Issue 22 | July 2025
Triannual | Bengaluru
An Azim Premji University publication

RNI No.: KARENG/2018/76619

Azim Premji University

Azim Premji University At Right Angles

A RESOURCE FOR SCHOOL MATHEMATICS

ISSN 2582-1873

Weaving Mathematics into the life of the class

A little bit of pattern in my life
A little bit of TLMs by my side
A little bit of weaving is all I need
A little bit of fun is what I see
A little bit of context in the sun
A little bit of dreaming all night long
A little bit of teaching, here I am
A little bit of you makes this your class!

Pattern, numbers, spatial relationships… the content domain of mathematics is beautifully woven by teachers across the world into the child's context, to transact lessons that build reasoning, logical thinking, communication, and the joy of mathematics. It may not always happen, but every teacher aspires to this, to build a canopy of beauty that makes children life-long learners.

From the Editor's Desk . . .

Dear Readers,

The July issue … summer in the North and the monsoons in the South have set in, and across India, it seems a perfect time for craft and quiet reflective thinking. A standard definition of weaving is that it involves two sets of yarns- the warp and the weft. Could these be the mathematics teacher and the content that they transact? The articles in this issue weave patterns of beautiful mathematics and the pedagogy to match – you will see this across the sections from Features to the Pullout.

Does one model fit all contexts in which fractions are used? Should we change the lens through which we view fractions? Narayana Meher picks up this thread in the Features section with *Interpreting Fractions*, describing various constructs for fractions, using examples from the textbooks and explaining why teachers should understand these constructs as they devise lesson plans and assessment.

In the Classroom section, we have Aakanksha and Garima describing their lessons on the topic of Shapes. What happens when students explore and raise questions and teachers have the courage to let them lead the flow of the learning? Their accounts will encourage you in this direction. With many down-to-earth, contextual examples and simple exercises, Anushka explains the different types of *Algorithms*, and students Nidhi, Ashwath, and Vyaan write an account of their *Data Collection Activity*, which helped them solve a question posed by their mathematics teacher.

Children can see mathematics everywhere- whether they are on a bus journey, or doing a dance, or finding shortcuts to solve problems, and when they learn to think about and document their findings, they populate the Joy of Mathematics section. With stories like the one Kshama Chakravarthy has reviewed, *(The 3 Firefighters)*, teachers can learn how to point their students in this direction - even if you are buttoning your shirt, you need to think of shape, size, and number!

And finally, the Pullout! The nitty-gritty of weaving mathematics into the life of the class -it's not just a beautiful idea, we are actually showing you how to do it! Enjoy crafting lessons with these ideas!

While all these absorbing ideas may keep you glued to the articles, do spare a glance at the back cover; we feature here the different weaves developed in regions across India. What diversity! And what talent! What can we do to encourage these craftspeople? And how can we ensure that we keep this harmonious whole intact?

Sneha Titus
Chief Editor, At Right Angles
AtRightAngles.editor@apu.edu.in

Editorial Office
Azim Premji University, Survey No 66,
Burugunte Village, Bikkanahalli Main Road,
Sarjapura, Bengaluru, Karnataka - 562125
Email: publications@apu.edu.in
Website: www.azimpremjiuniversity.edu.in

Design
Zinc & Broccoli
Bengaluru, Karnataka

Print
Repromen
Bengaluru, Karnataka

At Right Angles is a publication of Azim Premji University which provides quality mathematics learning resources for school teachers. It intends to facilitate more experiential and meaningful teaching-learning processes, not just inside the classrooms but also in the broader context of school processes. To celebrate purposeful and passionate teaching, At Right Angles showcases practical insights grounded in the realities of India and its diverse communities.

Azim Premji University
At Right Angles
A RESOURCE FOR SCHOOL MATHEMATICS

Azim Premji University
A publication of Azim Premji University

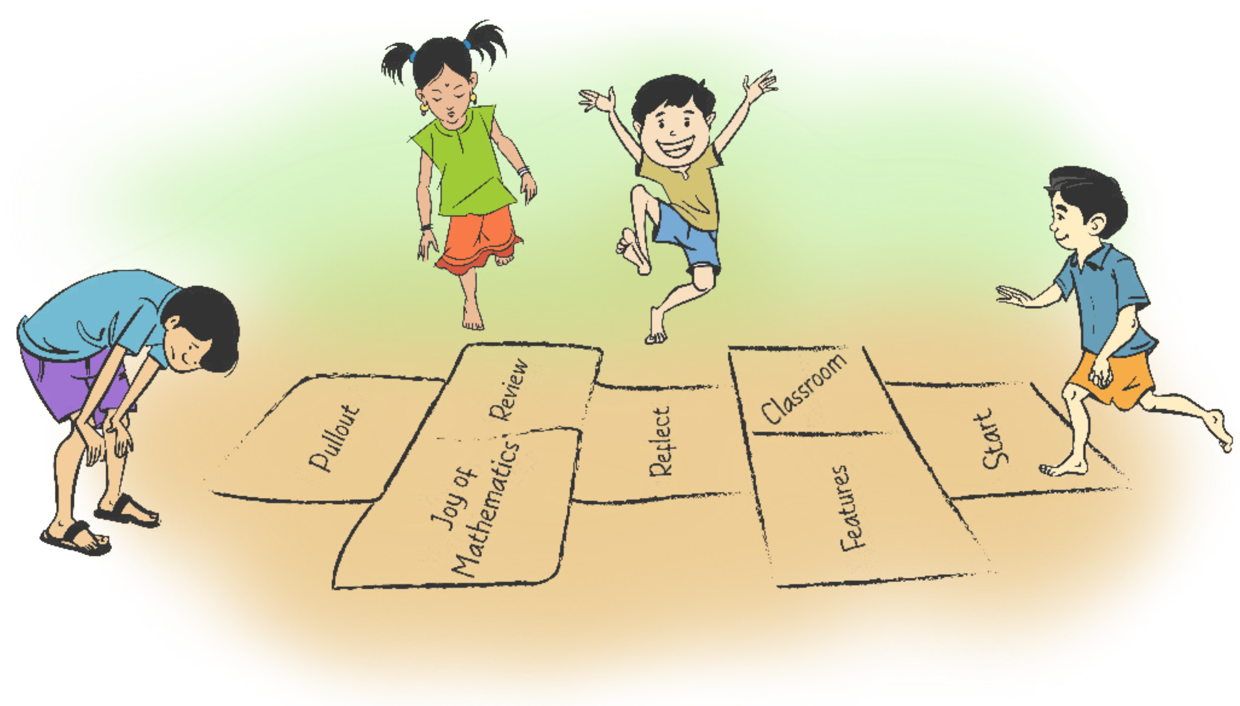
Features

Classroom

The Joy of Mathematics

Review

Pullout



Interpreting Fractions

Narayana Meher

This article aims to help the reader make sense of the multiple meanings and interpretations of fractions. This will help a teacher understand the pedagogical content knowledge needed to teach fractions at an early stage of school. It will also support them while helping children to make the transition from working with whole numbers to understanding fractions.

Fraction is a rich mathematical concept introduced at an early school stage. Their two-storied number representation, which is more complex than whole numbers, demands a meaningful introduction with a proper context. When teachers introduce fractions without doing this, the topic becomes a burden for students who do not have a deeper understanding of the concept. Teaching fractions through rote learning creates more problems for the successive grades.

A typical introduction to the topic of fractions goes like this in the classroom: *Fractions are expressed in the form* $\frac{a}{b}$*, here a and b are natural numbers. a is called the numerator of the fraction and b is called the denominator of the fraction. The numerator represents the number of identical pieces selected from a whole whereas the denominator indicates the number of identical pieces the whole is divided into. For example,* $\frac{1}{4}$ *of a cake indicates 1 piece when the whole cake is divided into 4 identical pieces.* $\frac{1}{4}$ *is also the size of each piece. Similarly,* $\frac{3}{4}$ *is nothing but 3 pieces taken from the same cake.* $\frac{3}{4}$ *also indicates 3 pieces each of size* $\frac{1}{4}$*. When the numerator is equal to 1 (or one part is picked), we call it a unit fraction, and when numerator is more than 1, we call it a non-unit fraction.*

Among fractions, we have 3 main cases:

a) *Numerator < Denominator (E.g.* $\frac{1}{4}, \frac{3}{8}, \frac{2}{7}$*, etc.) It is clear from the definition of numerator and denominator that such fractions are less than a whole or 1. They are called Proper fractions.*

b) *Numerator > Denominator (E.g.* $\frac{5}{4}, \frac{9}{2}, \frac{7}{3}$*, etc.)*
The value of these fractions is greater than 1. The meaning of $\frac{5}{4}$ *for instance, is that a whole is divided into fourths (or 4 equal parts), and 5 such parts are selected. It is clear that selecting 4 such parts make a whole or 1, and we pick another* $\frac{1}{4}$*. Such fractions, that are greater than a whole, are called improper fractions.*

c) *Numerator = Denominator (E.g.* $\frac{5}{5}, \frac{7}{7}$*, etc.) The value of this fraction is equal to one.*

BEWILDERING! Small wonder that students face ....

Keywords: Primary Mathematics, Fractions, Conceptual Understanding, Visualisation

Conceptual difficulties with fractions as compared to whole numbers

1. Fraction Notation

Fraction is always written by using two whole numbers (except zero as denominator). But the quantitative sense of the fraction is very different from the quantity the two whole numbers represent. For example, the fraction $\frac{2}{5}$ does not mean either 2 or 5 or a number between 2 and 5. $\frac{5}{2}$ is also different from $\frac{2}{5}$.

Adequate time has to be spent to help learners understand fraction notation with proper introduction in meaningful contexts.

2. New Vocabulary

New terminologies such as numerator, denominator, unit fraction, non-unit fraction, proper fraction and improper fraction are stressed upon too early, focusing on the vocabulary rather than the meaning in both transaction as well as assessment. This diverts students from the real significance of the meaning of the fraction.

3. The comparison and ordering of fractions

The comparison and ordering of fractions are more complex and difficult than whole numbers. 8 is greater than 2. But $\frac{1}{2}$ is greater than $\frac{1}{8}$. This brings real confusion to children. There are no whole numbers in between two consecutive whole numbers, but there are many fractions in between two non-equal fraction numbers. That's why ordering them is difficult. Comparison of non-unit fractions is even more complex and difficult.

4. Operations on fractions

In case of addition and subtraction of whole numbers, units are added to or subtracted from units, tens are added to or subtracted from tens, and so on. But in fractions, numerators are not added to / subtracted from, numerators and likewise for the denominators.

For example- 35 + 54 = 89 (5 units are added to 4 units and 3 tens are added to 5 tens)

But $\frac{1}{3} + \frac{3}{5} \neq \frac{4}{8}$ (Numerator cannot be added with numerator, neither can denominator).

But interestingly, in the case of multiplication, the numerators are multiplied together as are the denominators.

In division, even though it is more complex, the reciprocal of the divisor is multiplied with the dividend. The focus on these rules leads students through a maze of algorithms, the learning of which becomes an end in itself.

In this article, I will discuss different meanings and interpretations of fractions. Being familiar with this will help a teacher to direct her pedagogy towards understanding and reasoning rather than recall and execution.

Different meanings of fraction with examples and illustrations

Behr, Harel, Post, Lesh [1], Kieren [3], and Lamon [4] mention that fractions have multiple meanings and interpretations, identifying five different meanings and interpretations of fractions [2]. They are given below.

1. Fraction as part of a whole or part of a set
2. Fraction as measure
3. Fraction as the result of division
4. Fraction as ratio
5. Fraction as operator

It is quite amazing to think that the same fraction $\frac{a}{b}$ could mean any one of these things. When a fraction is presented to students in symbolic form without any context, it is difficult to make sense of what its intended meaning is. When students are guided to look at fractions through these different lenses, they make sense of different situations and problems, and their understanding of and operations with fractions becomes logical and reasoned.

Before introducing fractions, a teacher should equip herself with the different meanings of fractions and how each of them unfolds at different stages of elementary school. We will discuss the five meanings of fractions one by one.

1. Fraction as Part of a Whole or Part of a Set

The familiar and usual meaning and interpretation of fraction is the part-whole model. This meaning is generally experienced by students even before they come to school. Children share cake, chocolates, etc., equally among their siblings or friends. The relationship between the part and the whole represents the part-whole model of a fraction. There are two types of wholes:

1a. Whole being continuous

An example of a continuous whole is a cake. This is a simple and the most basic understanding of fraction which is introduced at the early stage of teaching fractions. For example, if a cake is shared among four people equally, each person will get one-fourth of the cake. This represents a part-whole relationship. Since each person receives 1 out of 4 equal parts of the cake, they get $(\frac{1}{4})$ of the cake. This is a unit fraction. This interpretation means we are selecting 1 part out of 'n' equal parts of a cake. This is denoted by $\frac{1}{n}$ part of the whole (read as the n^{th} part of the whole).

Part-whole relationship does not mean each piece is identical or congruent to another piece. We may compare some other aspects of the parts, such as the area or volume of the pieces. The pieces may not be congruent shapes but have the same area or volume [2].

The illustrations are given below.

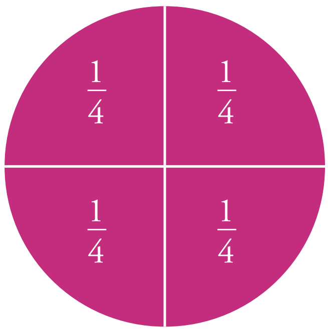


Figure 1

In Figure 1, each unit piece, $\frac{1}{4}$, is identical to other units (congruent)

In Figure 2, the big rectangle is divided into 4 equal parts, shaded in four different colours. Each unit piece (yellow, for instance) is not identical with, but is equal in area to the other unit pieces (green, peach and blue colour)-each of them are $\frac{1}{4}^{th}$ of the big rectangle.

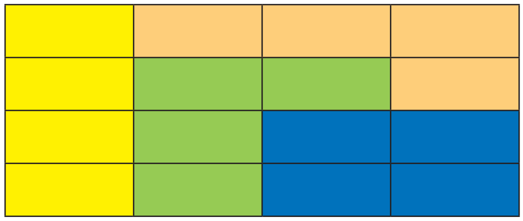


Figure 2

In Figure 3, Beaker A is full of water and represents the whole. Beakers B, C, D show $\frac{1}{4}$, $\frac{2}{4}$ and $\frac{3}{4}$ respectively of the volume of the water that Beaker A has.

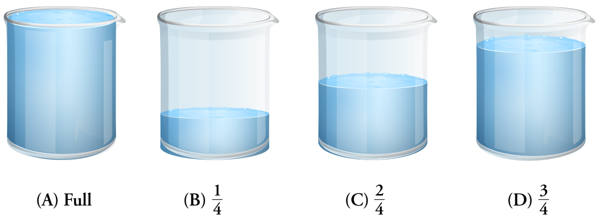


Figure 3

1b. Whole being discrete

The second type of whole is something we use in our day-to-day life very often – we make half, one-third or one-fourth of many things such as collections of eggs, fruits, groups of students, etc. The collection is a set, and we take a part of that set. The part of a set interpretation of the fraction ensures an **equal number** of objects or people in each unit. I would like you to recollect one of the famous scenes in the Hindi movie Sholay. Asrani, the police inspector while marching, asked half of the guards to move to the right and half to the left and the rest to follow him (Adha bayen, adha dayen aur baki sab mere piche). This fraction meaning is a part of a set. On a lighter note, it is important to discuss whether Asrani knew fractions or not, but he has some sense of part of a set meaning of fraction.

The set can either be organized in the form of a single line or array or left unorganized. The following illustration is an example of a set organized in an array.

In Figure 4, there are 12 eggs. $\frac{1}{2}$ of the eggs are in one row. But $\frac{1}{6}$ of the eggs are in one column.

Figure 4

2. Fraction as Measure

This meaning of the fraction is related to measurement. For example, a rope of 124 metres length is cut into 5 equal parts. While 120 m can be easily divided into 5 equal parts, each of length 24 m, there will be a remainder of 4 metres. These 4 metres can be converted to 400 cm and equally divided into 5 parts, each part getting another 80 cm. So finally, each part would be 24 metres and 80 cm. This is the way we divide length, weight and volume, till we reach the final quantity. This can be written as the fraction $\frac{124}{5}$ m. This also represents the division meaning of fraction. Similarly, $\frac{14}{10}$ can be contextualized as 14 litres of oil divided among 10 people. To measure quantity which is less than 1 whole or in between wholes, we use fractional units to measure, basically partitioning the unit in equal sub-units. For example- if 1 metre is cut into 3 equal parts, the length of each would be $\frac{1}{3}$ metre. Similarly, if 3 litres of juice is shared among 9 people, each of them will get $\frac{3}{9}$ or $\frac{1}{3}$ litre of juice.

This is not limited only to length and volume measurement but is equally applicable to weight, area and time measurement, such as 200 ml = $\frac{1}{5}$ litre, 250 g = $\frac{1}{4}$ kg. This can be explored further as given below.

52 g = $\frac{52}{1000}$ kg = 52 kg divided into 1000 parts = it means 52 times $\frac{1}{1000}$ kg.

27 ml = $\frac{27}{1000}$ litres = 27 litres divided into 1000 parts i.e., it means 27 times $\frac{1}{1000}$ litre

3. Fraction as the Result of Division

A fraction can be the result of the division of any two numbers. Here the whole can be either continuous or discrete in nature. It is explained below in detail.

Discrete objects

- A-Part of a set- If 12 mangoes are shared equally among 4 students, each student gets 3 or ($\frac{12}{4}$) mangoes. Since 12 is divisible by 4, the quotient is a whole number.
- B-Part of a set- If 12 apples are shared equally among 5 students, each student gets 2 $\frac{2}{5}$ (mixed fraction) apples.

Continuous objects

- C-Part of a whole- Let's say 1 litre of apple juice is shared equally among 3 people. Each of them gets $\frac{1}{3}$ litre of juice.
- D-Part of a whole- Let's say 1 watermelon is equally shared with 9 people. Each of them gets $\frac{1}{9}$ of the watermelon.

Even though all the scenarios A, B, C and D mean equal sharing. Scenarios A and B overlap with the part of a set, and scenarios C and D overlap with the part of a whole construct. In addition, scenario C also overlaps with the measure meaning of fraction.

4. Fraction as Ratio

A ratio is a quantitative relationship representing the relative size of one quantity to another. For example, if the length and breadth of a rectangle are 12 cm and 3 cm respectively, then the ratio of the length to its breadth is 4:1 which can be written as the fraction $\frac{4}{1}$. It means that the length is 4 times the breadth. It shows the multiplicative/ proportional relationship between length and breadth rather than the additive relationship - the length is 9 cm more than the breadth.

