Mobile Puzzles – Making Sense of Variables and Equations

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For the middle school student, the transition from arithmetic to algebra is often quite daunting. In grade VI, the concept of a 'variable' is encountered for the first time. This is the stage where either a child embraces the newly introduced 'Algebra' or gets overwhelmed with the idea of numbers being replaced by letters of the alphabet. This is also the stage where the students learn to solve equations and find the value(s) of the unknown(s). Quite often students get lost in the working of equations and memorize the rules without understanding the logic.

The equality sign "=" poses a challenge in the learning of algebra. While learning arithmetic in the primary years, children think of the equality sign as a prompt to find the answer to a mathematical sentence such as 15 + 8 = ? It is perhaps viewed as a symbol which connects the problem to the answer or an operation to be performed. However, while learning algebra, the student is baffled when she encounters a statement such as $a + b = c$, or $2x + 1 = 5$, where the "=" symbol represents an equivalence rather than a prompt to produce an answer. At this stage, children need scaffolding to move from an *operational view* of the equality sign to a *relational view*. A popular strategy to help the child develop a relational view of the equality sign and solve equations is to use the metaphor of a balance scale. In this model, equations are thought of as consisting of two sides of equal weight. Thus performing operations on each side must maintain the balance. Figure 1 represents this idea.

Keywords: Mobile, online manipulative, algebra, equation, solution

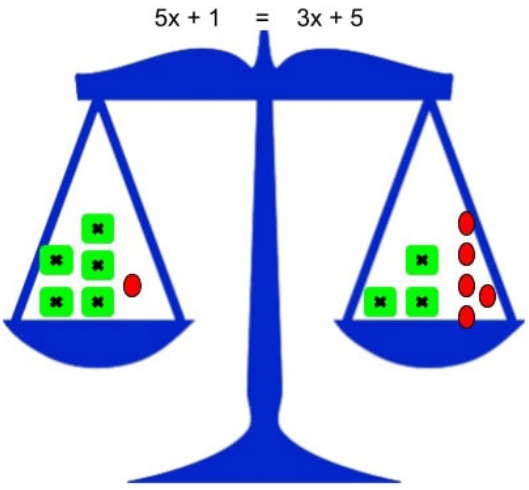

Figure 1

The website SolveMe Puzzles (http://solveme.edc.org/) uses the balance approach to enable the learner to visualize and explore the solutions of equations. It has an excellent collection of puzzles namely, Mobiles, Who Am I? and Mystery Grid. In this article we shall help the reader navigate through Mobiles ,which are colourful, interactive sculpture puzzles, designed to support algebraic reasoning in a fun and interactive manner.

The first screen or the main menu (http://solveme.edc.org/mobiles/#) provides the user with the option to '**Play**' or '**Build**' a puzzle. By clicking on '**Play**', we are taken to a screen (Figure 2), which offers three options – Explorer, Puzzler, Master; each is a collection of puzzles with increasing level of difficulty.

A mobile puzzle presents multiple balanced collections of objects. The horizontal beams are always suspended at the middle by strings and for that reason the two ends of each beam have the same amount of weight on them. Beams and strings weigh nothing and identical shapes represent the same weight whereas different shapes may have the same or different weights. The puzzler is asked to determine the unknown weight. Actually, the mobile puzzle presents a

