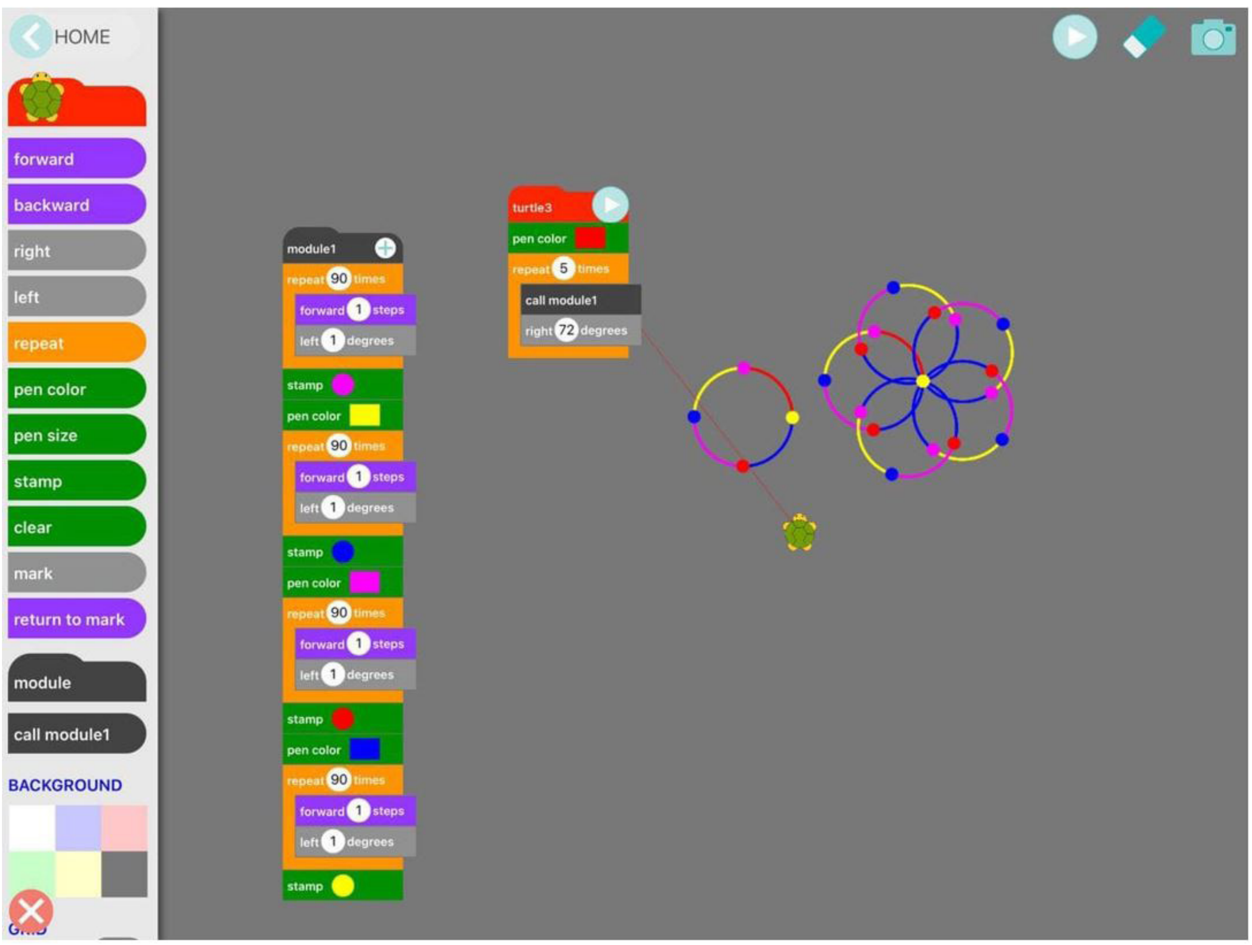


Figure 7. A pattern of intersecting circles using Turtle Blocks.

Abstracting concepts in a natural setting

Drawing a circle using Turtle Blocks may lead to the intuitive understanding of the degree as an angle measure. This happened with my daughter as well. She abstracted the idea that the the amount of rotation acquired by the turtle is determined by the degree of rotation. This helped her to develop an intuitive understanding of the concept of angle and its measure even before encountering the concept in class.