The part-whole relationship can easily convert into a ratio. Let's say there are 30 balls, out of which 20 balls are blue, and the rest are red. Blue balls are $\frac{2}{3}$ of the total number of balls. We can write this as a ratio. The ratio of blue balls to total number of balls is 2:3. Here the fraction can be written as a ratio, so $\frac{2}{3}$ = 2:3. It works when they are in the same units.

It seems very odd, conceptually, when two quantities involved in ratios are in different measures/units. For example, a car uses 10 litres of petrol to travel 150 km. The ratio of distance covered to the amount of petrol used is 15:1. It means that to travel 15 km, 1 litre of petrol is required. If we convert this ratio to a fraction, it becomes $\frac{15}{1}$, which is meaningless if we only consider the part-whole meaning of a fraction. Rather we can think of the division meaning of fraction, which is that the car can travel 15 km for each litre (unit) of petrol.

5. Fraction as Operator

As an operator, a fraction shrinks/reduces or enlarges, contracts or expands and multiplies or divides a number [4].

Operators are transformers which

- Increase or decrease the length of a line segment
- Increase or decrease the area of a figure or volume
- Increase or decrease the number of items in a set of discrete objects

When the operator is:

a. A proper fraction, it shrinks, contracts, reduces

A shopkeeper sells 2 chocolates for ₹3. How many chocolates will a buyer have after spending ₹x ? It means the number of chocolates is always less than the money spent, as shown in Table 1. The number of chocolates that can be purchased is $\frac{2}{3}$ of the amount spent. Here the number of chocolates is less than the amount of rupees spent.

Input (Rupees)	Operator	Output (No. of chocolates)
9	$\frac{2}{3}$	6
12	$\frac{2}{3}$	8
15	$\frac{2}{3}$	10
18	$\frac{2}{3}$	12

Table 1

b. An Improper or Mixed fraction, it enlarges or expands

Let us modify the previous example. If a shopkeeper sells 3 chocolates for ₹2, how many chocolates will a buyer have after spending ₹x ? Here the number of chocolates that can be purchased is $\frac{3}{2}$ of the amount spent. It means the number of chocolates is always more than the money spent, as illustrated in Table 2.

Input (Rupees)	Operator	Output (No. of chocolates)
8	$\frac{3}{2}$	12
10	$\frac{3}{2}$	15
12	$\frac{3}{2}$	18
6	$\frac{3}{2}$	9

Table 2

We have just seen that the part-whole meaning is insufficient to give a clear picture of different scenarios. $\frac{2}{5}$ metre of cloth, $\frac{2}{3}$ of the books of the store are in English, $\frac{9}{7}$ of the apples, etc. have other meanings like measure, ratios and equal shares respectively. By being acquainted with the part-whole meaning of fraction only, students' understanding of situations similar to those given above remains incomplete. When students are familiar with different meanings and interpretations of fractions, they make sense of different situations and problems, and their understanding of fractions get enriched.

We have discussed different meanings and interpretations of fractions. Researchers support that part-whole and part of a set meaning of fractions should be introduced at the early stage of learning fractions (Grades 3 and 4). The other meanings of fractions will be explored in a deeper way in Middle School. It does not mean that they should not be touched upon in primary grades. It is important that teachers are aware of the different meanings and interpretations of the fraction so that they bear these in mind as they plan their teaching, choose examples and do formative assessment and remedial teaching.However, care should be taken not to overload students with definitions. For example, the task given below is strictly for teachers and not intended to tax students in elementary school.

Based on the discussion given above, here is a task for teachers (Table 3). Go through each word problem, analyze the meanings and interpretations they carry and put tick marks on the relevant cell of the table given below. Remember that they are not always in water-tight compartments. These meanings and interpretations can even overlap with each other.

Sl No	Word Problems/Contexts	Part of a whole/Set		Measure	Equal Sharing	Operator	Ratio
		Whole as continuous	Whole as discrete				
1	Vamshi and Dhruva have gardens that are of exactly the same size. Vamshi used $\frac{1}{6}$ of his garden space to plant tomatoes. Dhruva used $\frac{1}{7}$ of his garden to plant potatoes. Who has more garden space left? Why do you think so?						
2	Sriram runs a library which has 420 books. $\frac{1}{3}$ of the books are on Science and $\frac{1}{4}$ of the books are on Mathematics. How many books are on Mathematics and Science? What fraction of the books is in the other categories?						
3	A pumpkin weighs $2\frac{3}{4}$ kg and a watermelon weighs 2340 grams. Which one is heavier- pumpkin or watermelon?						
4	Rabina mixed 3 cups of juice with 4 cups of water to make a special drink. What fraction of the drink is juice?						
5	Muthulakshmi spent $\frac{2}{5}$ of her monthly salary on her household expenses. What fraction did she save?						
6	Three equal sized cakes were shared equally among 11 students. How much of the cake did each of them get?						

Table 3

References

1. Behr, M. J., Harel, G., Post, T. R., & Lesh, R. (1992). Rational number, ratio, and proportion. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 296–333). Macmillan.
2. Chapin,S., & Johnson, A. (2006). *Fractions. In Math matters: Understanding the math you teach (Grades K-6)* (pp.99-112). Math Solutions Publications.
3. Kieren, T. E. (1988). Personal knowledge of rational numbers: Its intuitive and formal development. In J. A. Hiebert & M. J. Behr (Eds.), *Number concepts and operations in the middle grades* (pp. 162–181). Lawrence Erlbaum.
4. Lamon, S. J. (2020). *Teaching fractions and ratios for understanding: Essential content knowledge and instructional strategies for teachers.* Routledge.

NARAYANA MEHER is a faculty member in the Teacher Education group at Azim Premji University, Bengaluru. Before joining the university, he taught mathematics in Mirambika Free Progress School, Delhi and Heritage Xperiential Learning School (HXLS), Gurgaon. While working with HXLS, he worked closely with Jodo Gyan, a Delhi-based non-profit organization primarily working on innovative ways of teaching mathematics. He worked as a faculty and teacher educator at IAAT (I AM A TEACHER), Gurgaon. His area of interest is mathematics education. He is also interested in hands-on work and craft which demands spatial thinking and reasoning. He may be contacted at narayana.meher@apu.edu.in

Art in Numerals

6	9	12
27	30	33
48	51	54
69	72	75

Figure 1

3	6	9
24	27	30
45	48	51
66	69	72

Figure 2

Note the four numbers shaded in green in Figure 1 and Figure 2.

In both cases, when we add the four numbers and divide the sum by 4, we get the number in the centre of the quadrilateral. (Shown shaded in blue in each case).

Can you find a pattern connecting these numbers? Can you find such patterns in a different set of numbers? In a different grid? How are they related to each other in your grid? Send in your findings to AtRightAngles.editor@apu.edu.in

Contributed by **Carelin Christopher**
carelinchristopher@gmail.com

Getting in Shape!

Aakanksha & MATH SPACE

As a primary school teacher, have you used multiple materials and activities, such as 2-D shape cutouts or paper-folding, for students to engage with shapes? I am sure that if you did, you would have had a very clear and specific lesson plan to follow. Now, would you allow your students to deviate from the lesson plan you have created? Most teachers would hesitate. Often, we feel that if we allow this, it may become impossible to bring the class back to what we want the students to learn, the all-important lesson objectives! This article shares a case, where the teacher dared to let the students' questions direct the flow of the class. This is an account in the teacher's own words, sharing her experience of working with Shapes in Class 3. A representative from Math Space was an observer to the entire process and helped to document it. Let us see what happened subsequently, and whether we can learn anything from this.

My original plan was as follows:

Lesson Objectives: By the end of the unit, students should be able to:

- Know the difference between a circle and a triangle, square or rectangle.
- Find similarities and differences between a triangle and a rectangle.
- Understand how different shapes can be composed to make figures of familiar objects.

Accordingly, the day-wise activity plan was:

Day 1: Trace out different selected shapes and cut them out. Then, using the following questions, sort out the shape cutouts into 4 groups – circle, square, rectangle and triangle:

- What kinds of lines do we see in the tracing of the shapes?
- Which shapes, when traced, create straight/curved lines?
- Which shapes have equal/ unequal sides?
- How is a circle different from a square, rectangle or triangle?
- How is a triangle similar to a rectangle? How is it different from a rectangle?

End with a rhyme about shapes.

Keywords: Shapes, Properties, Sorting, Similarities, Differences, Classroom activity

This lesson went beautifully according to plan and so did most of the next day for which the plan is given below.

Day 2: Put students in groups of say 5, and give each group a random collection of shapes from several kits such as:

- Rangometry[1] – A collection of 2D shapes made of Ethyl Vinyl Acetate (EVA) that stick to the board when dipped in water – developed by Jodo Gyan.
- Tessellation kit – collections of regular polygons (pentagons, hexagons, etc.,) with the same side-lengths.
- Aakar Parivar – collection of 5 shapes (circle, semicircle, square, rectangle, equilateral triangle – each in a different colour and each in 5 sizes).
- Random shapes found in the classroom – one of these was an annulus (a doughnut shape).

Ask them to create figures of familiar objects and using the kits get them to draw the same on paper. Then have discussions on:

- What shapes did you use to make the boat?
- Why did you use that shape?
- What is the difference between the shape you selected and the shape you did not?
- What made it more suitable for the figure?

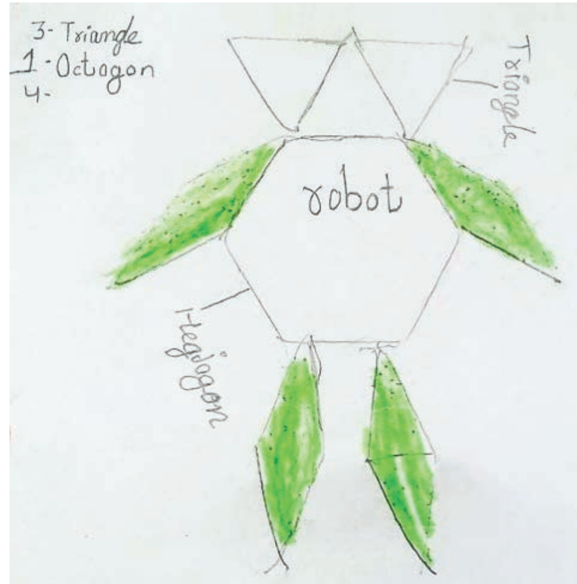


Figure 1

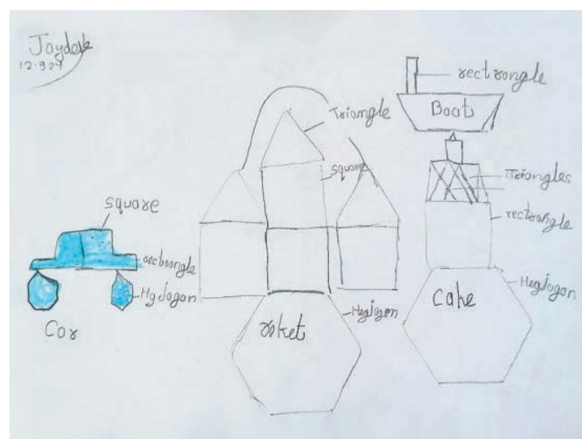


Figure 2

The groups were heterogeneous in terms of the abilities of the students. Each group had to make 5 figures- a car, a boat, a rocket, a cake and a robot. They got 5 minutes for each figure. The order of the figures for each group was determined by me to ensure that no two groups were working on the same figure simultaneously. These objects were also chosen based on the students' familiarity with them and the ease of making. The idea was to show that the objects in our surroundings are represented by putting different shapes together. It took longer than the expected 25 minutes due to the usual aspects of group work. They took time to settle down and work together, some groups wanted more materials. They were also interested in the figures the other groups were assigned, while each group took turns to make each of the figures. However, once they started making the pictures, they got fully involved. Then, they drew the same on a piece of paper provided to them at the start of the class. Some drew freehand while some traced the actual pieces. The decision was left to them.

1 Reviewed in the July 2023 issue of the magazine.

I noticed that they were keenly interested in the figures made by the other groups. When they exchanged shapes with other groups to execute their own ideas, they were taking inspiration from each other and exchanging resources without the class breaking into chaos. Since we ran out of time, discussions were postponed to the next day. This meant deferring the original plan which was:

Day 3: Tangrams – use the shapes of the given tangram set to make shapes of increasing complexity.

Days 4-6: Various explorations and discussions with shapes, followed by textbook exercises for formative assessment on Day 7.

Day 3 started with a discussion based on the pictures drawn by the students. Since the pieces involved many polygons and other shapes that were new to them, it opened a floodgate of questions and steered the discussion in a different direction.

We started finding different 4-sided shapes, when a student discovered a shape that looked like half a hexagon! Can you guess which 4-sided shape it was?

Figure 3

Now this good observation took the discussion towards symmetry and paper folding was brought in to show how this shape is half of a hexagon. We took a rectangular piece of paper and folded it along the horizontal mid-line. Then we opened the sheet of paper and folded the four corners so that they touched this crease. Next, we folded along the crease, and got the same shape!

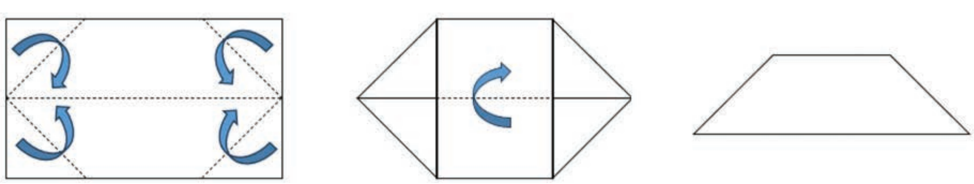


Figure 4

And then the students just took over! One student got stuck with the idea that the isosceles trapezium looked more like half an octagon rather than half a hexagon. How can you show that the quadrilateral in Figure 5 is actually half of a hexagon?

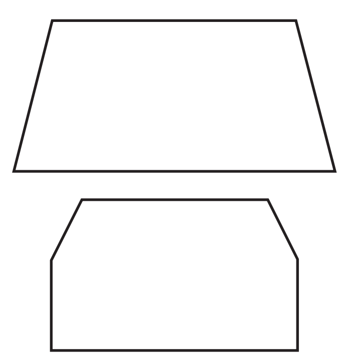


Figure 5

Misconceptions such as "hexagons must have all sides (and angles) equal" surfaced and were discussed.

The students then started experimenting with the folds and soon had created an octagon. Then one student figured out how to unfold one flap and convert an octagon into a heptagon. And once someone did it, several tried to replicate the same. And their enthusiastic eagerness to know the names of these shapes (with 7 sides and 8 sides) made it impossible to carry on with the planned activity. So, I went into the terminology of octa for eight, bringing 'octopus' into the discussion as an example. Thus, the paper folding activity took a life of its own, completely initiated and owned by the students! Here are some of the pictures related to the activity.

Figure 6: The original hexagon

Figure 7: Hexagon opened and new folds created to make an octagon

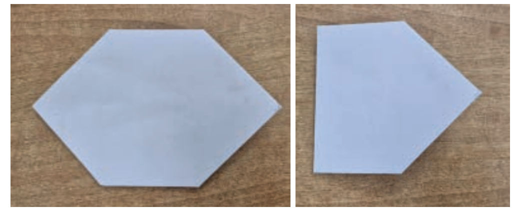


Figure 8: Another hexagon changing into a pentagon!

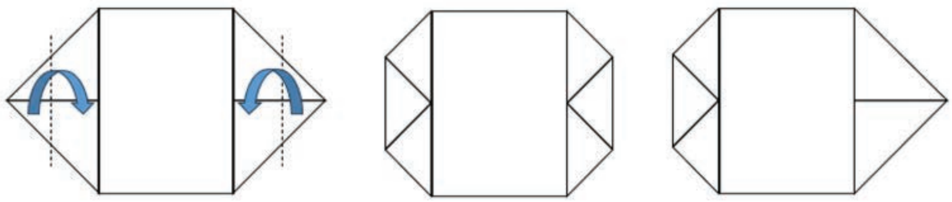


Figure 9: The details of the folding

Seeing those shapes, another student casually dropped the observation that the hexagon looked a little bit like a circle. And others felt that is true for the octagon too. The board got filled with various polygons as the discussion continued.

As the students got more involved, and excited, all wanted to be heard – either to ask a question or to share an observation. It became impossible to address each question, and they got impatient. So, I had to pause and ask them to write down their questions. But it was the end of the class by then, and this became the homework. Feel free to guess how sincerely these Class 3 students did their homework!

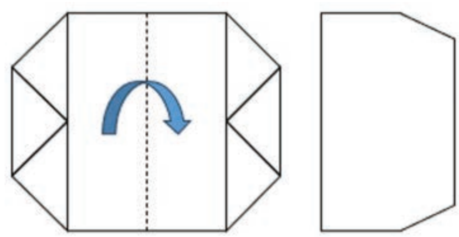
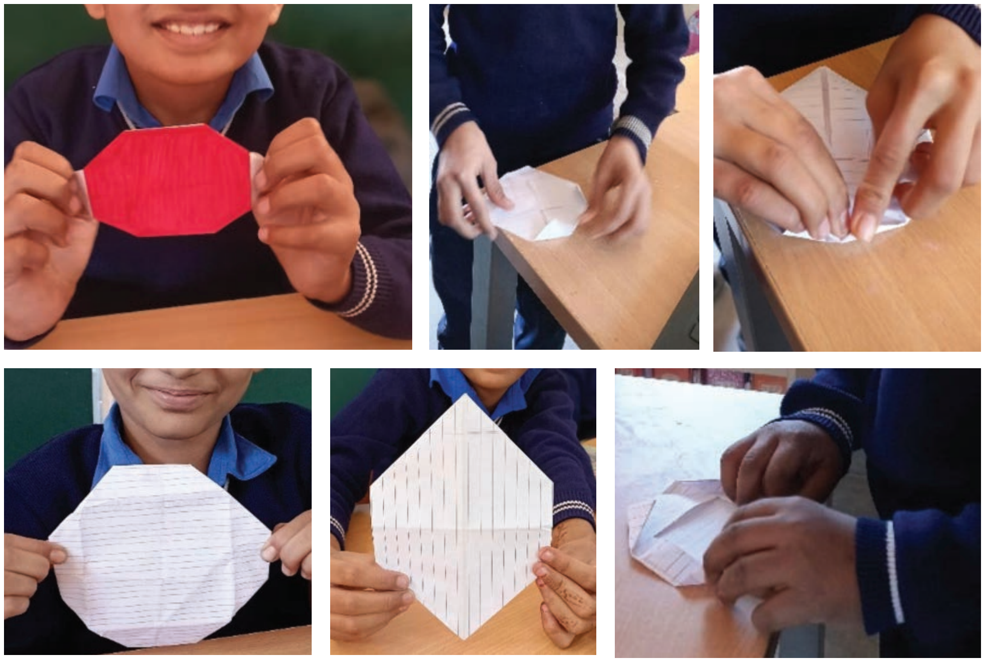


Figure 10

Upon reflection, we realized the following:

1. Though there was chaos, it was from too much eagerness to share their findings/questions. So, it was from deep engagement and active participation of the students in their own learning. And therefore, it was very different from unproductive distraction and disruption. The takeaway for us was that while the chaos needed to be contained, the students should not be scolded for making too much noise.
2. Giving freedom to the students was helpful. Those who could, drew freehand, and those who needed could trace to get more exact shapes. And on Day 3, their creativity, curiosity, observation and questions spearheaded the class.
3. They were not reluctant to learn from each other and this shared learning helped them to progress faster.
4. They figured out how to modify one shape into another through folding, thereby getting the sweet taste of discovery.
5. Their discoveries and curiosity took them far beyond their grade level.
6. They voiced their observations without hesitation and thus the teacher could build on that and more importantly, address misconceptions. So, in several ways, these classes were child centric.