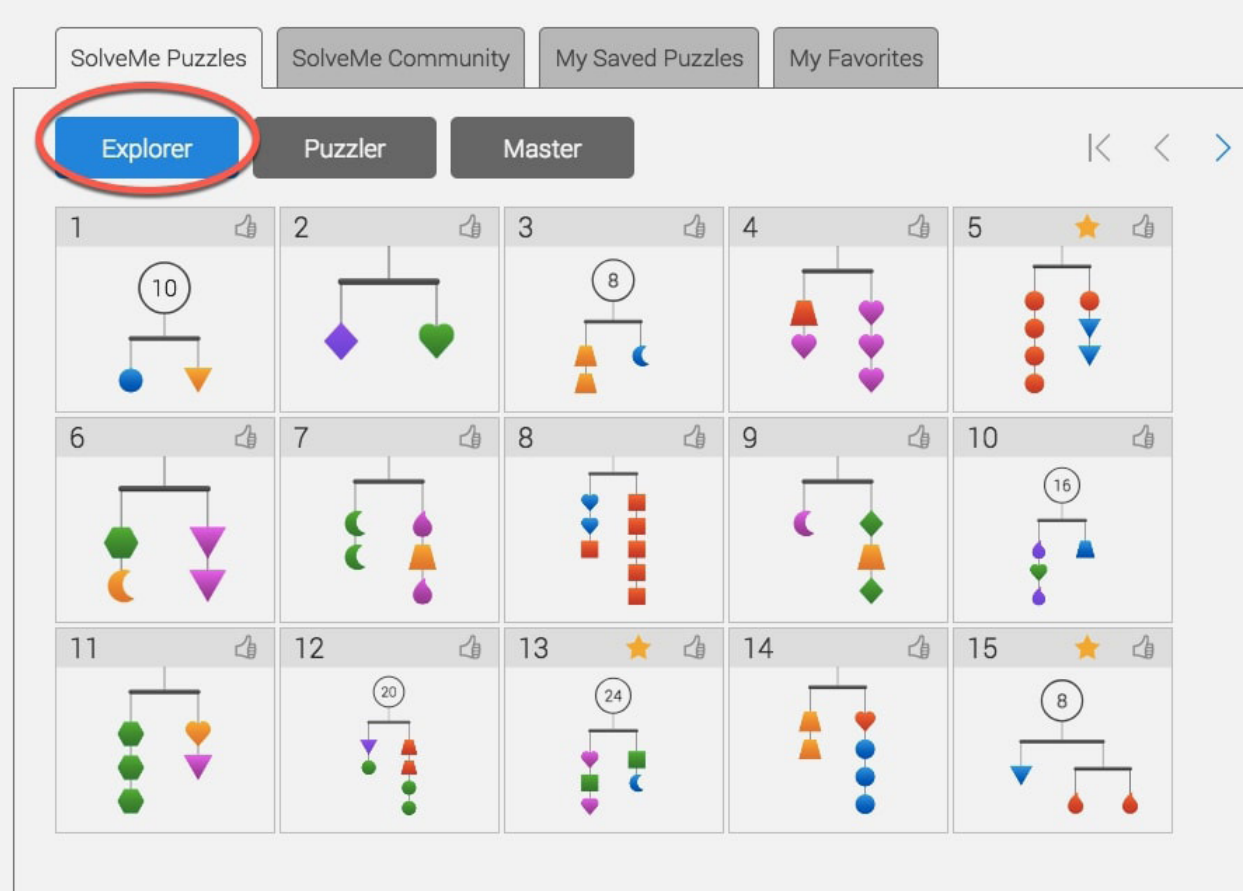

Figure 2

system of equations in the form of a picture, which highlights the underlying structure.

In 'Explorer' the initial puzzles are very simple and can serve as a 'warm-up' for the first time user. For example, Puzzle #5 (see Figure 3) shows four orange circles on the left side of the balance, each having a value equal to 4. The right side has two blue triangles and one orange circle. The learner needs to observe that removing one orange circle from each side will not disturb the balance. Once this is done, the two blue triangles on the right are equivalent to three orange circles on the left and both represent a value equal to 12. Thus, each blue triangle must represent 6. This would encourage learners to use proportional thinking to find the answer.

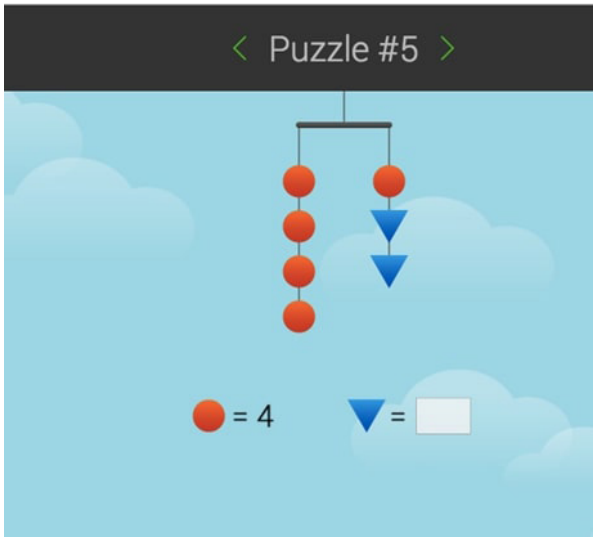

Figure 3

Other puzzles such as Puzzle #12 (Figure 4) have a circle with a number placed on top of the beam, which represents the total weight. This indicates that the values of the weights on both sides of the balance must add up to this number. Here, the weights on each side must add up to 10. Further the green circle is equivalent to 3, so this value may be substituted on both sides wherever there is a green circle. The idea of substitution, that is, replacing a shape by a number may be reinforced through such examples.

