Manipulative Review: Geoboard

Reviewed by Math Space

Unlike many other teaching learning materials (TLM) for math, which we would like to call mat(h)erials, geoboard is very well known among teachers and referred to in teacher education programs, pre-service in particular. It is a board – wooden or plastic, with many pegs or nails stuck on it. One can stretch a rubber band along some of these pegs to create many polygons. The pegs can be arranged in a rectangular array or in a few concentric circles (Figure 1).

Geoboards can be used to create shapes. The rectangular array version is a good precursor to the rectangular dot sheet. Check the Geometry and Geometry II Pullouts (At Right Angles, November 2014 and March 2015) for activities transitioning from tactile experiences, to drawing on paper, which are appropriate for young children to explore shapes (Figure 2). Geoboard is a good precursor to dot sheets because it provides a tactile experience, in which shapes can be changed much faster, and polygons are guaranteed straight sides. Moreover, it can be lifted up and displayed to the whole class.

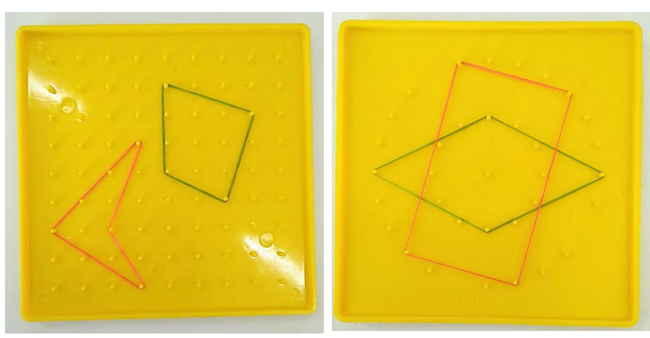

Figure 1

Keywords: Geoboard, shapes, identification, exploration, reasoning, justification

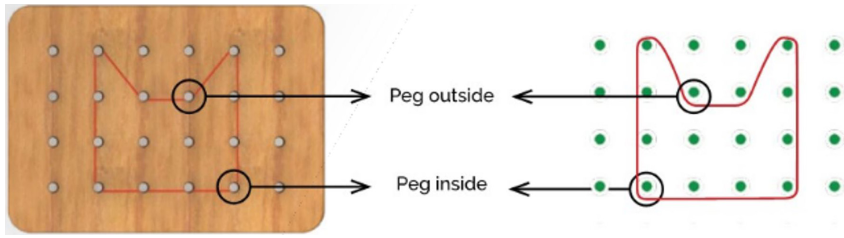

Figure 2 from Sikkim textbook

At the primary level, i.e., Class 1-5, it can help with the following concepts:

- Polygons, i.e., closed 2D shapes with only straight edges
- Corners and edges – especially arriving at the relation between number of corners and number of sides of a polygon
- Identifying and creating rectangles in different orientations
- Exploring angles – possibly with two rubber bands acting as the two arms of the angle
- Comparing angles

Similarly, at the upper primary or middle school level, i.e., Class 6-8, geoboard can be used for the following concepts:

- Types of triangles – children can be asked to identify and/or make different types of triangles; these can be done on the circular geoboard as well
- Types of quadrilaterals – similar to the above
- Diagonals – can be shown with different coloured rubber bands
- Concave and convex polygons – Are all pegs inside the rubber band? What is special about the peg or vertex that is outside the rubber band?

Stretchability of regular rubber bands may be a limitation, and many rubber bands may snap while playing with a geoboard. Also, the pegs, because they are fixed, may come in the way. This can be resolved by using a softboard with pushpins replacing the pegs.

However, a geoboard illustrates the notion of concave and convex shapes perfectly. In a geoboard one can make a polygon and its envelope using two differently coloured rubber bands. Then it becomes clear if the envelope is congruent to the polygon in question. For a concave polygon, some of the sides of the enveloping polygon (shown in pink) will not match those of the concave one (shown in green). These unmatched sides of the envelope are diagonals of the concave polygon lying outside (Figure 3). Also, the vertex untouched by the envelope is special. The internal angle at the vertex is a reflex angle. In a physical geoboard, the peg corresponding to such a vertex lies outside the boundary of the concave polygon created by the rubber band, while the remaining vertices corresponding to angles $< 180°$ lie inside.

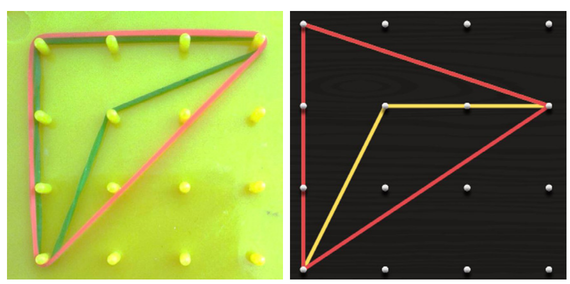

Figure 3

Virtual geoboards,such as https://apps.mathlearningcenter.org/geoboard/, are also available and a good substitute for the physical ones. They resemble the rectangular dot sheet more and the tactile aspect is reduced a bit. However, there is no restriction on the elasticity of the rubber bands and no chance of tearing those. They are available in multiple colours and can be stretched between just two points resembling a line segment much better than in