7. Planning could be improved by allocating more time for the activity on Day 2.
8. If too many want to speak at the same time, the teacher needs to immediately channel that to writing. It is important that the teacher articulates that in this way, s/he can get everyone's thoughts, and then respond accordingly. This explanation should help the students realize how writing helps in communicating each of their thoughts to the teacher, which can't be done by expressing orally given the limited class time. Usually when students see the reason behind any action, they resist less. Especially if the reason is connected to their need to be heard. It is also a good idea to get them to write down their thoughts from the Preparatory stage. Such habits are easier to build when they are younger and will have a lot of benefits later. A good way to get students started on this habit is to make a list on the board, giving students time to share their suggestions individually and then edit the list collectively.

If you want to have similar fun with shapes, then you should definitely have a collection of objects that can be used to trace shapes. These shapes can also be generated by paper. It is not important to introduce the names pentagon, hexagon, etc. One can stick to 5-sided shape, 6-sided shape, etc., initially. We hope to share a worksheet based on such paper folding activities in the near future.

AAKANKSHA joined Azim Premji Foundation, Barmer in 2023 and has been teaching mathematics for more than 7 years now. She has master's degrees in education and in English literature and has completed her bachelor's degree in science and education. Aakanksha likes engaging with young students and exploring innovative ways to make mathematics learning fun. She may be contacted at aakanksha.agarwal@azimpremjifoundation.org

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 people at 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

Math Space: https://sites.google.com/apu.edu.in/mathspace/home

Charting Shapes: A Fun Exploration of Perimeter and Area

Garima Bhatt

Reflection on a classroom activity: Here is an account of a Class 5 lesson, written in the words of the teacher. The lesson was focused on understanding the concepts of perimeter and area.

Introduction to the Activity

I started a hands-on classroom activity during the teaching of the unit on perimeter and area. Before diving into the activity, I made sure that the students:

- Had a solid understanding of key concepts such as recognizing basic 2D-shapes (squares, rectangles, and triangles).
- Knew how to measure the length of sides of polygons.
- Understood centimetres and inches – common units of measurement of length.
- Had a good understanding of the concepts of, and difference between, addition and multiplication, and could use these operations in simple sums, which is crucial for calculating perimeter and area.

The goal of the lesson was to help students explore how to find the perimeter and area of various shapes they encounter in everyday life. To begin, I asked students to think about objects they see regularly that have specific shapes, such as their books, desks, and tiles. This sparked a class discussion where students shared their ideas on how these shapes might be measured mathematically.

We then revisited the concepts of perimeter and area, with the key terms written on the board for reference. Through examples and group conversation, students worked together to explore the meaning of perimeter as the total length around a shape, and area as the space within its boundaries. We focused on familiar shapes such as squares, rectangles, and triangles, discussing each one as a group. As students shared their thoughts, we used their contributions to clarify and deepen our understanding of these concepts, making the discussion more interactive.

Keywords: Perimeter, Area, Classroom Activity, Shapes, Operations, Estimate, Fence

The Activity Setup

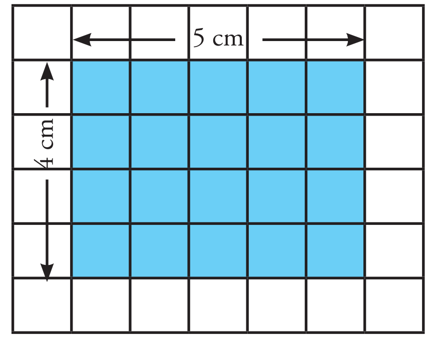


Figure 1

Once the introduction was complete, students were encouraged to explore and choose real-world objects in the classroom to trace on graph paper. They selected a variety of shapes, such as square books, rectangular boxes, circular plates, and irregular leaves. As they began tracing, students discussed how grid paper could help them chart the shapes and how they could use the squares to estimate areas.

We did this example for a rectangle that spanned across five squares horizontally and four squares vertically. They calculated the perimeter using $5 + 4 + 5 + 4 = 18$ cm and the area using $5 \times 4 = 20$ cm^2. (We were using a centimetre grid.)

During this time, students shared their ideas about how to measure perimeter, with some recalling that it was the total length of all sides. The example helped them recall how grid lines could be used to measure the sides of regular shapes by counting squares.

Each student was provided with graph paper, a ruler, and a pencil, and was encouraged to carefully trace the outline of the chosen objects. As they worked, students discussed their approaches with one another, sharing ideas about how to calculate the perimeter and area of the shapes they traced. While they engaged in this process, I moved around the room to observe their strategies, offering support and answering questions when needed. This allowed students to take ownership of their learning, while also having opportunities for guidance and clarification as they explored the concepts.

Student Engagement and Teacher Observations

As the students began their work, it was exciting to see their enthusiasm in applying what they had learned. Some students, however, expressed uncertainty about using the grid to calculate area. They shared their thoughts with the group, and through this discussion, they were able to refine their understanding of the concept. The collaborative exchange helped them move forward with greater confidence. It was rewarding to witness how the hands-on activity, combined with peer feedback, allowed them to engage deeply with the task.

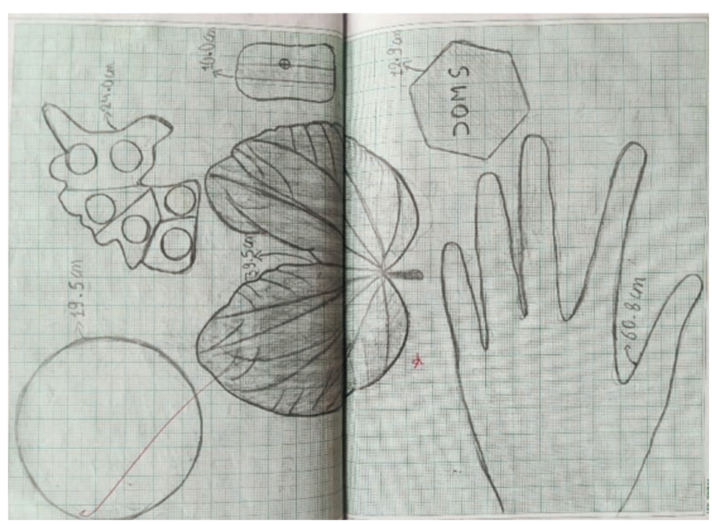


Figure 2

One student, while tracing her handprint, asked, "What if the shape has curved or irregular edges? How do I find the perimeter?" This sparked a conversation about different methods for measuring such shapes. Students discussed various approaches, including the use of thread to trace the outline, which could then be measured with a ruler to approximate the perimeter. As we explored why a straight ruler might not work directly for curved lines, students shared their own examples of irregular shapes where the thread method could be useful, further expanding their understanding of perimeter estimation.

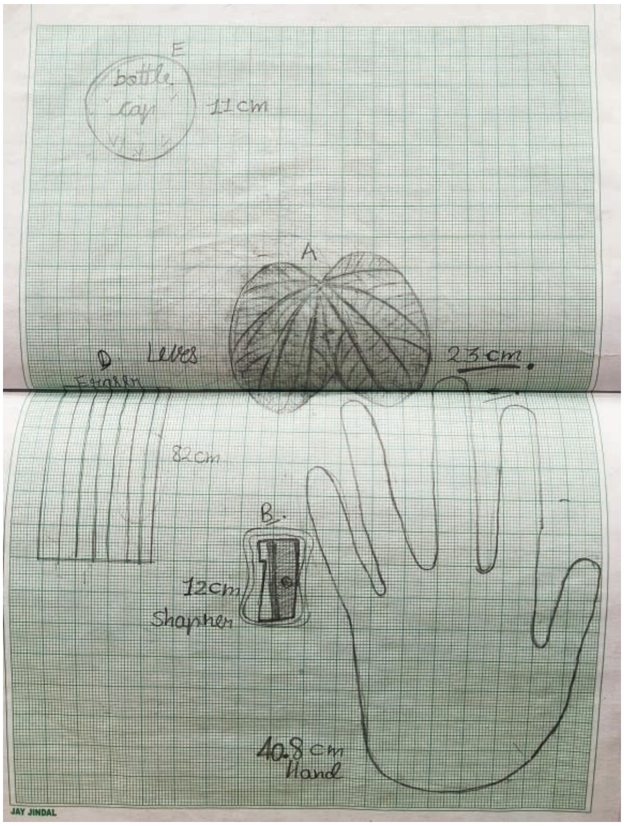


Figure 3

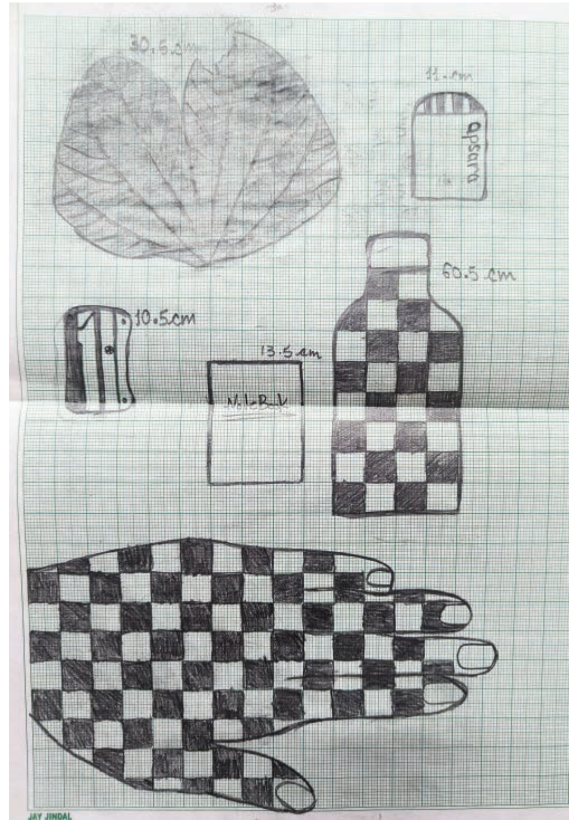


Figure 4

Then I observed something amazing. One student in the side desk, was tracing a leaf in his graph paper. For finding the boundary he didn't use thread; in fact he had drawn the sides of squares inside the leaf on the graph paper for finding the perimeter (Figure 5). It was unexpected but gave me the golden chance to have a discussion with all students on the **Estimation of perimeter**. (This was done in a subsequent class, when we compared his estimate with the estimate using thread.)

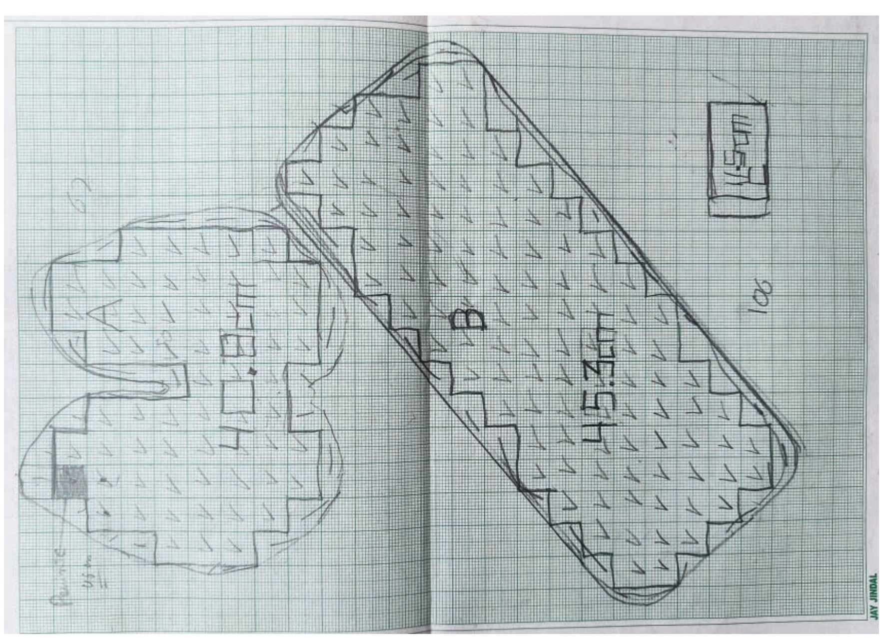


Figure 5

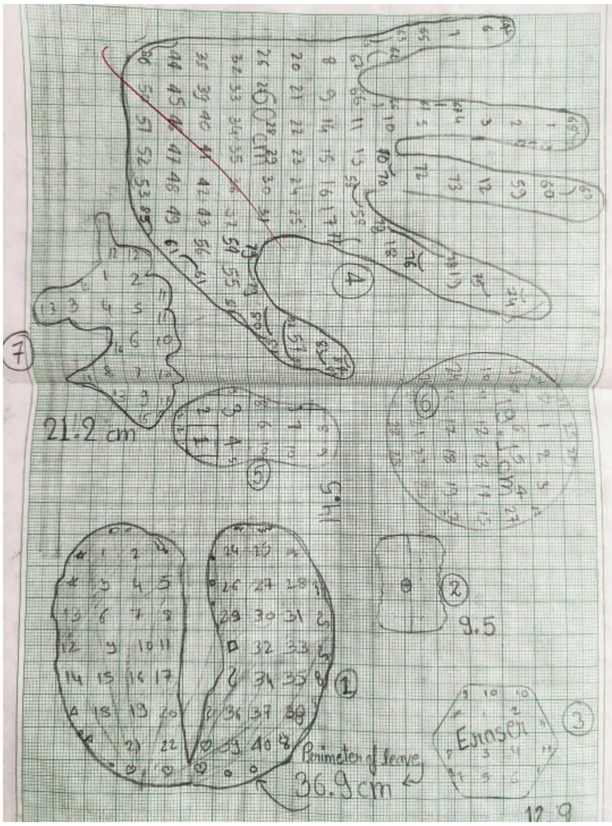


Figure 6

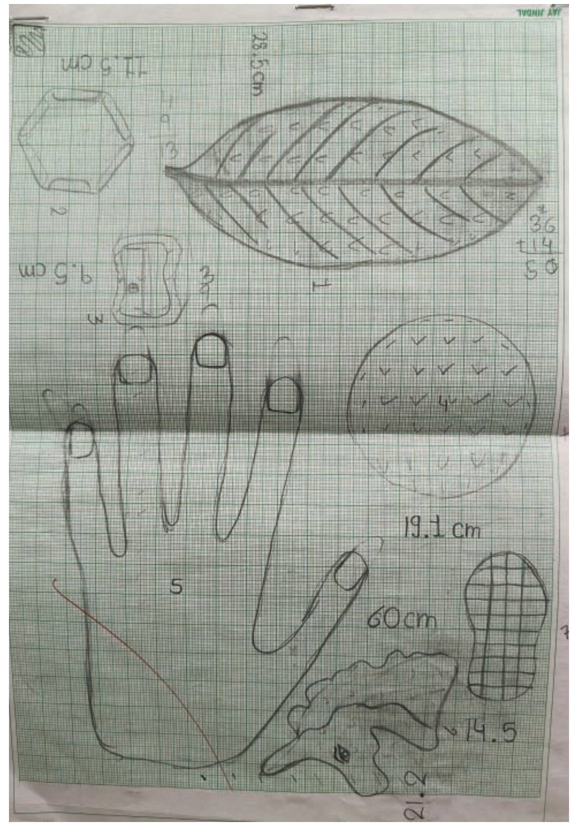


Figure 7

After using a thread to trace the perimeter of their irregular shapes, several students compared the measured thread length to their earlier estimates made using a ruler or by approximating with straight segments. They noticed that their initial estimates were often larger than the string measurement. This led to a valuable discussion about how estimating curved edges with straight tools can lead to overestimation, and why flexible materials like thread provide a more accurate measurement for irregular shapes. It helped students appreciate the importance of choosing appropriate tools based on the nature of the object being measured.

During the discussion, many students said that they had used thread to estimate the perimeter, showing their engagement with the method to measure irregular shapes. While this approach sparked interest and creativity, it also led to a conversation about its accuracy. Students discussed whether the thread method was the most reliable way to measure perimeter, especially for irregular shapes. The thread method doesn't offer the precision required for accurate measurements. This prompted me to reflect on how clearly I had communicated the purpose of using grid lines for measuring sides. We had discussed the grid as a more structured and precise method, allowing students to count units directly along the sides, making it a more reliable technique for calculating perimeter, especially for regular shapes.

Several students also had questions about how to deal with partial squares when calculating the area. One asked, "How do I count the squares that are only partially covered by the shape?" I demonstrated that they could estimate by counting all the full squares and then approximating the areas of partial squares, encouraging them to focus on getting close but not necessarily needing precision.

From the last bench of the classroom, a girl called me for help and asked, "What if the shape is like this? Is the boundary inside also part of the perimeter?" I looked at her shape. It was the set triangle from her geometry box (Figure 8). For area, she had calculated the region correctly but was confused about the perimeter. Since it was important to know for everybody, I took it up in the next class after discussion with the other teachers.