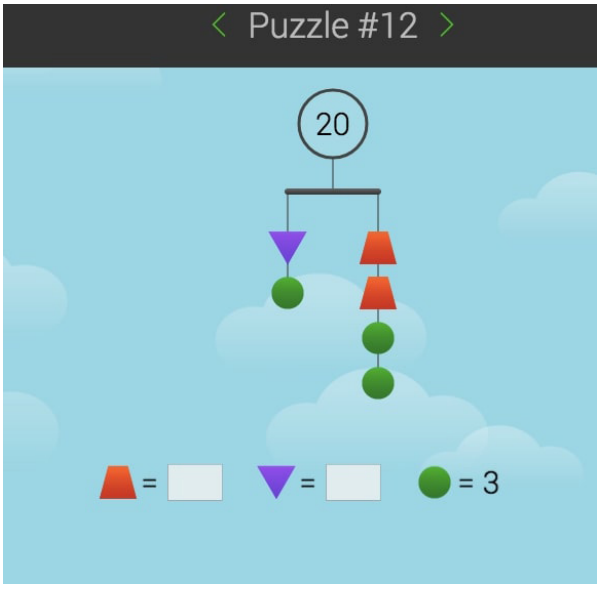

Figure 4

Some puzzles have two beams, for example, Puzzle #28(Figure 5). It has four blue triangles on the lower beam. Since this equals 8 (each blue triangle being equal to 2), the moon and the square on the right side of the upper beam must also add up to 8. Using the Pen tool (at the bottom right of screen), the user may scribble their observations (Figure 6) and calculate the values of the variables. The eraser may be used to make corrections.

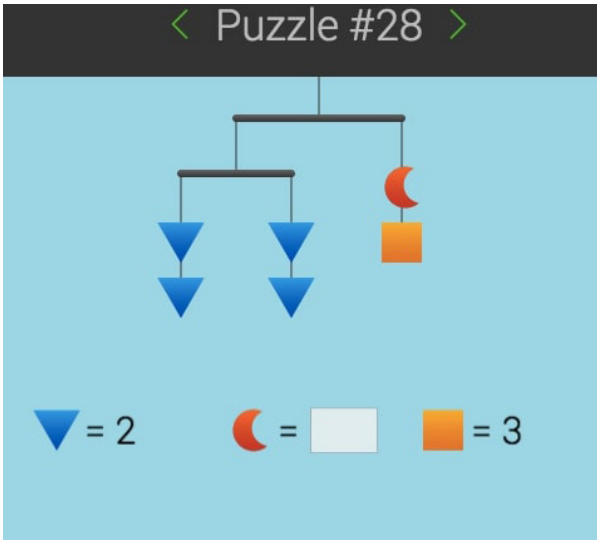

Figure 5

[1] Mobile: A mobile is essentially a hanging structure that supports baby toys and objects that stimulate and entertain the baby

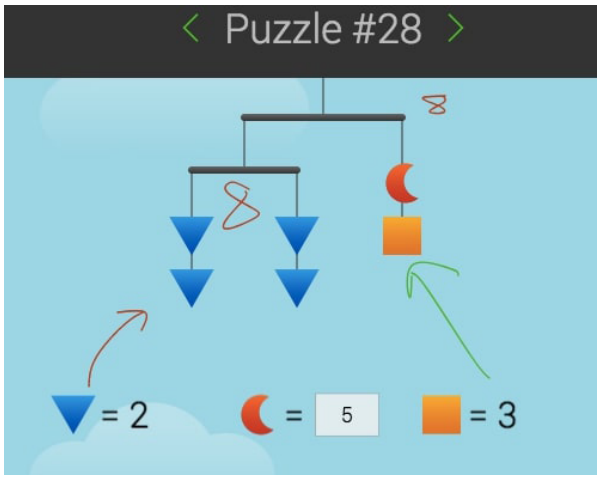

Figure 6

The sheer variety of puzzles seems to provide ample scope for practice and to build up the reasoning and strategy to solve for unknowns.