Creating your own algorithm

The Turtle Block encourages children to pose challenges to themselves. Further, the solution to a problem may be achieved in multiple ways and this leads to a learning experience widely different from the drill and practice routine of a typical mathematics classroom.

Every time the child encounters a new challenge, she is required to devise her own algorithm to address the problem. Very often strategies such as 'trial and error', 'building from examples' and 'breaking a problem into simpler problems' may be adopted. Figure 8 illustrates how an unusual and intricate pattern was created using repetitions of a subroutine.

Breaking a problem into simpler problems

Breaking down a problem into simpler problems is an important and well known problem solving strategy. I have observed my daughter using this approach too. In the examples given in Figures 7 and 9 we observed how the larger program consists of smaller subroutines. A complex pattern may actually be made up of several simple patterns which may be coded as subroutines. One

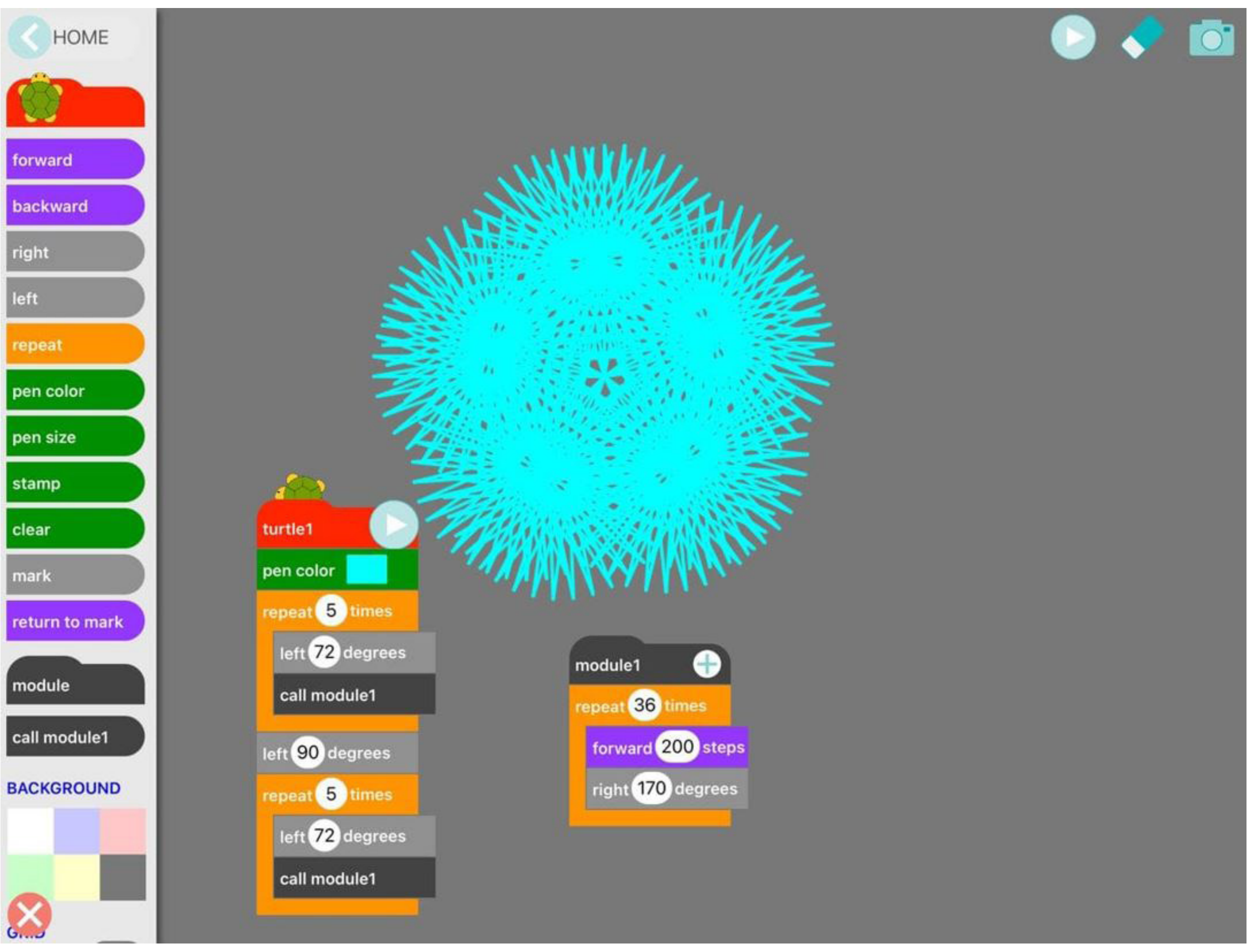


Figure 8: A pattern created by incorporating a subroutine in the main program.