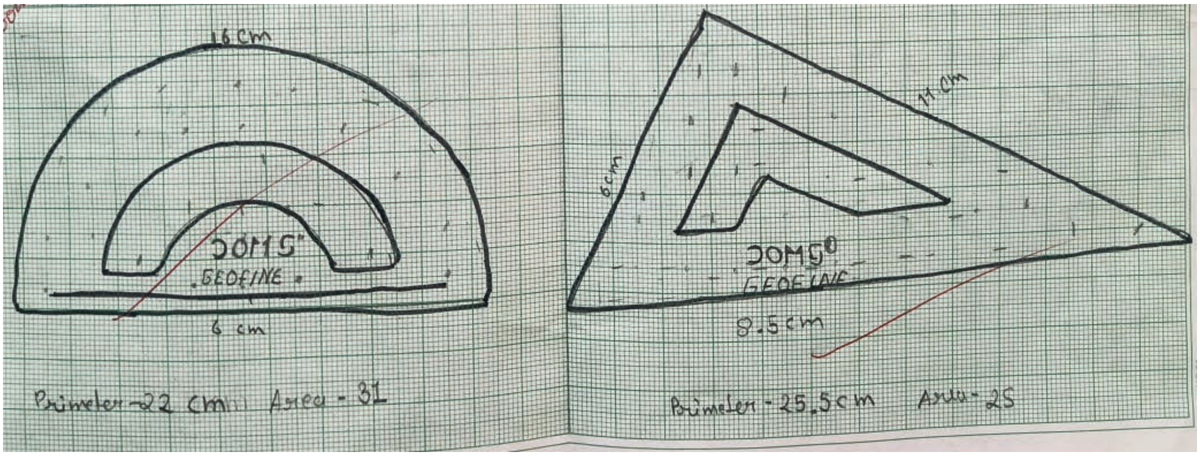


Figure 8

For providing the context, I started like this – let's imagine a park with a pond in the centre. I drew the shape of the park with the pond on the blackboard. Then I asked, "If I want to protect my park by putting a fence around the park, what do you think the total length of the fence will be?" They answered that the park needed to be protected from the outside, but to stop children from going into the pond, we need the fence around the pond also. So, for the total length of the fence of the park, we need to count the inside fence too.

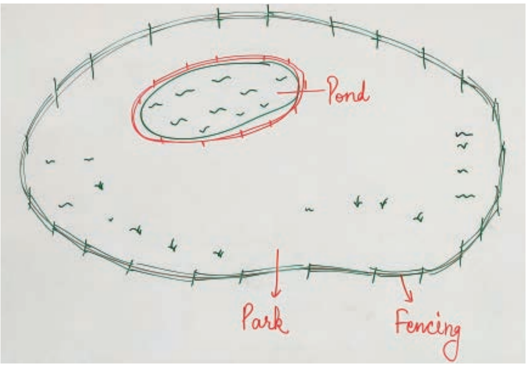


Figure 9

In response to the students' suggestion about needing to count the inside fence around the pond, I explained that this depends on how the fence is intended to be placed. I clarified that if the goal is to protect the park and its surroundings, the fence should only surround the perimeter of the park, not the perimeter of the pond. The fence around the pond would be needed only if we specifically wanted to separate the pond from the park, for example, to keep children away from it.

Teacher Reflections on the Activity

Looking back at the activity, I believe it was a valuable learning experience for both the students and me. The most successful aspect of the lesson was how students engaged with a variety of real-world objects. They seemed to enjoy tracing the shapes and experimenting with applying mathematical concepts in a hands-on, tangible way. The use of graph paper proved to be especially helpful, as students were able to visualize and count the squares, making it easier for them to determine the area of shapes, even those that were irregular. Their independent exploration and application of these concepts highlighted the importance of providing opportunities for students to learn through active involvement.

Student Responses and Growth

Throughout the activity, it was clear that the students were engaged and eager to learn. They actively participated in the tracing and measuring tasks, asking thoughtful questions along the way. Some of their responses demonstrated real growth:

- **Student 1** said, "I traced my dictionary and counted the squares on the graph paper. I found the area by multiplying the length and width, and the perimeter by adding up all the side lengths."
- **Student 2** shared, "I had trouble with my bottle cap because I didn't know how to find the perimeter of a curve, but after using the thread, it made sense. I used the thread to measure the boundary of the circle then found the length of the thread from my ruler."
- **Student 3** commented, "I traced a hexagonal eraser, and I had to break it and count the partial squares to find the area. It was tricky, but it worked!"

These responses showed me that the students were not only applying their knowledge but also thinking critically about how to approach more challenging shapes.

Conclusion

In conclusion, it was exciting to see how the students navigated challenges, whether it was measuring irregular shapes or figuring out how to count partial squares for area. Through their own exploration and problem-solving, they developed a deeper understanding of these concepts. Looking ahead, I plan to give students more opportunities to explore complex shapes and refine their skills in calculating perimeter and area, allowing them to practise and build confidence at their own pace. This activity was a great reminder of the power of hands-on learning and how, when students take the lead, they can surprise us with their creativity and insight.

GARIMA BHATT has been a teacher at Azim Premji School, Udham Singh Nagar since December 2022. She holds an MSc and B.Ed. in Physics from SSJ University, Almora.

Garima currently focuses on mathematics education in the primary grades, with a strong belief in making math fun, engaging, and meaningful for young learners. She enjoys creating a classroom environment where children can explore mathematical ideas through hands-on activities, games, and real-life connections, helping them build confidence and curiosity. Garima may be contacted at garima.bhatt@azimpremjifoundation.org

Understanding Different Types of Algorithms

Anushka Tonapi

In an earlier article published in the November 2024 issue [1], we explored the concept of algorithms and their significance and looked at different ways that we use them in everyday life. In this article, we will explore different types of algorithms and suggest activities to demonstrate these in the classroom.

An algorithm is a list of instructions that help you solve a problem or complete a task. We have discussed that there are multiple algorithms that can be used to solve a problem. But did you know that there are many different *types* of algorithms that use various methods to solve a problem? Some help you make choices, others help you find the fastest path, and some put things in the correct order. In this article, we shall explore the most common types of algorithms in fun and interactive ways.

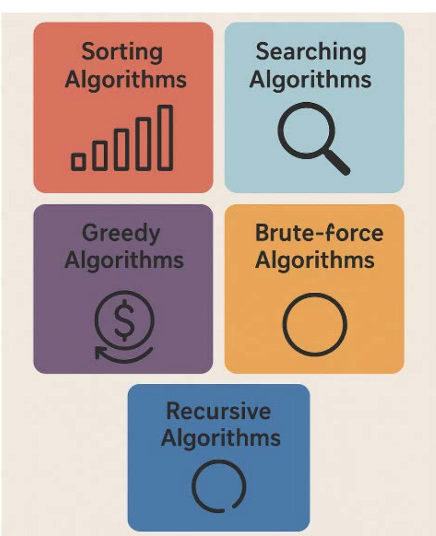


Figure 1 (Source: AI)

1. Sorting algorithms: Putting things in order

Let's start with something we all do - organizing! Sorting algorithms help us arrange items in a particular order, such as smallest to largest, or alphabetically.

Why sorting is important: When you arrange your books by height, your clothes by colour, or your crayons in a rainbow pattern, you are using sorting. Computers use sorting to arrange emails by date, numbers in a spreadsheet, or high scores in games, for example. In Figure 2, you can see six crayons sorted in the same order of the colours in the rainbow.

Figure 2

Keywords: Computational Thinking, Processes, Searching, Sorting, Algorithms

There are many different ways of sorting things, with the following list of sorting algorithms:

- **Bubble Sort:** Compare pairs of items and keep swapping them if they're in the wrong order. The biggest item "bubbles up" to the end in each round. For example, suppose we have the unsorted list: 1, 3, 4, 5, 2; and we want to arrange them in ascending order. Then we consider the first two numbers: 1 and 3. Since they are in order already, we aren't going to swap them. Similarly, we don't swap the next two numbers 3 and 4 either, or even 4 and 5. But 5 and 2 are not in order, so we swap 5 and 2 with each other to get 1, 3, 4, 2, 5. Once again, we swap 4 and 2 (since they are not in order) to get 1, 3, 2, 4, 5. Finally, we swap 3 and 2 to get 1, 2, 3, 4, 5. Notice how the number 2 "bubbles up" towards the left and 5 (the biggest number) "bubbles down" to the end.
- **Selection Sort:** Search the whole list for the smallest item and place it at the beginning. Then search for the next smallest, and so on. We consider our old example but jumbled a bit differently: 5, 3, 4, 1, 2. The smallest item is 1, so we place it in the left-most position 1, 5, 3, 4, 2. Then the next smallest item among the remaining items is 2, which goes next to 1: 1, 2, 5, 3, 4. Similarly, 3 and 4 also get placed in their respective places until we obtain the fully sorted list: 1, 2, 3, 4, 5.
- **Insertion Sort:** Insert each item into its correct place in an already sorted list. Such as putting your cards in order as they are dealt out during a card game. Suppose we have the same numbers as earlier, but now in the order 3, 1, 4, 2, 5.

Insertion Sort: Putting Mixed Cards in Order!

Step 1	3				1	4	2	5
Step 2	1	3			4	2	5	
Step 3	1	3	4		2	5		
Step 4	1	2	3	4	5			
Step 5	1	2	3	4	5			

Figure 3: Insertion Sort: Here the green represents the cards in hand and the pink, the cards being picked up, sequentially from left to right.

Classroom Activity: Take number cards from 1 to 10 and mix them up. Now try each sorting method. Which one takes fewer steps? Which one feels easier?

Try all the three given sorting algorithms with five balls of different sizes which have to be arranged in order of size from biggest to smallest:

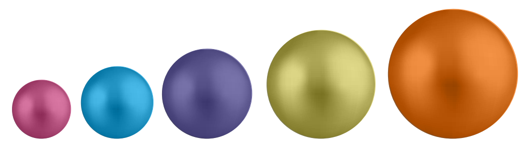


Figure 4: Balls that are in a sorted list from smallest to biggest

Which algorithm is the easiest/fastest?

2. Searching algorithms: Finding what you need

Imagine you are looking for your mathematics notebook in your school bag. You go through each item until you find it. That's a Linear Search! Linear Search is when many types of objects are carefully scoured through to find a specific object.

Types of searching algorithms:

- **Linear Search:** Check each item one by one. It's slow, but it works for unsorted lists.
- **Binary Search:** This only works for sorted lists. Suppose you are looking for a particular number in a list of numbers, sorted from smallest to biggest. If your number is smaller, search the left half; if it's bigger, search the right half. Repeat until you find it. Note: this algorithm works for more than just numbers! Suppose you want to look up the meaning of the word "Parrot" in your English dictionary. Since the dictionary is very thick and full of thousands of words arranged in alphabetical order, you know it would take a long time to search from the beginning, page by page. So instead, you decide to use a smarter method. You open the dictionary right in the middle and find the word "Lion". You know that the word "Parrot" comes after

"Lion" in alphabetical order, so you ignore the first half of the dictionary and now look only in the second half. Next, you open the middle of this new section and see the word "Tiger". Since "Parrot" comes before "Tiger", you now ignore all the pages after "Tiger" and look only at the words that come between "Lion" and "Tiger". You continue doing this, each time opening the middle of the remaining section and checking which half to keep, until finally, you find the word "Parrot".

Try This: Hide a card numbered 27 in an unsorted pile of cards numbered from 1 to 50. Then place the same card in the right place in a sorted pile of cards. Try finding it using both methods. Describe your search. Which pile was easier to search? Which search was faster?

3. Greedy algorithms: Choosing the best step now

A greedy algorithm makes the best choice it can at each step, hoping that all these good choices will add up to the best overall solution.

Example: Imagine you are collecting peppermints of different sizes. You want to pick the biggest ones but can only pick three. A greedy strategy would pick the biggest visible ones right away, without checking all the comparisons.

Figure 5: Peppermints

Activity: Suppose it's your birthday, and you get to choose toys to buy as a gift. Your box has limited space – with space available for only three toys. Make a list of five possible toys and give them a score out of ten based on how much you enjoy playing with each toy. For example, if you love playing with puzzles, give the puzzle box a score of 9 out of 10, and if you don't really enjoy playing with toy cars, give the car a score of 3 out of 10. You use the greedy algorithm to pick the toys with the highest score so that you can enjoy them the most. You may end up with three puzzles! Now, try making another selection without repeating any toys. You will see a different type of greedy solution (since the previous solution just involves repeating the toy with the highest score to maximize enjoyment and make it as high as possible).

Think about any other situation in your life where you can apply greedy algorithms to solve a problem.

4. Recursive algorithms: Solving problems by solving smaller ones

Recursive algorithms solve a big problem by solving a smaller version of the same problem. It's like asking a younger sibling to help, and they ask an even younger sibling, and so on.

Example: Russian matryoshka dolls are dolls nested within each other. Think of a problem as a set of matryoshka dolls, with smaller problems nested inside of it.

Figure 6: Matryoshka dolls
(source: Macalester College, Russian studies)

Activity: Build a tower of cups as shown below.

Figure 7: A tower of cups

Now, try to think of a way to remove the cups. To remove the cup at the bottom left, you must remove the cups on top of it, and to remove those cups, you must remove the topmost cup. This way, the problem of removing the cups gets reduced to a simpler problem using a recursive algorithm, and when you solve the smallest part of the problem, the rest gets solved sequentially; i.e., when you remove the topmost cup you can proceed to remove the next row of cups, and finally the last row of cups.

Problems that are solved using the recursive algorithm are better suited for higher classes, so we are not giving an example here.

5. Brute force: Try every possibility

Brute force means checking every possible solution. It's not clever, but it guarantees a solution.

Example: Suppose you have a lock on a door, and a set of keys with 10 keys in total. You have no idea which key unlocks the door, so you must try every single key and put it into the door lock to find which key unlocks the door.

Activity: Let students think of a number between 1 and 20 and let a partner guess it using a brute force method.

How many guesses did it take?

Conclusion: Think like an algorithm!

Algorithms are everywhere – they can help us be more organized, more efficient, and more creative. By learning different types of algorithms, you become a better thinker and problem-solver, because you can apply different methods of approaching a problem to try and solve it with these algorithms.

Next time you face a tricky challenge, ask yourself: Can I break this down into steps? Can I try different methods such as greedy, brute force or recursive algorithms?

Because when you think like an algorithm, no problem is too big!

Note from Editor: One may wonder if such algorithms should be introduced in primary classes. We would certainly not recommend naming and defining the algorithms for searching; however, you would have noticed that most of the examples used are from the everyday life of primary school children. It would be interesting to design tasks that require searches- if students can employ these different methods and compare them during reflection and discussion after the task, they would be absorbing the ideas of computational thinking and understanding its relevance in a fun and non-threatening manner.

Reference

1. Tonapi, A. (2024). Introduction to algorithms. *At Right Angles, (20),* 14–19. https://bit.ly/3XJ6E1e

ANUSHKA TONAPI is a 11th grade student at Alpine Public School in Bengaluru. She is a Young Member of the New York Academy of Sciences and she is a Spirit of Ramanujan Fellowship awardee. She enjoys solving math problems and is interested in theoretical computer science. Anushka loves playing chess and practises Carnatic music in her spare time. She can be contacted at Anushka.tonapi@gmail.com

Data Collection in Action: An Experiment by Upper Primary Students

Nidhi, Ashwath, Vyaan, Vinay

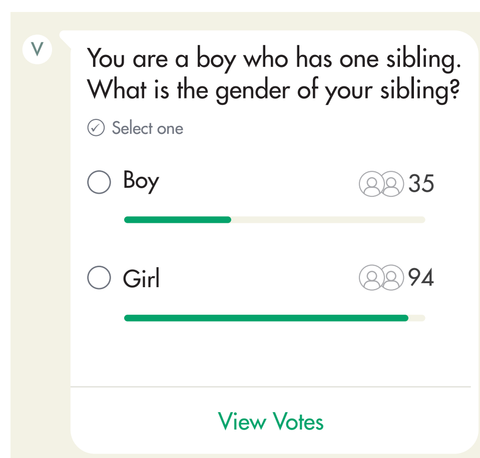
In our weekly Ganit Manthan class, we do mathematical explorations with school students. I posed a problem on probability to the students who knew only elementary aspects in probability and were not formally introduced to the subject. The question was as follows: You are talking on the phone with your friend who is a boy. He asks you this question: "I have a sibling. Can you put a guess whether my sibling is a girl or a boy?" If *you* were to place a bet on the gender of the sibling, what would you place a bet on - a boy or a girl? This article is the experience written in the voice of three students on how they went about solving this problem using empirical data collection. I hope that Mathematics teachers can draw ideas from this exercise on making Data Collection and Data Handling interesting and engaging using examples that may be relevant for the students. It can also give ideas on how to engage in a discussion on the process of data collection before the data is analyzed. And all this, within the gamut of learning ability of upper primary school students – Vinay Nair

Anecdotal Account of Response to the Question*: I am a boy and I have a sibling. Is my sibling a girl or a boy?*

At first, when we heard of this problem in our class, many of us felt that there were equal chances of the sibling being a girl or a boy.

To confirm our answers, we were asked to collect data and see if the data shows the same results. Thus, we used Statistics and Mathematics. Below is an account of the individual processes that each of us followed when we were given this task.

Vyaan: I did this experiment by collecting data on a WhatsApp poll in a group which had 129 males with exactly one sibling, and I got this result.

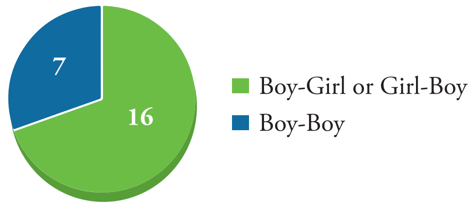


Out of the total of 129 outcomes, there were 94 boys who had sisters. Using the basics of probability that I knew, I calculated the chance of the sibling of a boy being a girl was 94/129 ≈ 2/3

Ashwath: I asked my mother to tell me the family details of our male relatives who had exactly one sibling and I tabulated them into two columns – Boy-Girl pair and Boy-Boy pair. From the data that I had collected, there were:

Keywords: Data Collection, Designing Experiments, Probability

- 16 Boy-Girl / Girl-Boy pairs
- 7 Boy-Boy pairs



The ratio of Boy-Girl / Girl-Boy pairs to total number of pairs was 16/23 ≈ ⅔.

Nidhi: When I thought of the question before looking at the data I collected, I assumed that there was a 50% chance of the sibling being a boy (or a girl). To check if my intuition was correct, I went about asking male members in my housing society and boys in my school if they had exactly one sibling, and if so, what their gender was. The statistics were counter-intuitive! Below is the summary of the data I collected from different people.

Since one of the siblings had to be a boy, there were two different groups that people could be segregated in:

- Boy with Boy sibling
- Boy with Girl sibling / Girl with Boy sibling

Data that I got was:

Boy-Boy	Boy-Girl	Total
15	34	49

Boy-Girl pairs / total number of pairs = 34/49 ≈ 2/3

Vinay: As I had hoped, both Data Collection and Data Handling became interesting using this example that was relevant for many students. It was not difficult for them to collect the data and they were able to get a hands-on experience about different ways to collect data and then analyse it.

Once the students came back with their findings, I continued the discussion as given below.

Let's say that we have 100 pairs of siblings. There will be four types of sibling pairs. In statistics, we say that there is a 25% chance of each type of pair.