The Puzzle#28 may be used to introduce the concept of equations. Puzzle#28 may be represented by the equation: $4t = m + s$ ('t' for triangle, 'm' for moon and 's' for square). We may substitute 2 for 't' and 3 for 's' to find the value of 'm'.

The puzzles increase in complexity and become more interesting. In Puzzle#58(Figure 7), the user is required to find the values of all three types of weights, namely the 'd' (the drop), 'c' (the circle) and 't' (the triangle).

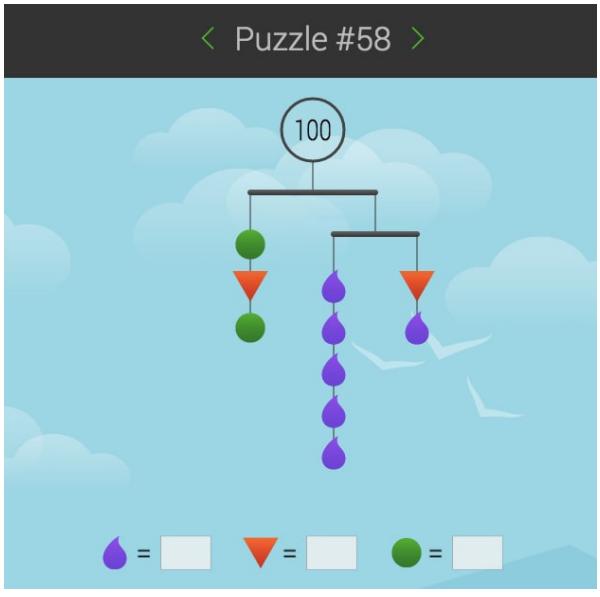

Figure 7

The only numerical value given is that of 100 in the circle. This figure translates to the following three equations

$5d = t + d$ (lower beam)

$2c + t = 6d + t$ (balancing both sides of the upper beam)

$2c + t + (6d + t) = 100$

All three equations may be used to solve the puzzle.

A middle school (or younger) student may work out such a puzzle by observing the weight of 100 equally divided into 50 each across the upper beam and further into 25 each across the lower beam. Five drops equaling 25 gives the first value; one drop (d) equals 5, which gives one triangle weight to be 20 leading us back to the upper beam left end giving the value of each green circle to be 15. The observation may vary from student to student and so the reasoning suggested here is one of the many possible ways to get the solution.

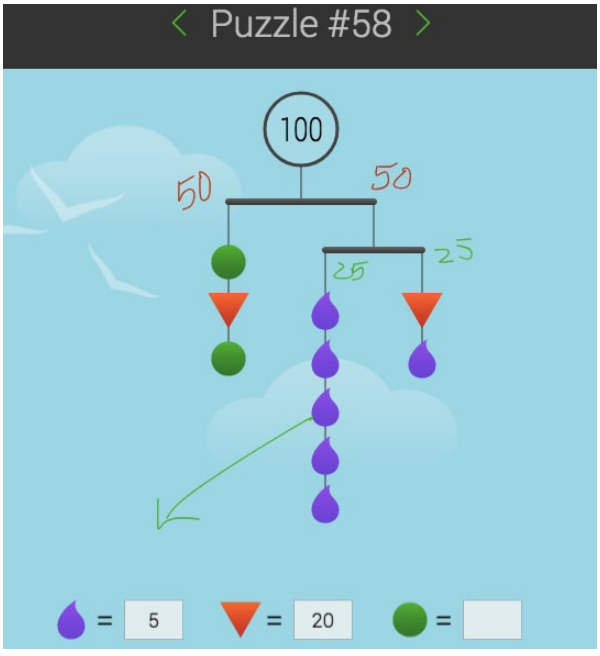

Figure 8

The logic of these puzzles reinforces the kind of reasoning required for solving systems of equations. The visual format makes these puzzles very appealing to a wide range of learners starting from middle grades to adults. Interactive features

including instant response to an incorrect value (Figure 9) and a celebratory message on submission of correct values (Figure 10) keep the user engaged and motivated.