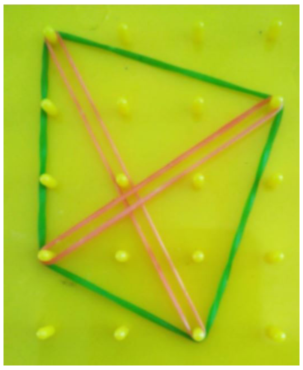

Figure 4

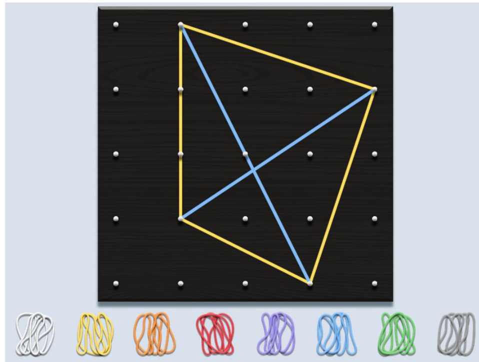

Figure 5

a physical geoboard. So, it can show the diagonals of a polygon much better than its physical counterpart. Also, the pegs don't come in the way (Figures 4 and 5).

However, the virtual geoboard doesn't distinguish a vertex corresponding to a reflex angle in a concave polygon as the physical geoboard does (Figure 6). Also, the rubber bands overlap exactly, hiding the one below completely. Check how the red envelope hides some of the (yellow) sides of the concave quad (Figure 3). It is uncertain if the virtual geoboard can be reprogrammed to address these issues.

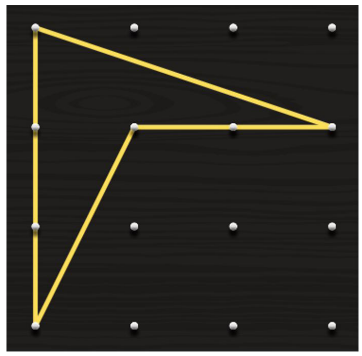

Figure 6. (w/o red envelope)

Reference

- Geometry pullout: http://publications.azimpremjifoundation.org/3090/1/geometry.pdf
- Geometry II pullout: http://publications.azimpremjifoundation.org/1644/1/17_Teaching%20geometry%20-%20II.pdf
- Sikkim SCERT Math textbook, Class 2, pp.172-174: https://online.fliphtml5.com/iuwdn/kgob/#p=172

MATH SPACE is a mathematics laboratory at Azim Premji University that caters to schools, teachers, parents, children, NGOs working in school education and teacher educators. It explores various teaching-learning materials for mathematics [mat(h)erials] – their scope as well as the possibility of low-cost versions that can be made from waste. It tries to address both ends of the spectrum, those who fear or even hate mathematics as well as those who love engaging with it. It is a space where ideas generate and evolve thanks to interactions with many people. Math Space can be reached at mathspace@apu.edu.in

Worksheet based on Geoboard (Class 6)

1. **Use the rectangular array geoboard and make the following triangles**
   - Make a square. Now release any one corner to get a triangle. Which type of triangle did you get? Consider both types of triangles, i.e., those classified by either side or angle.
   - Now make a rectangle. Again, release any one corner to get a triangle. How is this triangle similar to the earlier one? How are the two different?
   - Use different rubber bands to make as many isosceles triangles as you can keeping the base fixed. How does the angle opposite to the base change as you increase the height of the triangle?
   - Can you make an equilateral triangle on this geoboard? Why?
2. **Take the circular geoboard.**
   - Can you make an equilateral triangle here? Can you justify using symmetry?
   - Keep one vertex of the equilateral triangle fixed along with the line of symmetry passing through it. Change the remaining pair of vertices so that you get an isosceles triangle with the same line of symmetry.
   - Use different rubber bands to make as many isosceles triangles as you want with the same line of symmetry. Write down your observations.
3. **Use the rectangular geoboard and make the following squares and rectangles**
   - A square whose sides are tilted
   - A rectangle whose sides are tilted
   - A square whose sides are tilted by an angle less than 45°
   - A rectangle whose sides are tilted by an angle more than 45°
4. **Use the rectangular geoboard and make the following trapeziums**
   - An isosceles trapezium
     i. What shape do you get if you extend the sides?
     ii. Is it possible that no pair of opposite sides ever meet? When?
   - A trapezium with a right angle and an acute angle
     i. What do you observe about the remaining angles?
     ii. How many right angles are there?
   - A trapezium with two acute angles which are opposite to each other
     i. What shape do you get if you extend the sides?
     ii. Which quadrilateral do you get if the acute angles are equal?
5. **Use the rectangular geoboard and make the following quadrilaterals**
   - A kite whose halving diagonal is shorter than the halved diagonal
   - A kite whose equal angles are right angles [Hint: Can you use 3D cleverly?]
   - A kite with exactly one right angle
   - A kite with two unequal obtuse angles
     i. What type of angles are the equal ones?
     ii. If the unequal angles are acute, what type of angles are the equal ones?
   - A concave quadrilateral that has line symmetry
   - A concave quadrilateral without line symmetry

Send in your pictures and narratives (or those of your students) to MathSpace@apu.edu.in. We'd love to hear from you!