Older Sibling → Younger Sibling ↓	Boy	Girl
Boy	25	25
Girl	25	25

If we have a boy-girl pair we have 50 pairs (25 where the girl is older than the boy + 25 where the boy is older than the girl). There are only 25 boy-boy pairs. Here we do not consider a girl-girl pair, as we know for certain that one of the siblings is a boy. Therefore, the probability of getting a boy-girl pair would be greater than the probability of getting a boy-boy pair.

P (getting boy-girl pair) = 50/75 = 2/3

After we reasoned out our findings from the data collection exercise, we found that the chance of the sibling of a boy being a boy or a girl is not equal! And in answer to our friend's question, we should have said that his sibling was most likely a girl!

We also noticed how everyone had a different approach to conduct the survey.

	Nidhi	Vyaan	Ashwath
How the poll was conducted	Asked people in her apartment and school	Created a WhatsApp poll in a Rajinikanth Fan group	Asked his mother for family history
How many people took the survey	49	129	23

Although there were a lot of methods, the probability we arrived at was roughly the same. All in all, this problem truly intrigued us all, as something that we all expected to be right, turned out to be wrong!

Comments from the teacher

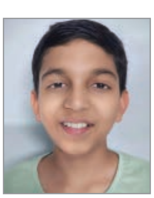
When the question 'whether the sibling was a boy or a girl' was posed to the students initially, the students felt intuitively that the answer is obvious and that there is a 50:50 chance of the sibling being a boy or a girl. This sparked a discussion on how to find out if this was true or not. Since the students weren't exposed to conditional probability, they only had loose arguments and intuition to back their answers. The discussion then led to the question of a tossing-two-fair-coins problem and the students had to debate whether Heads in the first coin and Tails in the second, was the same as Tails in the first coin and Heads in the second. The students seemed to be convinced that for a coin toss, HT and TH are two of the possible outcomes but they were not sure if the same would apply to the Boy-Girl and Girl-Boy order.

Towards the end of this discussion, some of them were convinced that the chance for the other child being a girl would be 2/3, but some of the students in the class weren't convinced. They also wanted to know if this would happen in reality. This is what led to the discussion of designing an experiment through which one can determine whether the answer that we get using mathematics will match with reality.

The students were then asked to collect the data and analyze. No guidance or hints were given to the students on how to go about the process of data collection. It was completely their choice. After the data collection, the students also voted for each other's methods and commented which method was better than the other. For instance, someone said that in the data collected through the WhatsApp group, we don't know every member personally and hence the data may not be reliable. Someone said that when data is collected from a particular family, there could be some biological factors which may lead to more members of a particular gender. Thus, it can also be skewed. These discussions also brought out the intricacies of data collection and how careful one should be while collecting the data if they have to rely on the same. While there is a lot of emphasis on data representation and data handling, introducing data collection can also be part of an activity. When it is followed by discussions, students will be forced to think critically and evaluate. It will also bring out their creative skills in data collection and analysis. While meaningful collection of valid data is one aspect of this article, the other is understanding the logic of the reasoning using elementary understanding of probability.

ASHWATH ARUNACHALAM is a 6th grader studying in PSBB T. Nagar, Chennai. He is passionate about Mathematics and has been part of prestigious math camps such as Epsilon India and RAM Maths Circle Chennai. He may be reached at ashwath.arunachalam20@gmail.com

NIDHI NAYAK is an 8th grader studying in Sri Kumaran Children's Home school, Bengaluru. She is also passionate about Mathematics and has attended math camps such as the All Girls Math Nurture Camp at Azim Premji University and Raising A Mathematician Training Program. She may be reached at nidhijnayak@gmail.com



VYAAN GUPTA is an 8th grader from Delhi studying in Allenhouse Public school. Vyaan loves mathematics and has been part of Epsilon India 2024 and RAM Maths Circle Chennai. He may be reached at vyan.gupta@gmail.com

VINAY NAIR is a mathematics educator and co-founder of Raising A Mathematician Foundation and Vichar Vatika. He works with students who are deeply motivated by Mathematics. He may be reached at vinay@vicharvatika.org

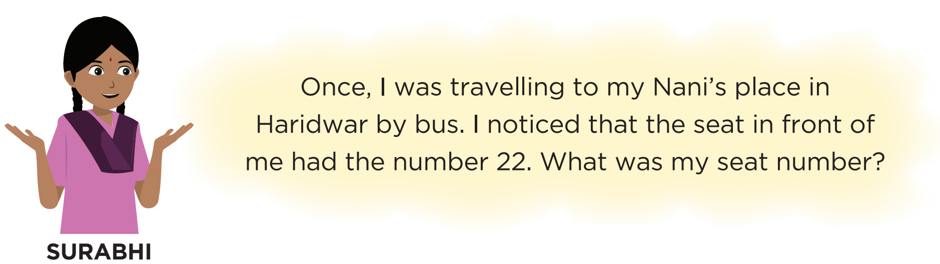
Seat Number 22

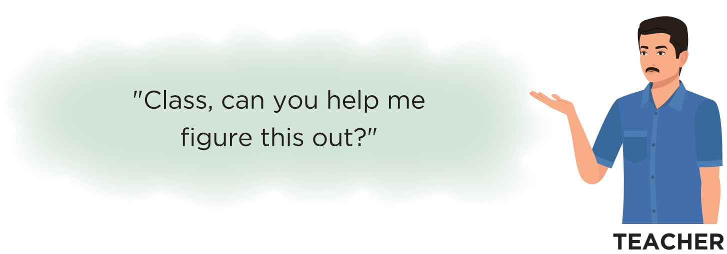
Ashok Prasad

What is the connection between a bus seat layout and a rectangular wave pattern? How do open-ended questions reveal unlikely connections? In this article, I share a personal classroom experience, in which students used visualisation to connect the concrete with the abstract. The open-ended conversations led to new insights and directions.

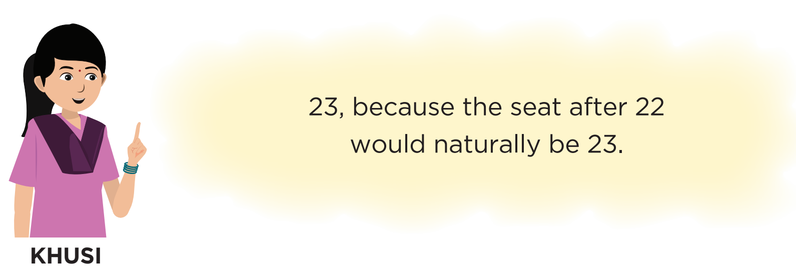
It was a Tuesday morning, and the 12 students of Class 7 at the local government school, were surprised to see me stepping in for their teacher. After a few friendly exchanges, I casually asked how many of them had travelled by bus, where they went, and why. What did the inside of a bus look like? How many types of buses had they seen?

The class lit up, sharing stories of bus journeys- visiting their *Nani's* (grandmother's) or *Mausi's* (aunt's) place in nearby towns. It was clear that everyone had travelled by bus before. I mentioned that I'd been talking to students from another school about their seat numbers on bus journeys, and that's when Surabhi chimed in with a question:





A quick guess is a pedagogical opportunity



Keywords: Seat Numbers, Patterns, Connections, Visualisation, Communication

PRIYANSHU

If there's only one column of seats in the bus, yes. But the buses I have seen, have more than one seat in each row. So, I think we might have to consider other possibilities besides just 23.

VINOD

Yes, sir. I think we need to draw a diagram showing the bus seats to really know how they're arranged. That way, we can be sure about Surabhi's seat number.

Sketching Solutions

It seems like you all enjoy drawing and visualising things, and that makes math even more interesting. So, let's put that into practice. I'd like everyone to draw the layout of a bus and number the seats as you think they are arranged. You can use the buses you've seen to guide you.

TEACHER

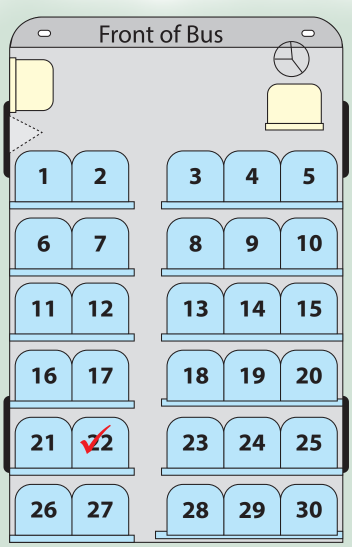


Figure 1: Deepak's Layout - 3+2 seats in each row. He has numbered each seat, so his guess is 27. How has he numbered the seats?

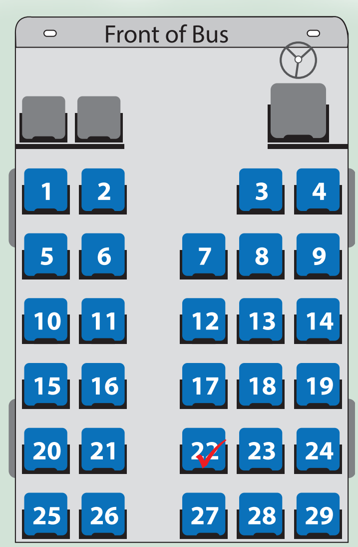


Figure2: Priyanshu's Layout - I also think Surabhi's seat number is 27, though my numbering is different from Deepak's in my drawing. There are only four seats in the front row of my layout.

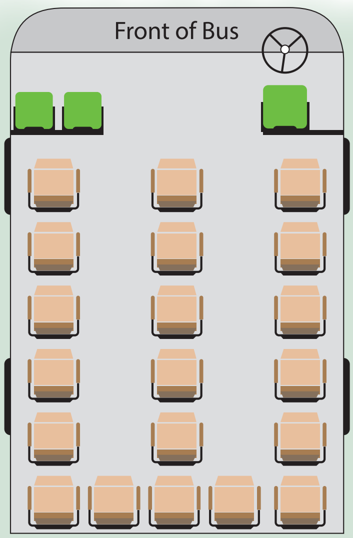


Figure 3: Yogesh's Layout - With door, windows, bus driver's seat and seats neatly laid out. Though Yogesh did not venture a guess, it was clear that he had visualised and represented a lot of details.

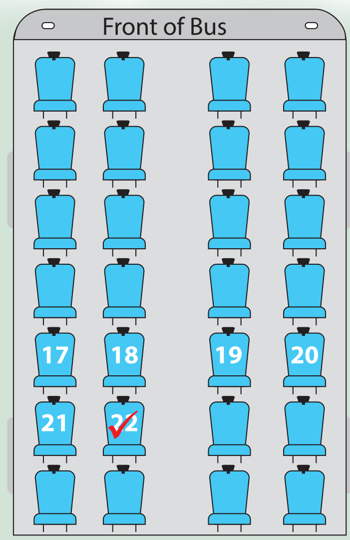


Figure 4: Ritik's Layout - 2 + 2 seats in each row, he got 26 as Surabhi's seat number. How did he number the seats?

Many of you arrived at the same conclusion, even though you visualized the bus layout in slightly different ways. Class, what are your thoughts on this?

Many Answers, Many Paths

Sir, depending on how you set up the drawing, Surabhi's seat could be 26, 27, ... there can be many correct answers. When I drew the bus layout, I started the numbering differently, and I saw that the seat numbers could be different each time.

Neha, could you show us how you got multiple answers?

Sure, sir.

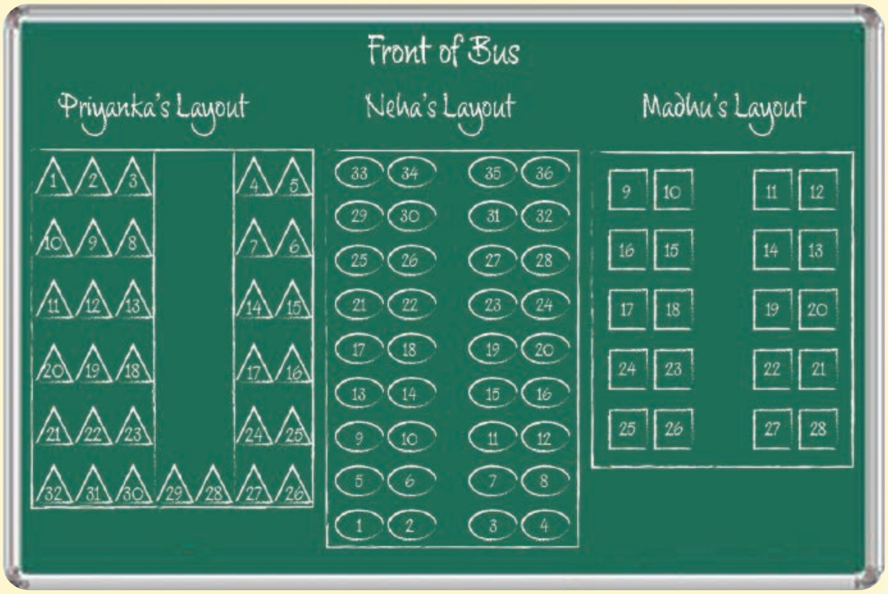


Figure 5

NEHA

If we start numbering from the very first seat on the left as 1, then Surabhi's seat could be 31.

If I number the seats from the very last seat on the left, Surabhi's seat number will be 18.

If Madhu also numbers the seats from the very first seat on the left but the seat numbers go in a different order, then Surabhi's seat number will be 27.

That's why I believe there isn't just one correct answer. It was the drawing, sir. At first, I was making a detailed drawing of each seat, but then I realised I didn't have to be exact. I just wrote the numbers in different ways, and that made me see that the arrangement could change Surabhi's seat number.

Excellent explanation, Neha! You showed how the starting point and the arrangement really affect the outcome.

TEACHER

MADHU

Sir. I took a different approach—I didn't even write the numbers on my drawing. I just drew simple rectangles to represent the seats. This way, I could choose any starting point for numbering, which shows that Surabhi's seat number need not be the same every time; it can change based on how you label the seats.

I love how you all are using symbols and drawings to explore the problem. It really shows that by playing with how we represent things—whether with detailed sketches or simple rectangles—we open up new ways of thinking about the problem. Mathematics isn't just about getting one "right" answer; it's about the process of exploring different ideas and understanding that the way we set up a problem can lead to multiple valid conclusions.

TEACHER

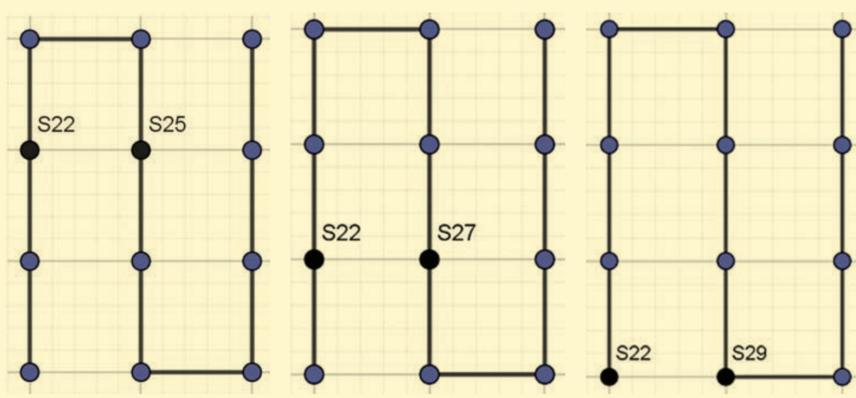
Playing with abstraction

I've noticed that Manisha and Arpit have taken a very different approach. Instead of drawing the bus layout like most of you, they have created a rectangular wave pattern. Manisha, can you tell me—according to your drawing, what is Surabhi's seat number?

TEACHER

MANISHA

Well, sir, based on my drawing, I'd say Neha and Madhu are right—the seat number could be anything. If S22 represents the seat in front of Surabhi in Figure 6, then her seat number is 25.



Manisha's Layout Arpit's Layout Amaira's Layout

Figure 6

That's intriguing. And why did you choose to draw just this small pattern instead of the whole bus layout?

TEACHER

ARPIT

Sir, I believe it's not necessary to draw the entire bus. To answer the question, I thought we only needed to understand

i. How many seats there are in a row
ii. If the numbering starts from the front or from the back
iii. If the numbering always starts from the left or continues in a wave.

The little pattern we drew contains all that information.

TEACHER

I see. So, in your view, the pattern itself is enough to decide the seat number. Manisha, you also mentioned there are rules to determine the seat number. Could you explain those rules?

MANISHA

Sure, sir. In the wave pattern, the position of seat 22 also matters. I got Surabhi's seat as 22 + 3, Arpit got it as 22 + 5 and Amaira as 22 + 7. These rules can change based on how we set up the seating. I can even see a position where it is 22 + 1! But of course, this also means that the position of the first seat will be at a random position and not always at the top left, which affects where seat 22 is.

TEACHER

Wow, Manisha, that's a great connection! It's fascinating how these rules can be applied to different arrangements. This shows how flexible our thinking can be when we use different representations. It's been wonderful to see how you all use your creativity and reasoning to tackle the problem.

Seat 22's Secret: What Students Taught Me

This classroom experience highlights the power of open-ended questions in fostering deep thinking and collaborative learning. When students were asked about Surabhi's seat number, their initial responses were intuitive and surface-level, such as assuming the seat number would simply be the next sequential number ($22 \rightarrow 23$). However, as the discussion progressed, students began to question their assumptions and explore alternative perspectives. This shift was facilitated by encouraging them to visualize the bus layout through drawings, which allowed them to engage with the problem more deeply. For instance, Deepak, Priyanshu, and Ritik drew detailed layouts of the bus, which helped them realize that Surabhi's seat number could be one of several answers. This shows how visual thinking can unlock new ways of approaching problems, especially when students are given the freedom to represent their ideas in their own way.

The use of symbols and abstract representations, as seen in Neha's and Madhu's work, further demonstrates how flexibility in thinking can lead to multiple valid solutions. Neha, for example, realised that the seat numbering could vary depending on how the numbers were arranged, leading her to conclude that Surabhi's seat number could be 26 or 27. This kind of reasoning is only possible when students are encouraged to explore problems without the constraint of a single "correct" answer. Similarly, Manisha, Arpit and Amaira took this a step further by using a rectangular wave pattern to represent the seat arrangement, showing how abstraction can simplify complex problems and reveal underlying patterns. Their approach underscores the importance of allowing students to move beyond concrete representations and engage with mathematical concepts at a more abstract level.

Asking follow-up questions such as, "Why do you think that?" or "Can you explain your reasoning?" encouraged students to articulate their thought processes and consider alternative viewpoints. This not only deepened their understanding but also fostered a sense of collaboration, as students began to listen to and learn from each other. For example, when Priyanshu challenged the initial assumption that Surabhi's seat number was 23, it prompted the class to rethink their approach and consider the layout of the bus more carefully. This kind of dialogue is essential for developing critical thinking skills and helping students see that problems can have multiple solutions.