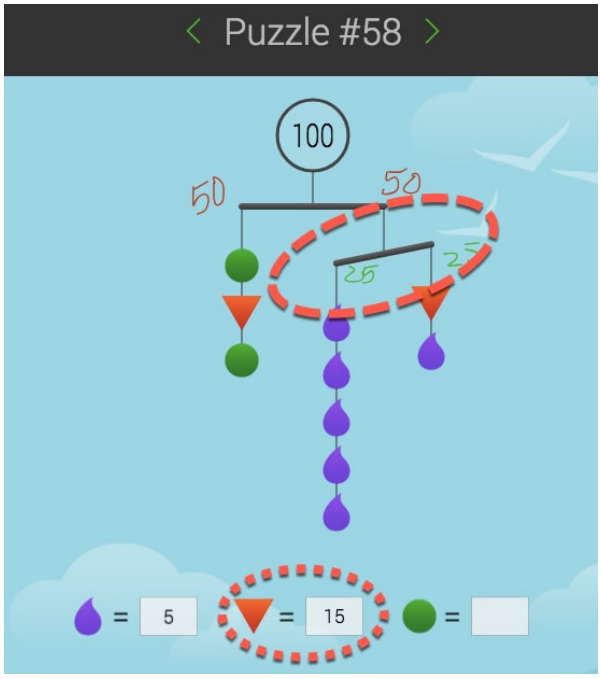

Figure 9

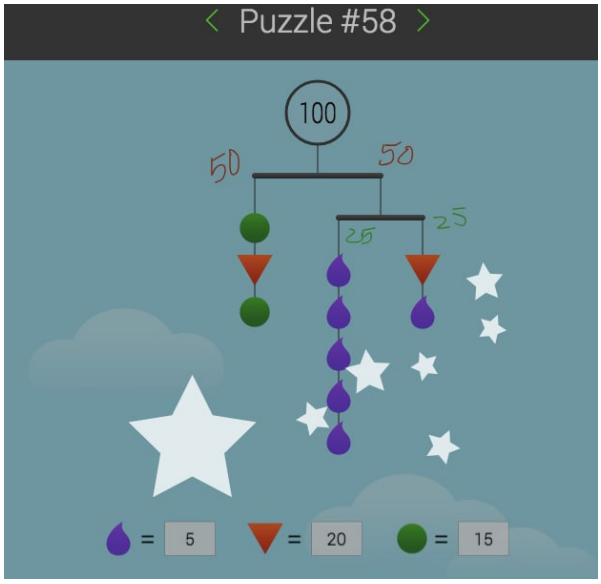

Figure 10

Now that you have experienced the 'Play' feature of SolveMe Mobiles, let us explore the "build' option which allows you and your students to create puzzles; building mobiles is a great exercise in reverse thinking. It is recommended that you create an account so that the puzzles created by you are saved and can be used at any given time. Students under 13 years of age can also create the account without using any email id.

To build your own mobile, first choose a shape (Figure 11) and then choose its colour (Figure 12).

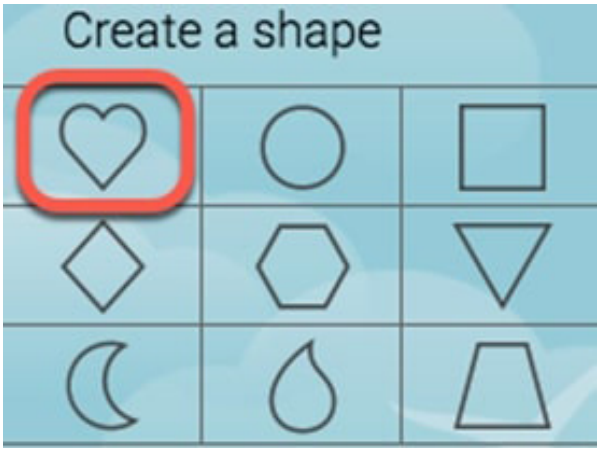

Figure 11

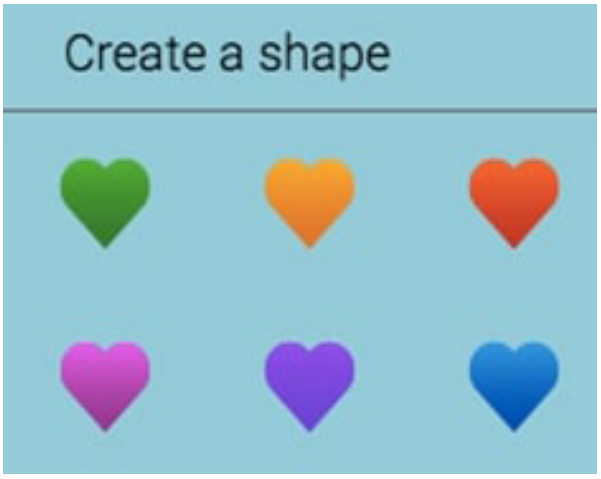

Figure 12

Then, set the weights of your shapes and drag the shapes and any other beams that you want from the Spare Parts bin onto the main screen. You can drag a total weight circle if you want to use it as a clue (Figure 13).