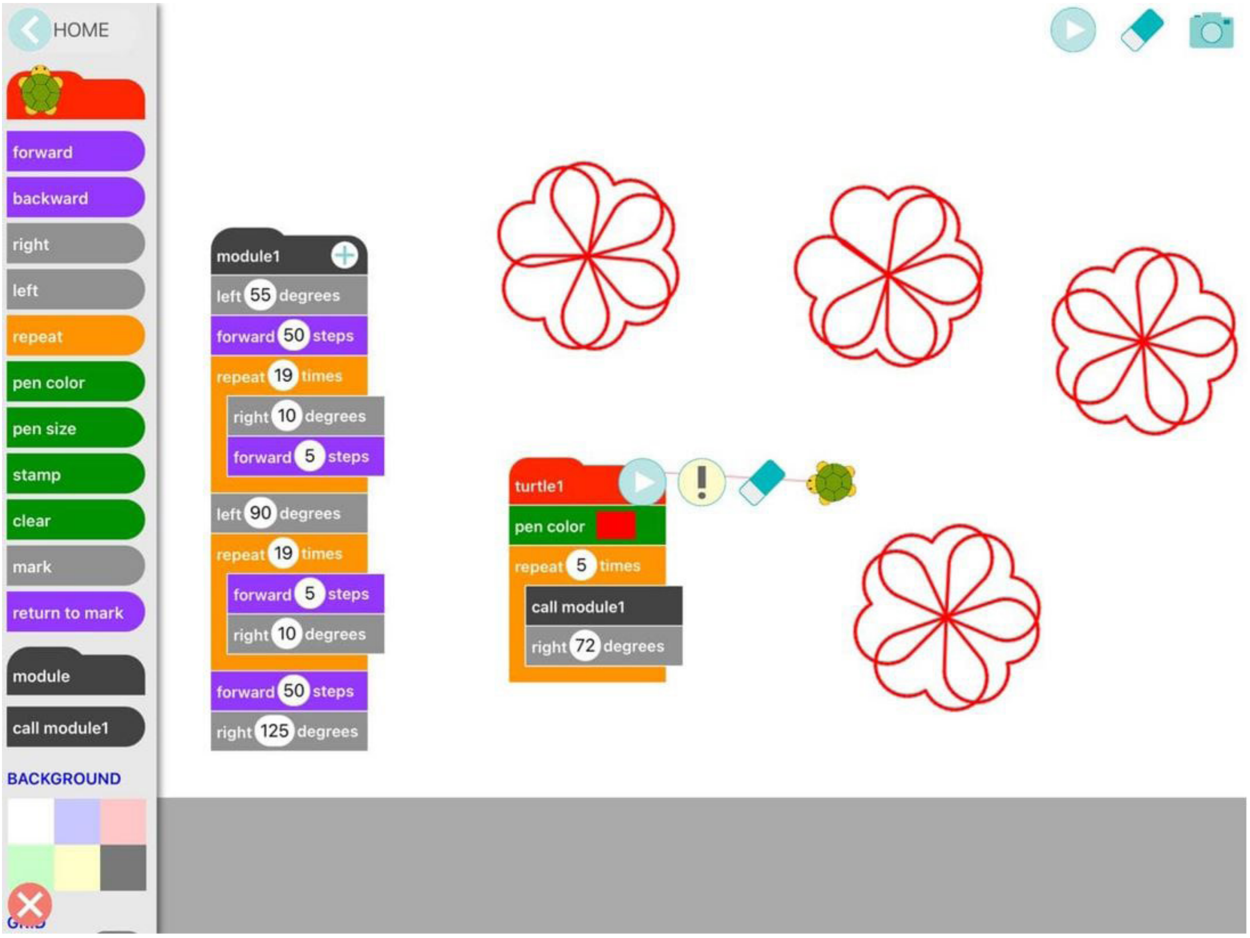


Figure 9. An example of a pattern drawn by trial and error

approach is to set up subroutines for the simpler tasks and then combine them to form the larger (main) program.