The class discussion exemplifies how an open-ended question—one that does not lead to a single fixed answer—enables students to explore, debate, and construct meaning. Instead of being passive recipients of knowledge, students became active participants in forming their understanding.

Finally, the article illustrates the importance of giving students time to reflect and revise their thinking. When students like Neha and Madhu were given the opportunity to revisit their initial ideas, they were able to refine their reasoning and arrive at more nuanced conclusions. This process of reflection is essential for developing a deeper understanding of mathematical concepts and for building confidence in one's ability to solve problems. By creating a classroom culture where mistakes are seen as opportunities for learning, mathematics can help students develop resilience and a growth mindset.

There was learning for me too. Looking back, I think connecting bus layouts to a number grid would have been great. This simple idea would have let students easily find patterns in rows and columns in various table sizes, making number exploration more engaging.

1	2	3	4	5
10	9	8	7	6
11	12	13	14	15
20	19	18	17	16
21	22	23	24	25
30	29	28	27	26
31	32	33	34	35

Table 1

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

Table 2

ASHOK PRASAD has been associated with the Azim Premji Foundation since 2012, contributing to teacher training, curriculum development, and teaching resource material development. Previously, he served as a middle-school Mathematics and Science teacher. His articles have been published in At Right Angles and Pathshala Bheetar Baahar. Ashok has also taught Applied Mathematics and Pharmaceutical Mathematics at the polytechnic and pharmacy levels. He may be reached at ashok.prasad@azimpremjifoundation.org

The Hidden Logic of Shortcuts-Unlocking Mathematical Patterns

Nikhil MZ, Jayasree S

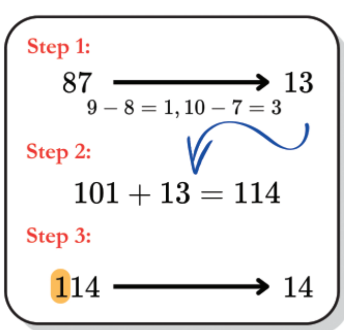
Nikhil, a part-time teacher at a Primary School in rural Palakkad has a fascination for numbers, and patterns among them. Motivated by his desire to make things easier for his students who struggle with basic operations, he figures out “tricks” and “shortcuts” that could potentially help students. Jayasree, an educator who met Nikhil at a teachers' workshop, probes into the logic behind Nikhil’s shortcuts and how and when they can be extended. In this article, we share some of Nikhil’s shortcuts and explain the logic behind them. We also discuss some possibilities for using such shortcuts in the classroom.

Converting Subtraction into Addition

Subtraction, especially when involving regrouping or “borrowing” is known to be a challenge for primary school students. Addition on the other hand is relatively easier. What if we could convert a subtraction problem into an addition problem?

Suppose we had to calculate 101 – 87. Let us now convert this into an addition problem (Figure 1). As the first step we consider the smaller number (87 here). We first subtract the units digit (7 here) from 10 and each of the remaining digit(s) from 9. This gives us 13. We need to add this number to 101: Adding 13 to 101, we get 114. We then drop the 1 at the hundreds place to get the answer 14.

$$101 - 87 = ?$$



So $101 - 87 = 14$

Figure 1

Here is what we did, step by step.

Step 1: Subtract the units digit of the number to be subtracted (referred to as the smaller number henceforth) from 10 and the digits in the other places from 9.

Step 2: Add the number obtained in Step 1 to the number from which the subtraction is to be done (referred to as the larger number henceforth).

Step 3: In the answer that you get in Step 2, count as many digits as there are in the smaller number from the right and subtract 1 from the immediately next digit to the left.

This will provide the answer to the subtraction problem. Let us look at a few examples.

Keywords: Shortcuts, Addition, Subtraction, Arithmetic Tricks, Basic Operations

Example 1:

$$312 - 123 = ?$$

Step 1:

$123 \longrightarrow 877$

$9 - 1 = 8; 9 - 2 = 7; 10 - 3 = 7$

Step 2:

$312 + 877 = 1189$

Step 3:

$1189 \longrightarrow 189$

So $312 - 123 = 189$

In Example 1, we need to compute 312 – 123. First, we find what number is to be added to 312 to find the answer. This we do by subtracting the units digit of 123 from 10 and all other digits from 9 to get 877. We then add 877 to 312 to get 1189. Since 123 is a three-digit number, we subtract 1 from the 4^{th} digit from the right (the thousands digit highlighted in the figure) to get 189. That is, the required answer is 189.

Note that the digit from which 1 is to be subtracted depends on the number of digits in the smaller number as the following example shows.

Example 2:

$$1123 - 89 = ?$$

Step 1:

$89 \longrightarrow 11$

$9 - 8 = 1; 10 - 9 = 1$

Step 2:

$1123 + 11 = 1134$

Step 3:

$1134 \longrightarrow 1034$

So $1123 - 89 = 1034$

In Example 2, since 89 is a two-digit number, in Step 3, 1 is to be subtracted from the 3^{rd} digit from the right or the hundreds digit as shown. This means, for instance, if we were subtracting a single digit number using this process, in Step 3, we would subtract 1 from the tens digit - the second digit from the right.

As we have noted, Step 1 says subtract the units digit from 10 and all others from 9. *What if the units digit is 0?* This gives us 10 as the units digit in the number to be added. Example 3 shows us how to handle this.

Example 3:

$$538 - 40 = ?$$

Step 1:

$40 \longrightarrow 60$

$9 - 4 + 1 = 6; 10 - 0 = 0$

Step 2:

$538 + 60 = 598$

Step 3:

$598 \longrightarrow 498$

So $538 - 40 = 498$

In Example 3, in Step 1, we retain the 0 of the units digit and add 1 to the preceding digit. Subtracting 4 from 9, we should have written 5 as the tens digit of the number to be added. We absorb the additional 1 from the units digit and change the number to 60. The remaining steps follow through.

Why does this process work? What exactly are we doing in this algorithm? Look carefully at Step 1. When we "subtract the units digit from 10 and all other digits from 9" we are essentially subtracting the number from the a power of 10, aren't we?

To subtract 87, we added 13, which is 100 – 87.

To subtract 123, we added 877, which is 1000 – 123.

To subtract 89, we added 11, which is 100 – 89.

To subtract 40, we added 60, which is 100 – 40.

So instead of subtracting a number N, the process described above suggests that we add $100 - N$, or $1000 - N$ or $10^n - N$ depending on the number of digits in the smaller number. (Here, the value of n is the same as the number of digits in N. For example, if N is a 2-digit number, then $n = 2$.) To get the correct result, we then subtract the 10^n that was effectively added. This is precisely what Step 3 does by subtracting 1 from the appropriate digit.

In short, $M - N = M + (10^n - N) - 10^n$

In Step 1 we compute $10^n - N$. In Step 2 we add this to M and in Step 3, we subtract 10^n to arrive at the final answer.

This shortcut is rooted in the decimal number system and the number relations within that system. In the primary classes, we highlight number bonds: 1 & 9; 2 & 8; 3 & 7; 6 & 4 and 5 & 5. These number bonds are related to pairs of numbers that add up to 10. We could extend the notion of number bonds to numbers that add up to other powers of 10 as well. This shortcut capitalises on number bonds between pairs of numbers that add up to 100, 1000 and other powers of 10.

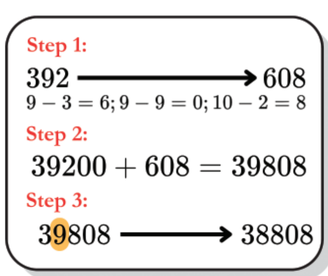
This shortcut may come in handy when multiplying numbers by 9, 99, 999, etc. These numbers are one less than 10, 100, 1000, etc. So multiplying by these numbers can be done easily by multiplying by 10, 100 or 1000 and subtracting the multiplicand from the result obtained. We may use the shortcut for subtraction to do this.

Example 4:

$392 \times 99 = 392 \times (100 - 1) = 39200 - 392$

Then we follow the above algorithm to get

$$39200 - 392 = ?$$



So $39200 - 392 = 38808$

We could also use other number relations to find 39200 – 392 such as

$39200 - 392 = 39200 - 400 + 8 = 38800 + 8 = 38808$

The basic idea is to use number relations flexibly in order to find easy ways of calculation.

When these are presented as a series of "how-to" steps for finding an answer, they can obscure the number relationships that form the basis of the shortcut. This is true of many calculation techniques commonly grouped under "Vedic mathematics." Stated purely as procedural rules, they risk making mathematics seem like a collection of clever tricks.

On the other hand, if we begin with a method of calculation that relies on underlying number relationships and invite students to formulate the "how-to" steps themselves, the focus shifts from memorising procedures to understanding the structure beneath them. With some exploration and reflection, the seemingly magical elements dissolve, and what appeared to be a trick begins to feel like the most natural way to think about the problem.

Engaging with such number-based strategies is a powerful way to nurture number sense. For instance, the following methods draw on properties of operations involving powers of 10. Ask students to express these as step-by-step procedures:

$643 \times 9 = 6430 - 643 = 6430 - 700 + 57 = 5730 + 57 = 5787$

$643 \times 99 = 64300 - 643 = 64300 - 700 + 57 = 63657$

Figuring out why a particular shortcut works can also be a good exercise for unravelling these number relations. We now share another shortcut for you to figure out the logic.

Multiplying by 98: Can you figure out the logic?

If the multiplicand is less than 50:

Step 1: Write down the number that is 1 less than the multiplicand.

Step 2: Subtract the multiplicand from 50 and multiply the result by 2. Append this to the number in Step 1.

Example 5:

$$98 \times 37 = ?$$

Observation: $37 < 50.$

Step 1:

$$37 - 1 = 36$$

Step 2:

$$2 \times (50 - 37)$$
$$= 2 \times 13 = 26$$

Append

$$3626$$

So $98 \times 37 = 3626$

If the multiplicand is greater than 50:

Step 1a: Write down the number that is 2 less than the multiplicand.

Step 2a: Subtract the number from 100 and multiply the result by 2. Append this to the number in Step 1a.

Example 6:

$$98 \times 75 = ?$$

Observation: $75 > 50.$

Step 1:

$$75 - 2 = 73$$

Step 2:

$$2 \times (100 - 75)$$
$$= 2 \times 25 = 50$$

Append

$$7350$$

So $98 \times 75 = 7350$

Further questions for the reader to ponder: Why does this algorithm work? How would you extend it to three-digit numbers? How does this shortcut relate to multiplication by 102? What might a similar shortcut look like for multiplication by 998? For *what kind of numbers* would a similar shortcut work?

The last words

As teachers, we may have had occasions when our students came up with such shortcuts or alternate methods of doing calculations (as Nikhil's teacher Ms. Rosly surely did!). Rather than being treated as the "most natural things in the world", such occasions call for small celebrations of these discoveries (as Nikhil would vouch), and probing if they would always work and why/when they would work.

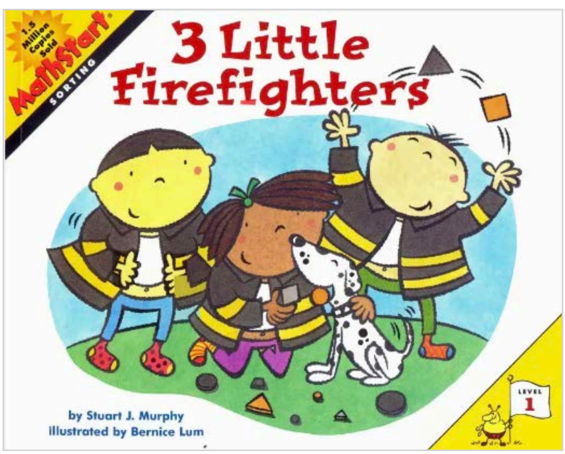
Acknowledgement: Nikhil is grateful to Mr. Praveen. R, Trainer, Block Resource Coordinator, Palakkad for his support and to Ms. Rosly, his Mathematics Teacher at school who sparked his interest in mathematics through her encouragement.

NIKHIL MZ is a primary school teacher from Attapadi in Kerala. He has been involved with "Unnati" a special programme organised by the Kerala Institute of Local Administration to help the students with learning difficulties, especially those in tribal areas of Kerala. He has also been a resource person in many training camps for competitive exams, and Mathematics camps for tribal students.

JAYASREE SUBRAMANIAN is a teacher and teacher educator who has a range of experience working with students across age ranges and with teachers. She has a fascination for recreational mathematics and tries to make maths fun and interesting for students. She currently works as the Educational Outreach Officer at IIT, Palakkad.

Review: 3 Little Firefighters

By Stuart J. Murphy
Reviewed by Kshama Chakravarthy



This article reviews the book "3 Little Firefighters" by Stuart J. Murphy, published by HarperCollins publishers. This book is part of the "MathStart" series. Stories in this series can be read out to students, followed by relevant and interesting discussions. Storytelling is recommended specifically as one of the ways that students enjoy learning (Pg 93, NCF-FS, 2022).

Figure 1

"3 little firefighters" is one of the books in the "MathStart" series and is a Level 1 book. In total there are three levels of books.

Level 1: Pre-K and Kindergarten
Level 2: Grades 1 and 2
Level 3: Grades 3 and 4

The first two levels are in line with the foundational stage as envisioned in the NEP 2020.

The topics covered in the series range from matching and sorting to bar graphs, integers, and finding unknowns. Level 3 books can be used in Grades 5 and 6 too, depending on how one holds discussions with students. For instance, the chapters on Fraction can begin or end with a read aloud of the story "Jump, Kangaroo, Jump" that covers dividing a discrete number of objects into equal groups. This can be a discussion that supplements what is covered in the textbooks. The list of topics in each of the 3 levels is shown in Figure 2. The details of all the books in each of the 3 levels can be accessed at https://www.mathstart.net/books.html.

Keywords: Review, Storytelling, Inter-disciplinary, Problem-solving, Sorting, Shape, Size, Number

Level 1	Level 2	Level 3
Patterns	Adding	Estimating
Comparing Sizes	Collecting Data	Classifying
Recognizing Shapes	Subtracting	Dividing
Counting	Regrouping	Time
Opposites	Time Lines	Fractions
Ordinals	Understanding Halves	Bar Graphs
Comparing Amounts	Symmetry	Counting Coins
Odd and Even Numbers	Calendars	Building Equations
Subtracting One	Probability	Capacity
Matching	Counting by 2s, 3s and 4s	Subtracting 2-digit Numbers
Sequencing	Measuring	Multiplying

Figure 2

The book "3 Little Firefighters" deals with the concept of sorting and can be read out to children between the ages of 3 ½ and 6 years. I used it for a storytelling session with children in this age group and found the book to be quite engaging! The objective of this particular session was to allow kids to explore the topic of sorting in a real-life context. The assumption was that they were already introduced to sorting, and through the story and a follow-up activity they could move to more challenging situations involving sorting, based on various criteria that are either pre-defined or left for them to figure out on their own.

Figure 3

The book introduces the mathematical concept of sorting by attributes through an engaging story about three young firefighters preparing for a parade. The story follows three firefighters who discover, just before a big parade, that their coats have missing buttons. To solve this problem, they must find three sets of matching buttons, sorting them by attributes such as shape (circle, triangle, square), size (big, medium, small) and colour (grey, black, yellow). The narrative unfolds with a sense of urgency and fun, as the firefighters scramble to organize their buttons in time. The vibrant illustrations by Bernice Lum complement the text, making the sorting process visually clear and appealing to young readers.

3 little firefighters are getting ready for a parade. They each need to wear a coat and find that the buttons are missing. They need 4 buttons each, so as to cover their belly buttons! (Through the entire session each reference to the belly button tickled the children pink!) They find a bunch of buttons and try to sort it by various parameters, to ensure they each have 4 buttons to wear. They first try to sort by shape. One boy gets 4 circles, but the other two only find 3 sets each of triangles and squares, and their belly buttons are seen! They cannot have that, and so they decide to sort again, this time by colour. Two of them are able to find a set of 4 each in black and orange, but the grey set has only 3! (Figure 3) Again, this sorting does not work.

Next, they try to sort by size- small, medium and large. And now, quite magically, each of them gets 4 buttons! See Figure 4. This is a good point to pause and ask children what exactly happened. They eventually realise that there are 12 buttons in all, and in the first two cases there were a few "extra" buttons that did not fit the criteria.

Figure 4

Satisfied about having done their job well, they proceed to the parade.

The book suggests a few activities that can be done while reading out the book. One of them is to make the various buttons- replicating the size, shape, colour and getting children to sort each time based on the criteria mentioned, to check for themselves if 4 sets each are formed. Figure 5a shows all the buttons arranged by shape (horizontally). Figure 5b shows the buttons arranged by size (vertically).

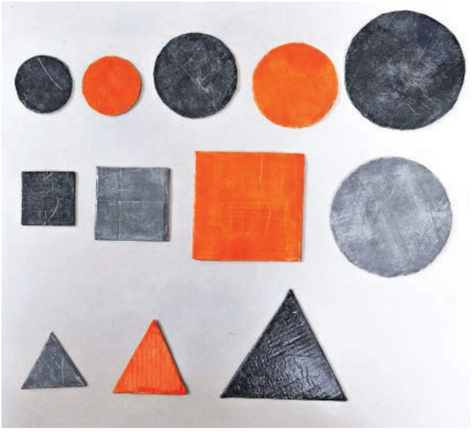


Figure 5a

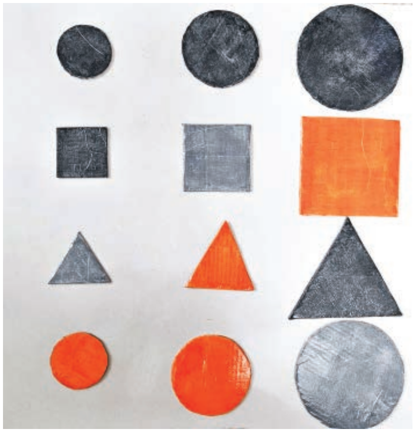


Figure 5b

I found this really useful and engaging during the session, as children could work with these large-sized buttons, trying to replicate what was given in the book. They enjoyed trying to sort and see who was able to make a set of 4 and who could not. Moving the buttons around and exchanging the pieces every time the criteria changed, helped them pay attention to the changes based on the criteria. It possibly helped them in the follow-up activity where real buttons of various sizes, shapes, colours and patterns were distributed, and they were asked to sort them based on the criteria mentioned (by colour, shape, size and so on). Next, I placed a few buttons in three different groups and asked them to identify the "rule". Based on their response I would place more buttons in the groups to contradict their reasoning, till they arrived at the logic I had used to sort the buttons. In the final round, each child took turns to sort, based on a certain criterion in their mind, and the rest of them guessed it.