Now decide which clues to give the player. Which of the weights are you going to hide? (You must hide at least one to make a puzzle.) Use the toggle button to hide weights and the little "x" to remove unwanted shapes.

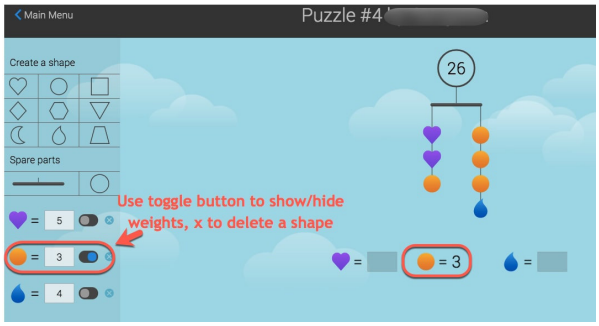

Figure 13

For example, the puzzle in Figure 13 shows the total weight of the mobile (26) and the weight of the orange circle (3). The weights of the purple heart and the blue drop are hidden for the puzzle-player to figure out.

Finally, you can save & play your puzzle (Figure 14) and you can share it!

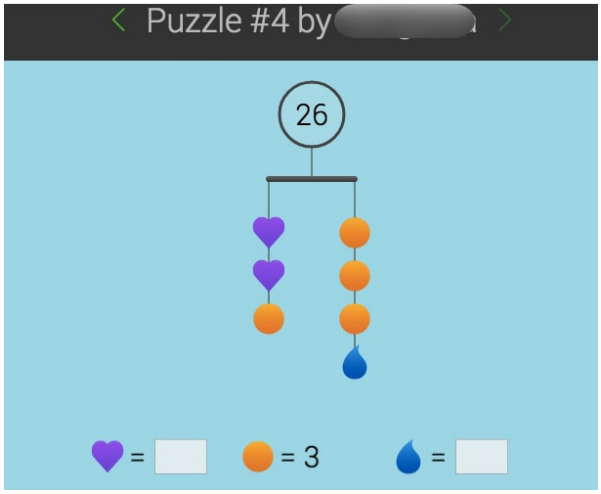

Figure 14

You can find the puzzles you have created under "My Saved Puzzles" in the Puzzle Menu.

In the Classroom: Teacher can give a certain number, which is the total weight, and students can be asked to create their own mobiles. They may work in groups or individually drawing out the mobiles on paper before recreating on the website, and they can challenge others to solve their mobiles.

We hope this article will help the teacher to design some interesting tasks on solving equations for her students. Although this method of mobile puzzles is not meant to replace the actual procedural method for solving equations, it can certainly be used as a precursor to motivate the student. Students may be asked to sketch the mobiles and then designate values to the weights/shapes leading to formation of equations. Class competitions can be organized wherein students make mobiles with multi-levels and varied number of weights/shapes and challenge the class to solve their creations.

SANGEETA GULATI is the Head of Mathematics Department, Sanskriti School, New Delhi. A teacher of mathematics for the past twenty-eight years, she has been teaching students in grade 11 and 12. Sangeeta has been actively involved in exploring the use of technology in teaching and learning of mathematics. Recipient of the 'National Award for using ICT for Innovation in Teaching, 2016' and a Google Education Certified Innovator-2014, Sangeeta was awarded the prestigious Fulbright Distinguished Award in Teaching in 2011. Sangeeta has contributed to several professional development and technology orientation program all over India. Resource person with NCERT in developing ICT curriculum and e-content, she has developed video lessons for class XI & XII with Central Institute of Educational Technology, NCERT. She conducts workshop on GeoGebra, Desmos, Google Apps and Online Resources. Her website Tech+Maths can be accessed at www.tinyurl.com/SGulati92 and she may be contacted at sangeetagulati92@gmail.com