Learning from mistakes

When children play with Turtle Blocks, making mistakes may actually lead them to explore further and think about the process involved in obtaining the desired pattern. Every time a child fails to make the turtle draw the desired figure she has to revisit and rectify her algorithm. Thus rectifying errors can lead to interesting challenges in themselves.

The pattern in Figure 9 illustrates how the method of trial and error can be used to arrive at a symmetrical pattern. Module1 in the figure comprises instructions for drawing a heart. My daughter tried to create a pattern of overlapping hearts using this module. In the first attempt, she called Module1 five times, selecting the rotation angle as 63 degrees. However, this resulted in an asymmetrical pattern. Note that the main program calls the module for drawing a heart multiple times and each time the heart rotates by some angle.

In the second attempt, she entered the rotation angle as 69 degrees but this choice also didn't yield the desired result. Finally selecting the angle as 72 degrees led to the beautiful symmetrical pattern shown in the extreme right of Figure 9. This eureka moment also led to a discussion as to why the choice of 72 degrees led to the required pattern. How can one arrive at 72 degrees? Some scaffolding led her to conjecture that 360 degrees divided by 5 is 72. Hence the choice of rotation by 72 degrees leads to hearts being arranged in a symmetrical manner.

Appreciating the mathematics of shapes and patterns

An appreciation of mathematical properties of patterns comes naturally when young children use Turtle Blocks. They tend to extend these ideas in daily life as well. I have observed my daughter looking at patterns around her and trying to create codes using Turtle Blocks to replicate them. We also discuss different ways of creating patterns thus analysing them from a mathematical point of view. One of the important processes of learning mathematics is about observing patterns, not only in geometry, but also in numbers and their representations, algebra, trigonometry and various other topics of the school curriculum. Turtle Blocks help to initiate an exploration of geometrical patterns in young children.

Multiple ways of approaching a problem

Using Turtle Blocks, one can challenge oneself to draw a shape or pattern using different approaches. Sometimes a particular approach may reduce or increase the number of steps involved in a set of instructions. For example, while drawing a rectangle one can observe a sequence of steps being repeated. These steps may be incorporated in the form of a loop within the code of the main program. Loops help to modify programs thus enabling the user to try different approaches to arrive at the solution. The process of modifying codes to make them more concise is also a great learning opportunity for young children. I have often observed with great satisfaction how my daughter explains the codes created by her and then modifies them herself to obtain a different set of instructions. This opportunity provided