The book excels in its ability to weave a mathematical concept into a relatable and entertaining story which presents sorting in a way that feels natural and engaging. The firefighters' predicament is a practical problem that children can understand, and the repetitive structure of sorting by different attributes reinforces the concept without feeling didactic. The inclusion of activities at the end of the book is a significant strength. These activities encourage parents and educators to extend the math lesson into real-life scenarios, such as sorting objects at home or in the classroom.

References

1. National Council of Educational Research and Training. (2022). *National curriculum framework for foundational stage.* NCERT. https://ncert.nic.in/pdf/NCF_for_Foundational_Stage_20_October_2022.pdf
2. MathStart. (n.d.). *Books.* https://www.mathstart.net/books.html

KSHAMA CHAKRAVARTHY is an educator. She holds masters' degrees in Mathematics from IIT Madras and in Education from Azim Premji University. With over 15 years of experience in math education, she has worked in areas like content development, teaching, and teacher training, as well as conducting student interviews and creating assessments. Passionate about nurturing young minds, Kshama loves spending time with toddlers and enjoying nature. She can be reached at kshamagc@gmail.com

Call for Articles!

At Right Angles is a quality resource dedicated to mathematics education in India's public education system. It is specifically designed for teachers and teacher educators at the foundational, preparatory, and middle school levels.

We invite articles from mathematics teachers, educators, practitioners, parents, and students. If you are looking for a platform to contribute articles that support and enhance the learning experience of mathematics particularly for students approximately in the age group 6-14 years , we welcome your submissions.

Suggested Topics and Themes

Submitted articles should focus on curricular content applicable to Classes 1-8 and could:

- Explain and illustrate themes and topics outlined in the National Curriculum Framework for School Education 2023 (NCF-SE 2023).
- Specifically address challenges discussed in the NCF-SE 2023.
- Be substantiated accounts of the history of mathematics or the history of mathematical thinking.
- Include innovative worksheets or methods to engage students in drill and practice.
- Describe real-life applications of mathematics relevant to the child's context.
- Describe interdisciplinary activities or projects.
- Review puzzles or games with a practical connection to the syllabus.
- Offer guidance on selecting relevant content, including online resources.
- Develop pedagogical strategies for foundational numeracy as well as computational thinking.
- Assist teachers in implementing differentiated teaching practices.
- Review of Teaching Learning Material (TLM) or describe how to use local context, and local TLM in the math class.
- Provide material to help students bridge gaps in conceptual understanding.
- Address issues in assessment.
- Suggest ways to identify and address misconceptions in mathematics learning.
- Offer a list of problems along with discussions on their solutions and problem-solving strategies that are not commonly found in textbooks.

In addition to full-length articles, we also welcome shorter pieces that can include a variety of engaging content. These could be reviews of books, mathematics software, or YouTube clips that explore mathematical themes. Other contributions can be 'proofs without words', mathematical paradoxes, 'false proofs', or creative expressions such as poetry, cartoons, or photographs with a mathematical theme. We also welcome anecdotes about a mathematician or interesting examples of 'maths in craft, movies, etc'.

Articles may be sent to
atrightangles.editor@apu.edu.in

Please refer to specific editorial policies and guidelines on the inside back cover.

Policy for Accepting Articles

At Right Angles is an in-depth, magazine on matters of consequence to early mathematics and mathematics education. Hence articles must attempt to move beyond common myths, perceptions, and fallacies about mathematics.

The magazine has zero tolerance for plagiarism. By submitting an article for publishing, the author is assumed to declare it to be original and not under any legal restriction for publication (e.g. previous copyright ownership). Wherever appropriate, relevant references and sources will be indicated in the article.

At Right Angles brings out translations of the magazine in other Indian languages. Hence, Azim Premji University holds the right to translate and disseminate all articles published in the magazine.

If the submitted article has already been published elsewhere, the author is requested to seek permission from the previous publisher for re-publication in the magazine and mention the same in the form of an 'Author's Note' at the end of the article. It is also expected that the author forwards a copy of the permission letter, for our records. Similarly, if the author is sending his/her article to be re-published, (s) he is expected to ensure that due credit is then given to **At Right Angles**.

While **At Right Angles** welcomes a wide variety of articles, submissions that are found relevant but not suitable for publication in the magazine may be used in other avenues of publication within the University network, with the author's permission.

Specific Guidelines for Authors

Prospective authors are asked to observe the following guidelines.

1. **Engaging Introduction:** Write in a readable and inviting style, aiming to capture the reader's attention from the start. The first paragraph of the article should convey clearly what the article is about. For example, the opening paragraph could be a surprising conclusion, a challenge, a figure with an interesting question, or a relevant anecdote. Importantly, it should carry an invitation to continue reading.
2. **Catchy Title:** Title the article with an appropriate and catchy phrase that captures the spirit and substance of the article.
3. **Style:** Avoid a 'theorem-proof' format. Instead, integrate proofs into the article in an informal way.
4. **Balance:** Refrain from displaying long calculations. Strike a balance between providing too many details and making sudden jumps that depend on hidden calculations.
5. **Accessible language:** Avoid specialized jargon and notation that will be familiar only to specialists. If technical terms are needed, please define them.
6. **Use visuals:** Where possible, provide a diagram or a photograph that captures the essence of a mathematical idea. Never omit a diagram if it can help clarify a concept.
7. **Concise References:** Provide a compact list of references, with short recommendations.
8. **Exercises and Questions:** Make available a few exercises, and some questions to ponder either in the beginning or at the end of the article.
9. **Citation format:** Cite sources and references in their order of occurrence, at the end of the article. Avoid footnotes. If footnotes are needed, number and place them separately.
10. **Abbreviations and Acronyms:** Explain all abbreviations and acronyms the first time they occur in an article. Make a glossary of all such terms and place it at the end of the article.
11. **Labelling visual elements:** Label and number all diagrams, photos and figures included in the article. Attach them separately with the e-mail, with clear directions. (Please note: the minimum resolution for photos or scanned images should be 300 dpi).
12. **Precise references to visuals:** Refer to diagrams, photos, figures and tables by their numbers and avoid using references of these kinds: 'here', 'there', 'above', 'below', 'to the left', 'to the right'.
13. **Author Bio:** Include a high-resolution photograph (author photo) and a brief bio (not more than 50 words) that gives readers an idea of your experience and areas of expertise.
14. **British Spelling:** Adhere to British spellings – organise, not organize; colour not color, neighbour not neighbor, etc.
15. **Format for submission:** Submit articles in MS Word format or in LaTeX.

Printed and Published by Rishikesh B S, Registrar, on behalf of Azim Premji University
Printed at Repromen Offset Printers Pvt. Ltd., #46/47, 3rd Cross, Krishna Reddy Colony, Domlur Layout, Bengaluru, Karnataka – 560071
Published at Azim Premji University, Survey No. 66, Burugunte Village, Bikkanahalli Main Road, Sarjapura, Bengaluru – 562125
Editor: Sneha Titus

Azim Premji University
At Right Angles
A RESOURCE FOR SCHOOL MATHEMATICS

Azim Premji University

WEAVING IN MATHEMATICS

PADMAPRIYA SHIRALI

A publication of Azim Premji University

WEAVING IN MATHEMATICS

In January 2025, two editors of *At Right Angles* made a visit to the District Institutes of the Azim Premji Foundation at Bhopal and Damoh. As part of this visit, they spent time at some of the schools that the Resource Persons of the Foundation interact with. This Pullout is a follow up of the observations made by Padmapriya Shirali who was part of this expedition.

In Padmapriya's words: *In the primary and middle school classrooms at Bhopal, I noticed a lot of beautiful artwork created by students displayed on the bulletin boards. Sneha, who was with me remarked on how such interest in art could be used in mathematical learning. This article is an exploration of how we connect an enjoyable and satisfying act such as weaving, with mathematics.*

Weaving with paper strips holds potential for a lot of creative artwork and gives scope for connecting mathematical number and geometric patterns with the generated designs.

It is possible to incorporate these activities from Class 4 onwards once the children develop finer motor skills. The complexity of the weaving patterns can be raised gradually, and adequate opportunities can be provided to come up with new patterns and designs.

There is ample scope for studying the generated patterns for various properties of shapes, tiling designs, reflection and rotation symmetry, angles, etc. Rudiments of algebra are integrated into this activity. As many weaving patterns are found in woven clothes, particularly in sweaters, sarees and carpets, students can study these designs, make grid drawings of them, and try to create these with colourful paper strips. The work itself involves measuring, counting, devising and structuring patterns, coding the pattern, bending and folding according to the plan and the required dimensions, and decision making.

The question is whether skills such as weaving, knitting, crochet, origami, etc., will enable mathematical intuition in understanding spatial concepts through the tactile experience. Can weaving contribute to the development of geometric and visual cognition? The ability of indigenous basket weavers and carpet weavers does demonstrate that they have an intuitive understanding of patterns and the complex ways in which shapes emerge and interact. Perhaps, when we approach mathematics only through the mind and in the abstract form, we lose out on the possibility of learning through the tactile approach.

Keywords: Tactile Learning, Patterns, Sequence, Decision Making, Coding, Weaving.

Hence, the attempt here is to see if learning can happen while making things and noticing patterns.

The material and equipment needed for paper weaving is easily available. It only needs paper in two or three colours (using waste materials by rolling up colourful magazine papers is a good idea), a cutter or a pair of scissors with which one can make the required strips, and a gum stick. Let us begin with some simple activities. As we go through the activities, let us also look for ways of connecting it with the math concepts and drawing the students' attention to the underlying mathematics.

To create any pattern, students will need to make the basic paper frame in this form.

1. Take a piece of paper and fold it in half.

2. Cut slits from the folded side of the paper leaving space at the top. The cuts must be evenly spaced so that the strip width is uniform. The number of slits to be made can be based on the pattern or can be any number between 8 and 12. To get a feel of the pattern one needs a minimum of 8 to 10 slits (columns).

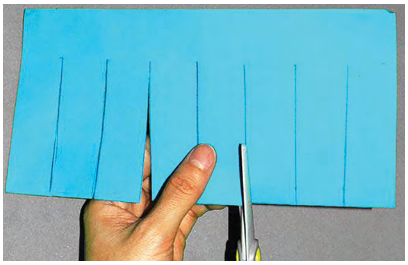


Figure 1

3. Unfold the paper. This will serve as the base frame.

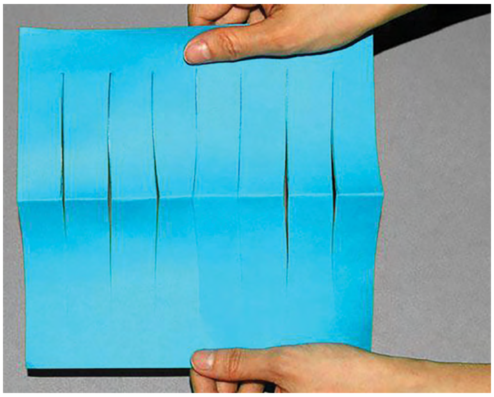


Figure 2

4. Cut strips of another colour (of the same width as the slits) to weave. The number of strips can be the same as the number of slits.

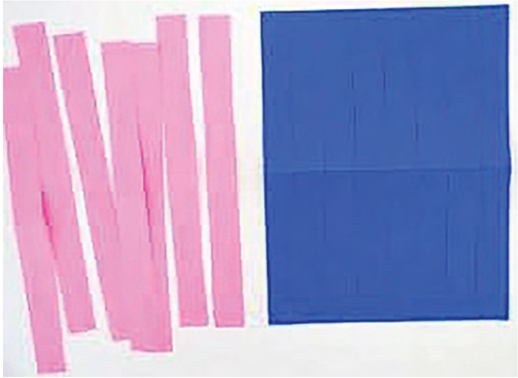


Figure 3

Design 1: Basic weave

This is a 1-1 pattern that follows 1 over, 1 under process (can be coded as OU)

1. Take one paper strip and weave it across the slits, going over and under (OU) the slits alternately.
2. Weave the second strip in the reverse order (UO), by going under and over the slits.

Weave more strips following steps 1 and 2 repeatedly to create a chess board type design.

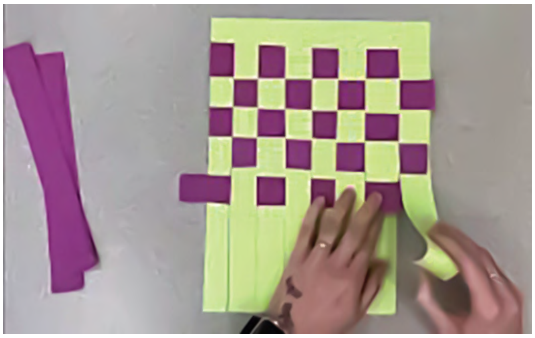


Figure 4

Questions can be posed to get students to visualise how the pattern would look if they followed a 2 - 2 (OOUU) pattern instead of a 1-1.

If a 1-1 pattern produced squares of the same size what would emerge out of a 2-2 pattern?

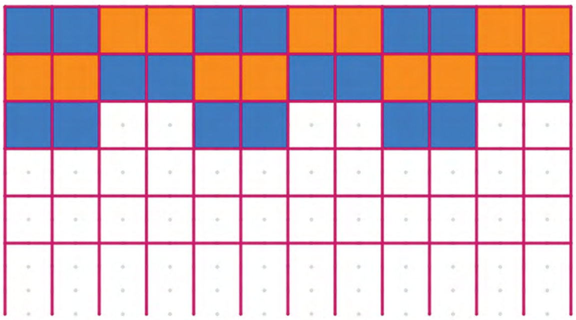


Figure 5

Students can draw the design on a grid paper and colour it before attempting the weave.

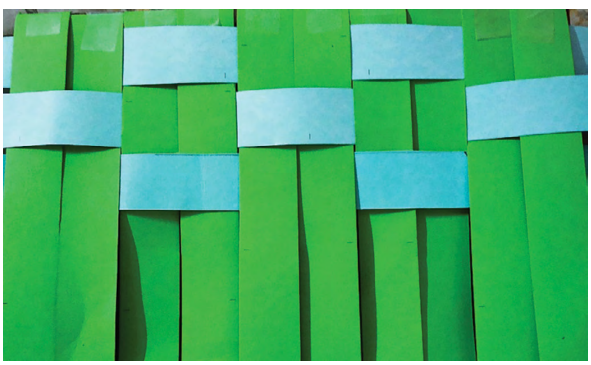


Figure 6

Further possibilities can be raised by the teacher or by the students. In explorations such as this, students begin to pose questions and investigate them.

What would a 1 - 2 (OUU) design look like? If the second row is woven in the reverse order as 1 - 2 (UOO), what shapes is it going to create? What is the repeating unit of such a design?

The outlined rectangle of Figure 7 shows the repeating unit.

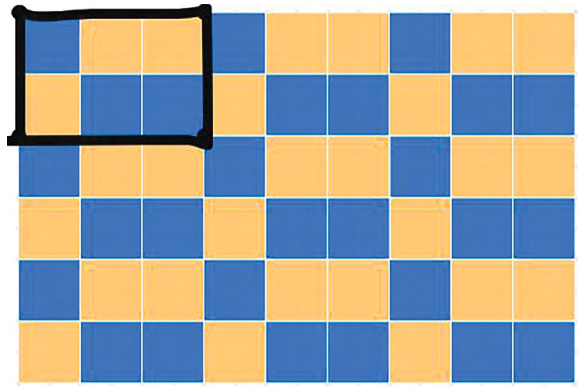


Figure 7

What would the design be if we had followed 1 - 2 (OUU) for the first row and 2 - 1 (UUO) for the second row?

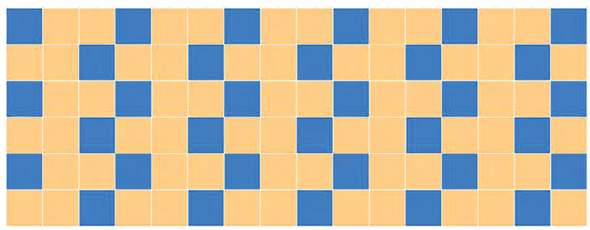


Figure 8

It is interesting for the students to realise how a small change in the code can produce a different design altogether.

Students might be able to predict and verify what shapes would be produced by a 1 - 3 design. They can try to visualise how the rectangle will be extended.

Will the pattern of alternating squares occur in the 1 - 3 design?

What would the repeating unit look like?

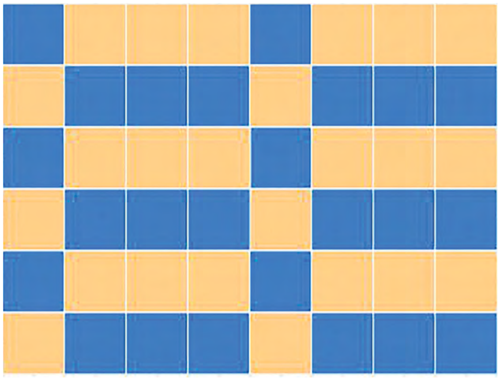


Figure 9

After making a guess, they can create the 1 - 3 (OUUU) design alternating with 1 -3(UOOO).

How would a 1 - 3 (OUUU) design look if the second row is a 3 - 1 (UUUO) in opposite colour?

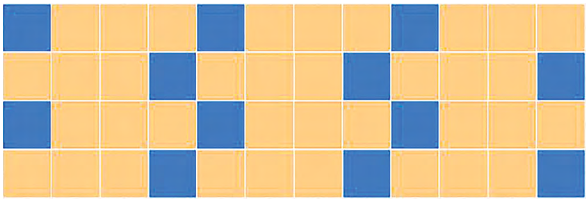


Figure 10

Teachers' Note

Lesson objectives: What do you want your students to understand at the end of the lesson?

Teaching tools: Materials needed, class set up, discussion points, etc.

Observation notes: Student participation, good questions, unexpected challenges, assessment insights, etc.

Design 2: Symmetrical design

This is a 1-2-3-2-1 (UOOUUUOOU) pattern. The numbering is like a palindrome (something that reads the same from left to right and right to left, like the word MADAM) and it creates a vertical symmetric line in the weave.

Figure 11

Take one paper strip and weave it across the slits, going under 1, over 2, under 3, over 2 and under 1 (UOOUUUOOU). Weave the second strip in the reverse way, going over and under (OUUOOOUUO) the slits.

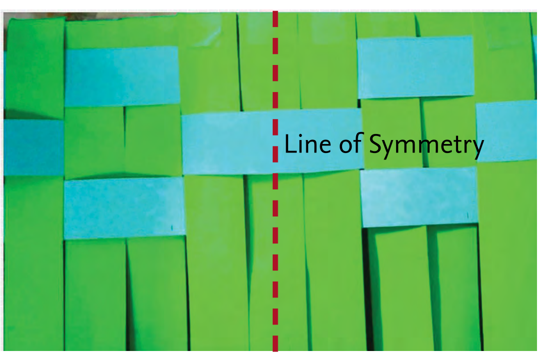


Figure 12

What would a 1- 2 -3 -2 -2 -2 -3 -2-1 pattern look like?

