Use of RangoLee Art in Elementary Mathematics Education

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Abstract

In this workshop paper a strategy to teach basic and advanced math concepts using RangoLee designs is discussed. The author has developed a supplementary mathematics scheme called DOT.MATH based on RangoLee designs, following the NCTM standards for grades K to 8. This scheme is aligned with the regular math curriculum; however some higher level concepts and activities such as combinatorics, computer algorithms and network theory are also addressed. In the workshop, aimed at teachers from elementary schools, interested participants will learn to create RangoLee designs and experience the use of the scheme. Participants will be encouraged to assess the advantages and disadvantages of the method and the tools.

RangoLee is an ancient folk art from India. There are many names for it in the Indian languages. (e.g. Kolam in Tamil, or Alpana in Bengali). Every morning a woman of the household draws RangoLee in the front yard of the house using white or colored flint powder. A pinch of flint powder is held in the thumb and forefinger, and, by rolling the thumb over the fore finger, flint powder is allowed to fall on the floor. RangoLee designs can be categorized as drawn with dots or without dots. The dot matrices can be drawn as rectangular, isometric, radial, fractal or composite, such as fractals made up of rectangular matrices. The following figures (1, 2, 3, 4, 5) show various ways of drawing the dots.

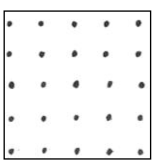
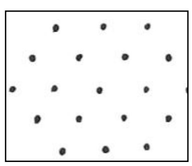
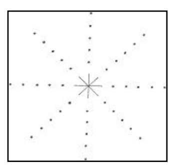
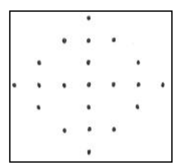
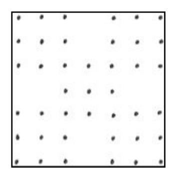

Figure 1: *Rectangular* **Figure 2:** *Hexagonal* **Figure 3:** *Radial* **Figure 4:** *Fractal* **Figure 5:** *Composite*

Dots can be connected by straight lines or curves (figures 6, 7, 8) or a line can be drawn around the dots (figures 9, 10) to make a pattern. Rotational and dihedral symmetries in the designs and the use of bright colors for decoration make them look beautiful. More designs can be found in the author's book [1].

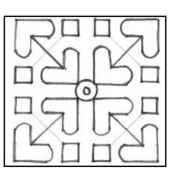
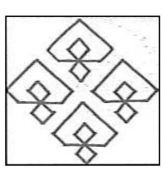
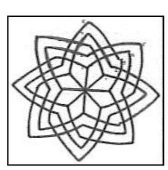
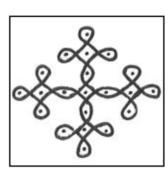
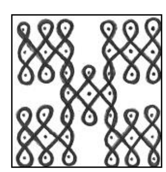

Figure 6: *Contemporary* **Figure 7:** *Coconut* **Figure 8:** *Dnyankamal* **Figure 9:** *Grapevine* **Figure 10:** *Vertical grapevine*

They can also be categorized as either traditional or contemporary. Many of the traditional designs have names, and often have some cultural significance. Some have stories or myths attached to them. In both traditional and contemporary designs both those with dots and those without dots may be found. The designs with dots can be drawn either by connecting the dots or drawing lines around the dots.

The mathematics in these designs has been investigated by Bapat [2], Ascher [3] and many others [4, 5, 6, 7]. There are four basic mathematical principles in RangoLee designs: algorithmic thinking, Eulerian graphs, transformational geometry, and iteration. Unlike an ordinary sketch or painting these lines are drawn according to an algorithm: a precise series of moves and turns that are repeated each time they are drawn. Learning algorithmic thinking is fundamental to math and computing. Most of the designs are Eulerian graphs: they can be drawn as a single line that never re-traces its path. Some put two or more Eulerian graphs together to make more complex patterns.

In some RangoLee designs one may find reflection across an axis (mirror symmetry). Some other designs show rotation around a single point. Finally, in many south Indian designs one finds scaling symmetry applied in cycles: you can build bigger patterns out of a smaller base pattern. Mathematicians identify this type of iteration as a recursion. The iterations allow the implementation of many NCTM algebra standards along with number work, math facts, symmetry, geometry, measurement, as well as making connections between math and other subjects such as art and culture.

Some math educators such as Geevarghees [8] have anticipated and tested [9] the positive effects of using these designs in elementary math education. Inspired by these books and the designs described this author has developed a supplementary scheme called DOT.MATH. A brief description of the methodology and teaching strategy for a Bridges workshop follows.

When children see the demonstration of RangoLee art, they get excited about the method of drawing it using colored flint powder. Using this as a motivation, mathematical concepts are introduced through the art. This author uses the following sequence for grades 3-6: first, they are asked to draw two, three, four, five dots in all possible arrangements. Then they are asked to connect three, four then five dots respectively in all possible combinations/ways without the aid of numbers. This gives them ample opportunity to use their imaginations and come up with symmetric and innovative designs. They are asked to compare their designs with their friends' designs and discuss which looks nice and why. The following figure (11) should give an idea of the many possibilities to connect two and three dots.