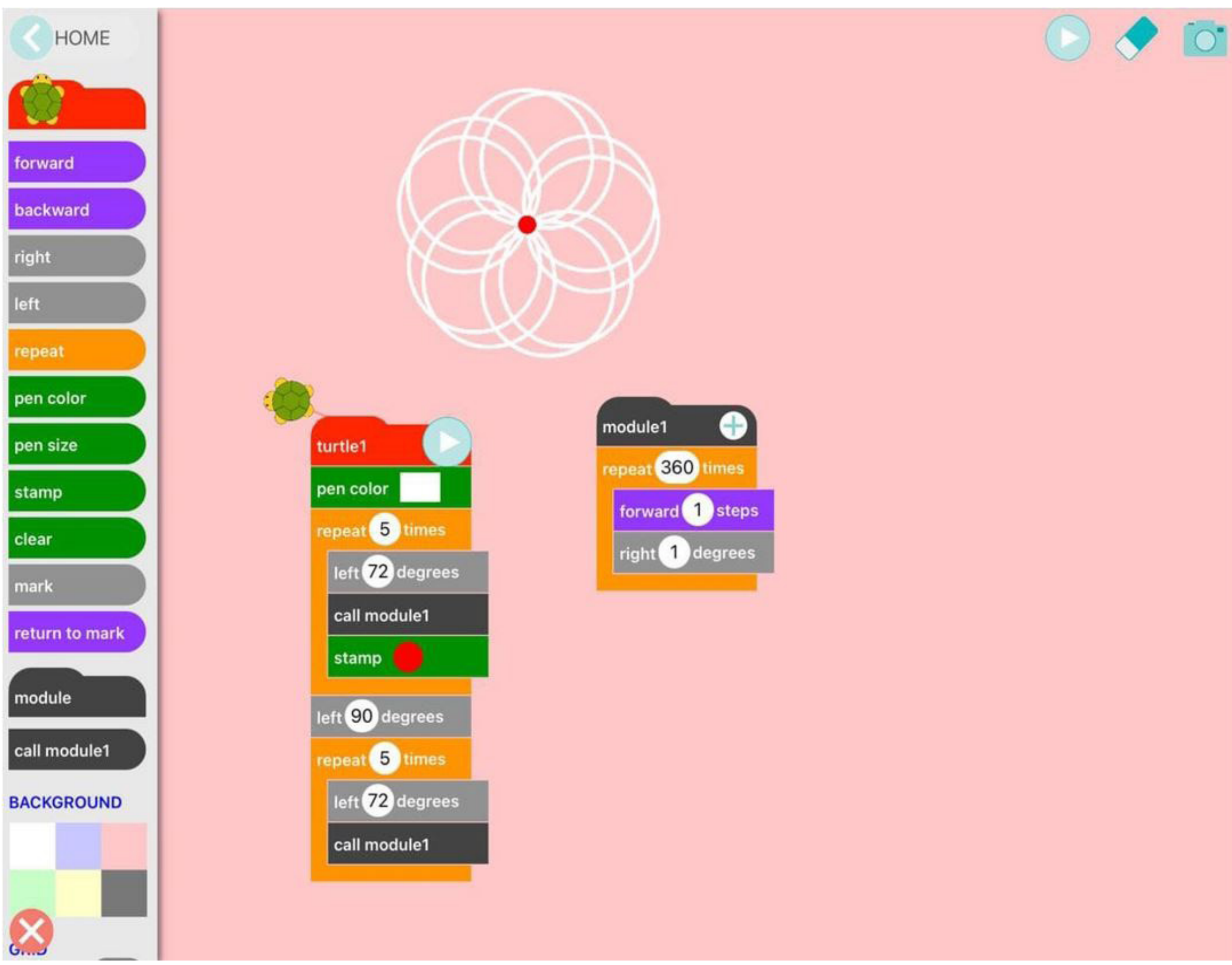


Figure 10: How patterns emerge from circles

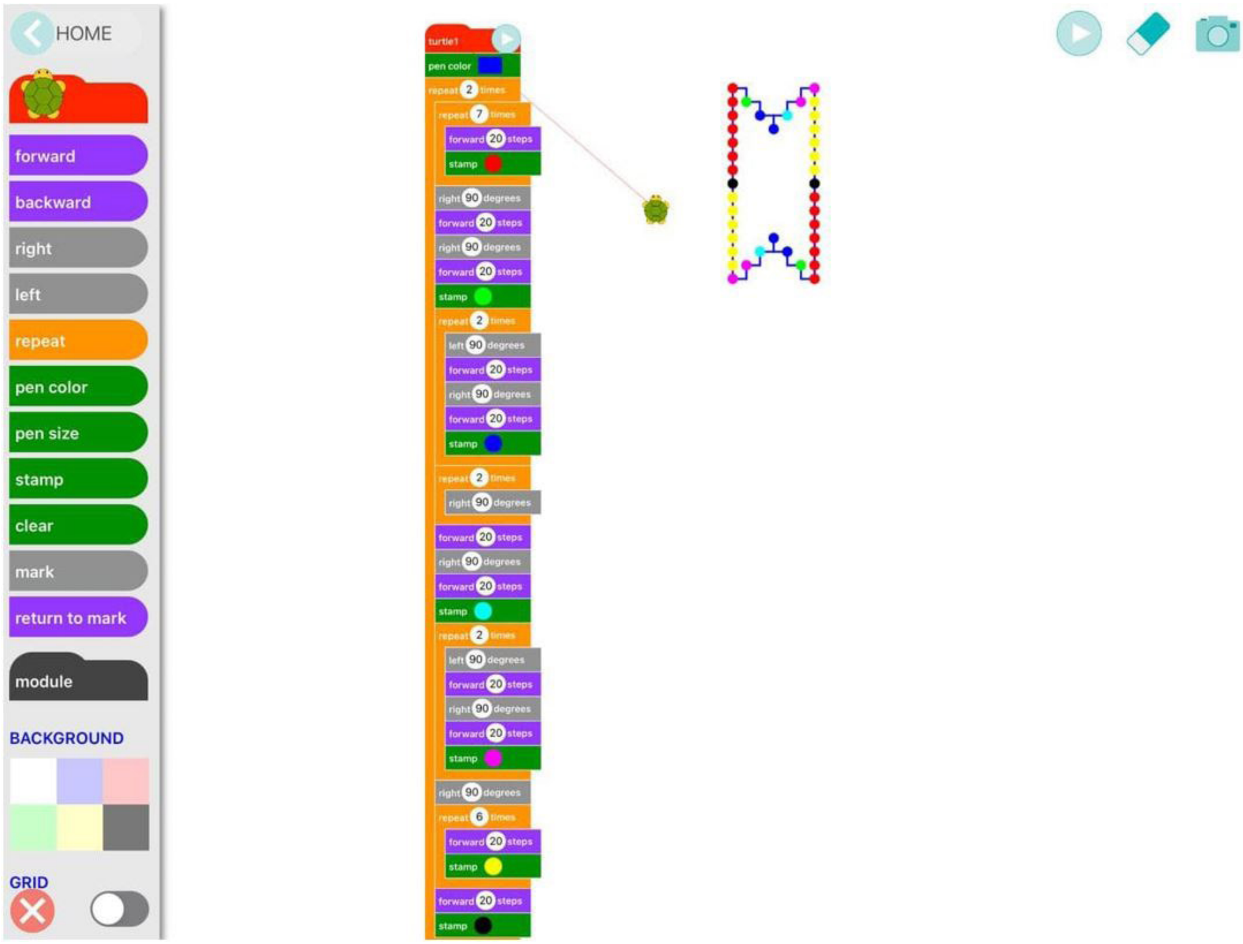


Figure 11: A symmetrical pattern obtained using Turtle Blocks.

by the tool also enables the learner to look at problem solving in different ways.

Exploring symmetry

Using Turtle Blocks can lead to drawing shapes and patterns which are symmetric. I have observed that whenever my daughter creates patterns, they have symmetry in some form. If the symmetry is broken, she modifies her instruction set until she is able to visualise some symmetry. Figure 11 illustrates an example of a symmetric pattern created through free exploration.

Is Turtle Blocks about coding?

Coding is the buzzword these days and it might appear that Turtle Blocks is yet another Software designed for learning programming. Although it does involve programming it is quite different from the plethora of commercial tools available for introducing children to programming techniques. It encourages the user to develop an intuitive understanding about patterns as well as engage in problem solving. It inculcates the skills required for writing codes to create new patterns or solve problems. In fact one might say that such a tool can help to develop computational thinking which entails the processes of decomposition, abstraction, developing algorithms and debugging codes. According to Jenette Wing [4]

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability.

Wing [2,4] further articulates that computational thinking entails thinking like a computer scientist which "means more than being able to program a computer. It requires thinking at multiple levels of abstraction." Thus computational thinking is not merely about writing codes but more about understanding how machines work and about how the computer can be used to solve problems efficiently.

Turtle Blocks may be a very effective tool in enabling young children to engage in computational thinking. The tool is open ended in nature and offers a canvas of possibilities. This is almost similar to handing a canvas and a paintbrush to a child. Knowing how to program a computing machine has been recognised as an important 21st century skill. A tool such as Turtle Blocks can indeed provide a natural way to engage in Computational Thinking.

Sites and Apps to play with Turtle Blocks

1. https://turtle.sugarlabs.org/
2. For iOS - https://apps.apple.com/us/app/turtles-learn-to-code-for-fun/id1454902715
3. Javascript/HTML5 port of Turtle Blocks: https://github.com/sugarlabs/turtleblocksjs
4. https://blockly.games/turtle?lang=en

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