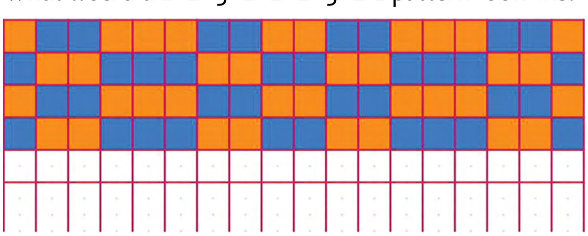


Figure 13

How would a 1- 2 -3 -2 -2 -2 -3 -2-1 pattern look if each row is repeated thrice in the same way before reversing the pattern?

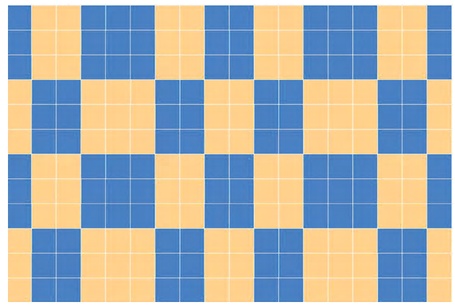


Figure 14

Students can contrast the two grids and make their observations about how the design has transformed. What has remained the same? What has changed?

Figure 15

How can we create a symmetric step like design?

This has been made in an 8-column frame (Figure 15).

At the centre, two strips will be covered. In a frame with an odd number of columns, only one column will be covered.

Students will need to work out the code for each row ensuring that the design acquires a symmetrical step formation.

If this design has to be horizontally symmetrical as well, can they work out the code for 4 more rows?

Teachers' Note

Lesson objectives: What do you want your students to understand at the end of the lesson?

Teaching tools: Materials needed, class set up, discussion points, etc.

Observation notes: Student participation, good questions, unexpected challenges, assessment insights, etc.

Design 3: Diagonal patterns

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 16

We are all familiar with the multiplication pattern of 3.

We can create a chart with 10 slits to create this weave.

If this number chart of 10 × 10 was a weaving grid, how do we write the number pattern for the first row?

Over 2, Under 1, Over 2, Under 1, Over 2, Under 1, Over 1 (OOUOOUOOUO)

How do we write the number pattern for the second row?

Over 1, Under 1, Over 2, Under 1, Over 2, Under 1, Over 2 (OUOOUOOUOO)

How do we write the number pattern for the third row?

Under 1, Over 2, Under 1, Over 2, Under 1, Over 2, Under 1 (UOOUOOUOOU)

One obtains a diagonal pattern by creating a shift or displacement of the pattern in subsequent rows. Here:

Row 1: 2-1-2-1-2-1-1
Row 2: 1-1-2-1-2-1-2
Row 3: 1-2-1-2-1-2-1

Figure 17

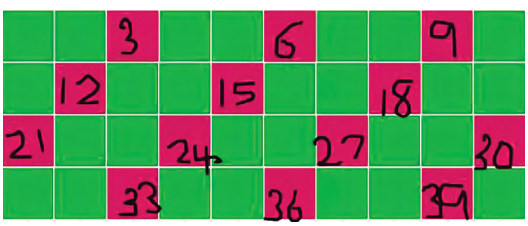


Figure 18

What is happening in each row? The first row ends with number 10. Since we are considering multiples of 3, (10 divided by 3 gives a remainder 1) one square is left covered at the end of the first row. The second row goes up to 20. 20 divided by 3 gives a remainder of 2, so two squares are left covered at the end of the second row. The third row goes up to 30. 30 divided by 3 gives no remainder, so no squares are left covered at the end of the third row.

What would the pattern of multiples of 3 look like if we had used an 8-column frame?

How many squares will be left uncovered at the end of the first row?

Using our prior understanding, 8 when divided by 3 leaves a remainder of 2. So, 2 squares will be left covered at the end of the first row. In the case of the second row, the squares are numbered till 16 (twice 8). 16 when divided by 3 gives 1 as remainder. So, there will be one square left covered at the end.

How would the multiples of 4 be coded in general? OOOUOOOUOOOU...

Now, let us try to deduce how many squares will be left covered at the end of each row in a 7-column frame that shows multiples of 4.

First row: 7 divided by 4 leaves a remainder of 3. Hence there will be 3 squares covered at the end of the first row.

Second row: 14 (twice 7) divided by 4 gives remainder 2. Hence 2 squares will be covered at the end of the second row.

Third row: 21 divided by 4 gives remainder 1. Hence 1 square will be covered at the end of the third row.

What will happen at the end of the fourth row?

How would the multiples of 2 be coded in general? OUOUOUOUOUO..

If we have a 9-column frame that shows multiples of 2, what will happen in the different rows? Is there a pattern?

This can lead to many explorations with varied column frames and multiples of varied numbers.

What kind of a design is generated if the first row is UOOUUOOUU....and the second row is UUOOUUOOUUOO....

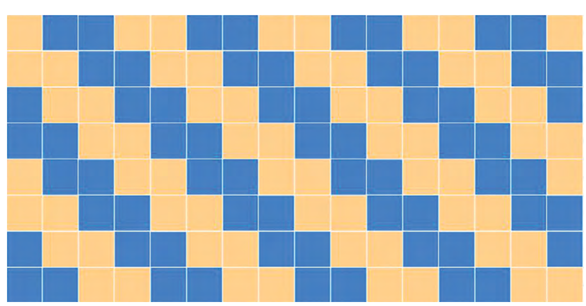


Figure 19

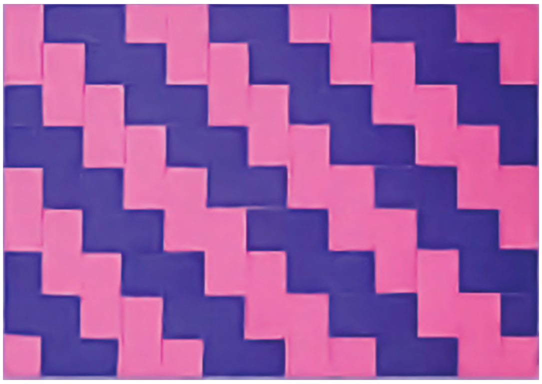


Figure 20

It produces a diagonal pattern of rectangles. These rectangles have a width of 2 units. What else can be said about the diagonal line? It is going in one direction. We can say it is going downwards from left to right or upwards from right to left.

What else can be seen in the woven piece? The vertical and horizontal rectangles are alternating. One diagonal is made up of vertical rectangles. The other diagonal is made up of horizontal rectangles.

What is the repeating unit here?

Can the students write a number pattern for diagonal rectangles of width 3 units?

That will be 1, 3, 3, 3, 3 (OUUUOOOUUUOOO) in the first row, 2, 3, 3, 3, 2 (OOUUUOOOUUUOO) in the second row and 3, 3, 3, 3, 1 (OOOUUUOOOUUUO) in the third row.

It will produce a diagonal weave like this.

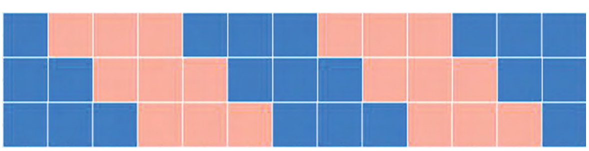


Figure 21

What can we do to turn the direction of the diagonal?

How do we write the number pattern for it?

Obviously, the last step of the pattern has to be reversed.

By repeating the second row under the third row 2, 3, 3, 3 (OOUUUOOOUUU) it turns back.

Doing 1, 3, 3, 3 (OUUUOOOUUUOOO) in the fifth row will complete the horizontal reflection of the design.

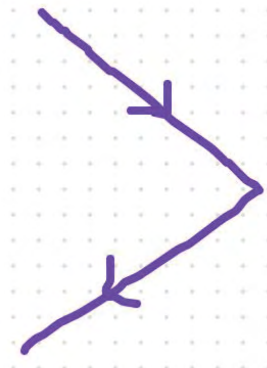


Figure 22

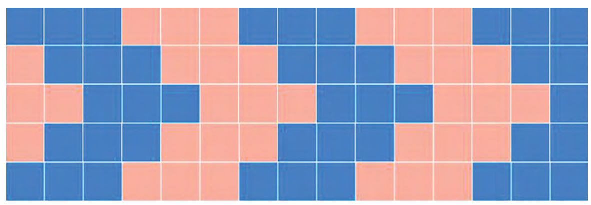


Figure 23

By playing around with strips of different colours one can generate various designs.

These designs in Figure 24 and Figure 25 have horizontal symmetry.

Figure 24

Figure 25

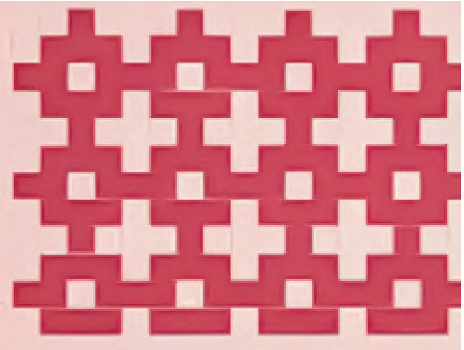


Figure 26

How do we generate the number pattern for these beautiful designs of Figure 26 and Figure 27?

Students can make a small scale version of it on a grid to understand the pattern and code it as a number pattern.

Most of these designs have 3 types of symmetry: horizontal, vertical and diagonal.

Figure 27

Teachers' Note

Lesson objectives: What do you want your students to understand at the end of the lesson?

Teaching tools: Materials needed, class set up, discussion points, etc.

Observation notes: Student participation, good questions, unexpected challenges, assessment insights, etc.

Design 4: Weaves and reverse designs

Students can be given a design on the grid paper and asked to write the code for making it into a weaving pattern.

What is the code for the grid work of Figure 28?

For how many rows does one need to write the code?

The reverse side of a weave is interesting to observe. In paper weaves, we get to see the reverse side of the design. What is the relationship of the code that has been used to the code of the reverse side? What gets reversed?

In Figure 28, the second grid shows the reverse side of the design in the first grid.

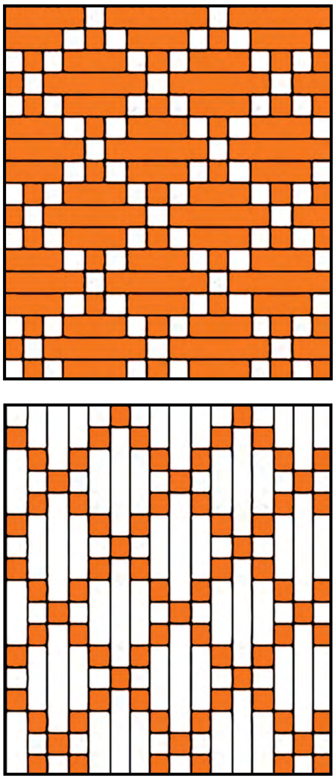


Figure 28

This figure has vertical, horizontal and diagonal symmetry.

Can the students identify the lines of symmetry in each case?

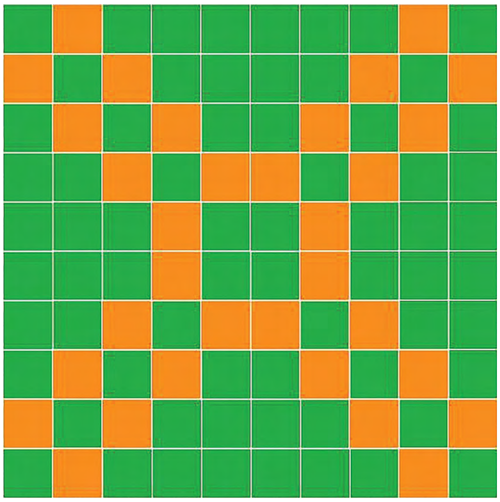


Figure 29

Challenge! Here is a design made from a number chart based on _________ numbers!

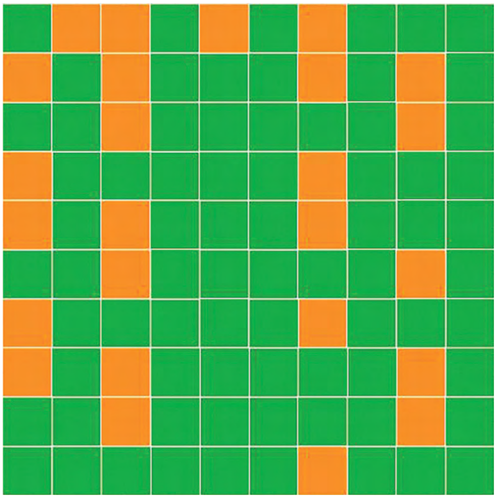


Figure 30

What do you notice about the orange squares? Why are there no orange squares in the last column?

Cover the top row with a ruler and look at the columns.

Why are there no orange squares in some columns from the second row onwards?

Teachers' Note

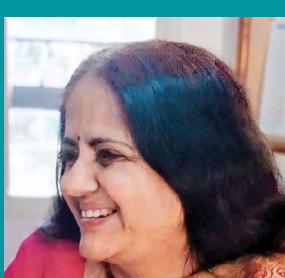
What worked	What didn't work

References and credits

1. Dilling, M. (2012, August 6). *Weaving inverse operations, multiples and factors into the feet.* Math in Your Feet. https://mathinyourfeet.blogspot.com/2012/08/weaving-inverse-operations-multiples.html

2. Origami Resource Center. (n.d.). *Weaving patterns.* Retrieved June 18, 2025, from https://origami-resource-center.com/weaving-patterns/

3. Pinterest. (n.d.). *[Image of a weaving pattern].* Pinterest. https://i.pinimg.com/236x/2f/ec/c2/2fecc2a81f028f5d1639603229c6e66a.jpg

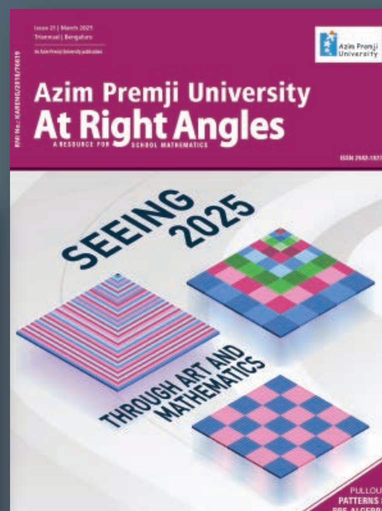


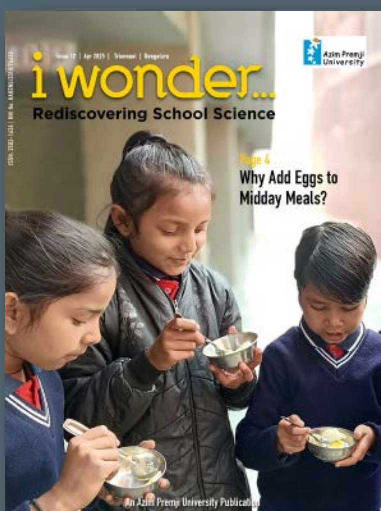
PADMAPRIYA SHIRALI

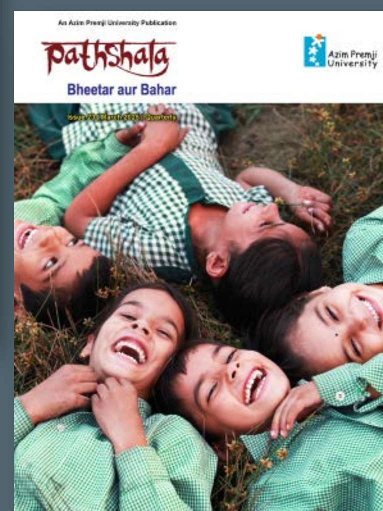
PADMAPRIYA SHIRALI is part of the Community Math Centre based in Sahyadri School (Pune) and Rishi Valley (AP), where she has worked since 1983, teaching a variety of subjects – mathematics, computer applications, geography, economics, environmental studies and Telugu. In the 1990s, she worked closely with the late Shri P K Srinivasan. She was part of the team that created the multigrade elementary learning programme of the Rishi Valley Rural Centre, known as 'School in a Box.' She is currently part of the the NCERT textbook development group. Padmapriya may be contacted at padmapriya.shirali@gmail.com

Azim Premji University

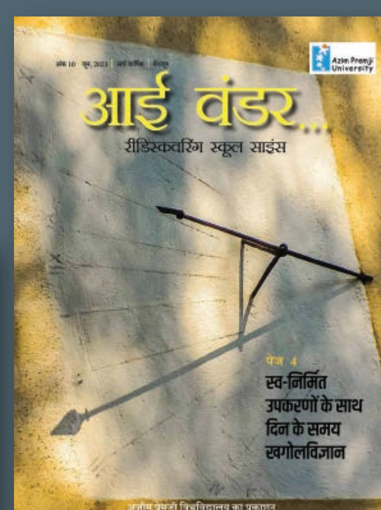
Azim Premji University Magazines







Scan here to subscribe
to At Right Angles for free!



To know more about our other publications, write to us at publications@apu.edu.in

Azim Premji University
At Right Angles
A RESOURCE FOR SCHOOL MATHEMATICS

An in-depth magazine on mathematics and mathematics education

For teachers and teacher educators at the primary and middle school level.

India: Woven together in different ways

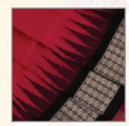

Kashidha

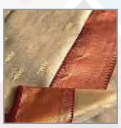

Kasavu


Tant Weave


Phulkari


Kulluvi Pattu


Bomkai


Chanderi Saree


Banarasi Silk Weaving

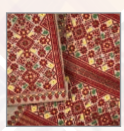

Sambalpuri Bandha Saree

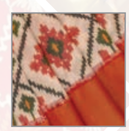

Kota / Leheriya

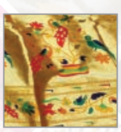

Bhagalpur Silk


Kosa


Patola Craft


Muga

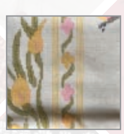

Pochampalli

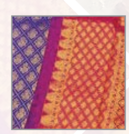

Paithani Weaving


Gadu or Mirijim Weave


Uppada Jamdani Sarees


Mysore Silk


Moirang Phee


Kanchipuram Silk Weaving


Ilkal Weave


Puan Weave


Kandangi Weave

Azim Premji University
Survey No. 66, Burugunte Village,
Bikkanahalli Main Road, Sarjapura
Bengaluru – 562125

azimpremjiuniversity.edu.in

Facebook: /azimpremjiuniversity
Instagram: @azimpremjiuniv
X: @azimpremjiuniv