Figure 11: *Many possibilities to connect two and three dots.*

Later the author gives copies of a (1, 2, 3, 2, 1) array as shown in figure (12), and asks students to count and add the number of dots in all possible ways. Then they are asked to connect them with a straight line or a curved line in as many ways as they can imagine as shown in figure (13). They are asked to share their designs with other students, and asked to discuss which ones look esthetically appealing and why. Next they are shown the designs called Bilve Patra and are asked if any of their designs look similar to this one. After that they are given a new copies of the (1, 2, 3, 2, 1) array and asked to connect them to form Bilve Patra designs for practice. Finally they are asked to color them with only two colors in all possible ways. They compare their colored drawings with others. Figures 12, 13 and14 illustrate the activity.

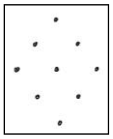

Figure 12: *(1, 2, 3, 2, 1) array*

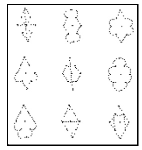

Figure 13: *Connecting dots*

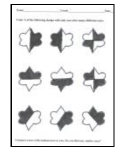

Figure 14: *Coloring 1/2 of the design*

The exploration may continue by coloring the designs for half or quarter of the total shape in many different ways as shown in the figure 14. This activity may help to develop an understanding of equivalent fractions. To study the symmetry of the shapes students are asked to fold the paper on dotted lines. They are also provided with a plane pocket mirror to study the symmetry by observing reflections.

Students are given beans or beads to study the geometrical properties. They are asked, for example, to estimate how many beans they would need to outline the boundary of the shape, then they actually use real beans (or beads) and count the number they use. After that they compare the actual number with their prediction. Furthermore, students are asked if they would need more or fewer beans if they were bigger or smaller or of different color. As an alternative, students could use thread.

The concept of area is introduced by using beans to fill the whole shape. First, students are asked to estimate the number of beans required to fill the shape. Then they actually do it and count them and compare that number with their estimation

A practice sheet is provided to learn to draw the complex design of the first iteration of a pattern. Students are asked to count the number of basic patterns in the first three iterations of the design. Following that they are asked to fill the chart and draw graphs. Third and fourth graders draw bar graphs and 5_{th} and 6_{th} graders draw bar and line graphs. Then they are asked to predict the number of basic patterns in the next iteration. Through this process they are guided to learn the relationships $y = 3x$ as shown in figures 15, 16 and 17 and $y = x^2$ in figures 18, 19 and 20.

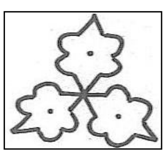

Figure15: *Bilve Patra iteration 1*

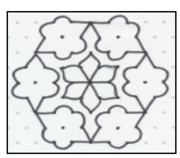

Figure16: *Bilve Patra iteration 2*

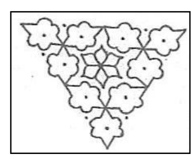

Figure17: *Bilve Patra iteration 3*

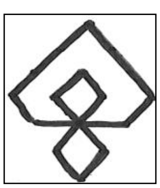

Figure18: *Coconut design iteration 1*

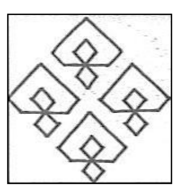

Figure19: *Coconut design iteration 2*

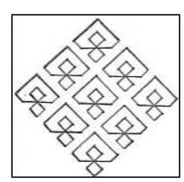

Figure 20: *Coconut design iteration 3*

Many children are visual learners, and hands-on activities make math not only fun for children but also very engaging and meaningful. Children, especially the ones that are intimidated by the word 'math', are interested in doing these activities not knowing they are doing math. In addition to the emphasis on estimation, predictions and collaborative efforts through communication, higher level concepts such as combinatorics, computer algorithms and the theory of networks are introduced to elementary education. The author hopes this methodology will help children to think outside of the box and prepare future generations to tackle problem-solving in all facets of life.

One of the advantages of the DOT.MATH curriculum is the incorporation of art into mathematics. Along the way children are introduced to stories from other cultures which enrich their social studies knowledge. Activities from this curriculum work for all children. They provide an opportunity to children who already excel in math to apply it in a different setting. Children who are mathematically challenged get excited about art, and do the worksheets maybe not knowing they are actually doing the math. Worksheets are already designed and aligned to the regular curriculum, so no extra time is needed from teachers other than making photocopies of them. Thus, this interdisciplinary wholesome tool is very easy to follow and enjoyable for both teachers and children.

In this one and a half hour workshop the participants will perform four activities: 1. Watch a 20 min educational video produced by the author on the topic. This video includes myths and stories about RangoLee, footage of women in India drawing them, some computer simulations to show the rotational and reflective symmetries, and interviews with three experts. The video also includes footage of a classroom where children are actually doing the activities. 2. Learn how to create the RangoLee designs and decorate them with colored powders. 3. Learn the methodology by completing about 10 worksheets from the DOT.MATH curriculum for one design, as if they were the students. Teachers will follow the same sequence of activities as described earlier in the methodology and teaching strategy. They will be provided with all the required material such as white and colored flint powders, worksheets, pencils, crayons, beans, thread, rulers and plane pocket mirrors. 4. Participate in a discussion on the advantages and disadvantages of the tool, methodology and curriculum. Square or round tables to seat 4-6 people at each would be ideal set up for this workshop.

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