

Mathvember

By Whizz Education

Making Maths Magical

How to Enthral Your Students with Maths

Webinar Handout

Not seen the webinar? View it here:
https://www.youtube.com/watch?v=KzoBRu7vXFk&t=734s




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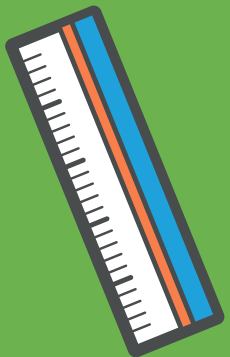

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Ideas for Teachers

How can we bring the magic of mathematics to the classroom?

We look at how one problem can be rich enough to provide the right level of challenge for all students and take a look at strategies for adding some WOW and sparkle to problems.

A good maths problem is one that is:

- ☑ **Playful**
- ☑ **Surprising**
- ☑ **Just the right level of challenge**
- ☑ **Hands-on**
- ☑ **Collaborative**

Low floor, wide walls, high ceiling problems

We have chosen a problem that has relatively easy entry points so that all students can begin, but also has scope for exploration and challenge for students at all levels. The problem will allow students to think, reason and make decisions – in other words, to work like mathematicians at a level and pace appropriate to them.

Start with a simple game: Sum to 15

Two players have digit cards 1 – 9 spaced out between them. The players take it in turns to pick a digit card. The idea of the game is to be the first to make the sum of 15 with three cards.

Just the right level of challenge for all:

• Using a more **concrete resource** with a distinct structure like dot cards, Numicon or even Cuisenaire rods instead of digit cards, supports the visual concept of combining of two or more numbers. The learners can see the values and physically manipulate the numbers.

• The **complexity** comes in finding the winning strategy...
- the choice of numbers made at each turn
- whether it matters who goes first
- what are all the winning combinations?

Digit and dot cards are also available with this download.

Find out more at www.mathvember.com

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The game is simple enough to play. The depth comes in prompting questions that encourage students to formulate strategy. In our experience, without these prompts students will tend to think they have a strategy just based on whether they win or not!

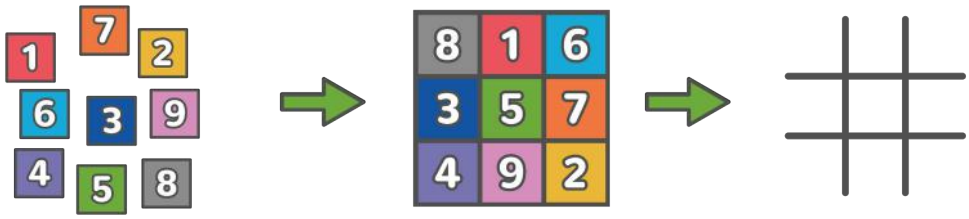
Some prompts for Sum to 15:

- Which digit card is it best to start with?
- Which cards will you pick up when?
- How will you block your opponent?
- Does it matter who goes first?
- What are the winning combinations?

After a few games you should ask students - what does the game remind you of?
Some students are likely to pick up the similarities with tic-tac-toe:

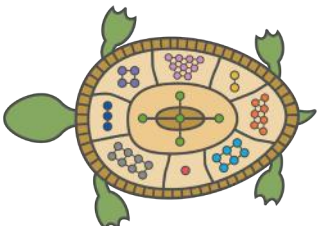
- a winning set consists of three elements
- some moves block potential sets from your opponent
- sometimes a player wins by setting up two winning sets, only one of which could be blocked
- some games end in a tie

To make the link between our game and tic-tac-toe, we can use magic squares!



Magic squares are a fascinating object of study in their own right – let's take a brief look.

What's 'Magic' about a magic square?



4	9	2
3	5	7
8	1	6

In the ancient Chinese legend of 'Lo Shu', there's a story about a huge flood that destroyed all the crops and land. People offered sacrifices to the river god so that one of the flooded rivers (the Lo river) would calm down. Every time the river flooded, a turtle would walk around the sacrifice. One day a child noticed a pattern on the shell of the turtle. It told people how many sacrifices they need to make for the god to accept. The pattern consisted of circular dots arranged in a 3-by-3 grid, where the number of dots in each column, row and diagonal summed to the same amount, fifteen. So, they realised they needed to make 15 sacrifices to keep the god happy.

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To create a 3 x 3 magic square, you have to place the digits 1 – 9 into a 3 x 3 grid so the rows, columns and diagonals have the same total, called the 'magic number'.

Can you work out the 'magic number' before placing the numbers into the grid?

The magic number can be found by adding all the numbers in the square (so here we have 1 – 9 = 45) and dividing by 3 (as it's a 3 x 3 grid and the total is shared equally across 3 rows and 3 columns). 45 ÷ 3 = 15. So 15 is the magic number for this magic square and we can begin to see how it relates to our Sum to 15 game.

There is also magic to be found in the symmetry of how all the lines add up to the same amount. There are six different symmetries of a 3 x 3 magic square with the same set of numbers:

Original

Rotation $\frac{1}{2}$

Rotation $\frac{1}{4}$

Rotation $\frac{3}{4}$

Reflection through vertical

Reflection through horizontal

Magic squares

Place the digits 1 – 9 into a 3 x 3 grid so the rows, columns and diagonals have the same total.

Just the right level of challenge for all:

- Using **concrete resources** to support the recognition of values, learners could start with a simple version by limiting the size of the numbers. For example: using three of each of the numbers 1, 2 and 3. The resources can be placed in a grid. This particular version shows students how the problem works without having to worry too much about the addition. (The magic number is 6.)

- In completing the challenge, the placement of the numbers in the magic square will differ among students – this is a good opportunity for students to compare and discuss differences, work out how many symmetries there are, and discuss strategies they used to complete the magic square.

Taking the learning further:

- Is the centre number in a 3 x 3 magic square always one third of the magic number?
- Place the digits 1 – 16 into a 4 x 4 grid so the rows, columns and diagonals have the same total.
- What do you notice about the Gnomon Magic Square?
- There are 86 ways to total 34 picking 4 numbers between 1 and 16. Can you find 86 ways?

Magic Square templates are also available with this download.

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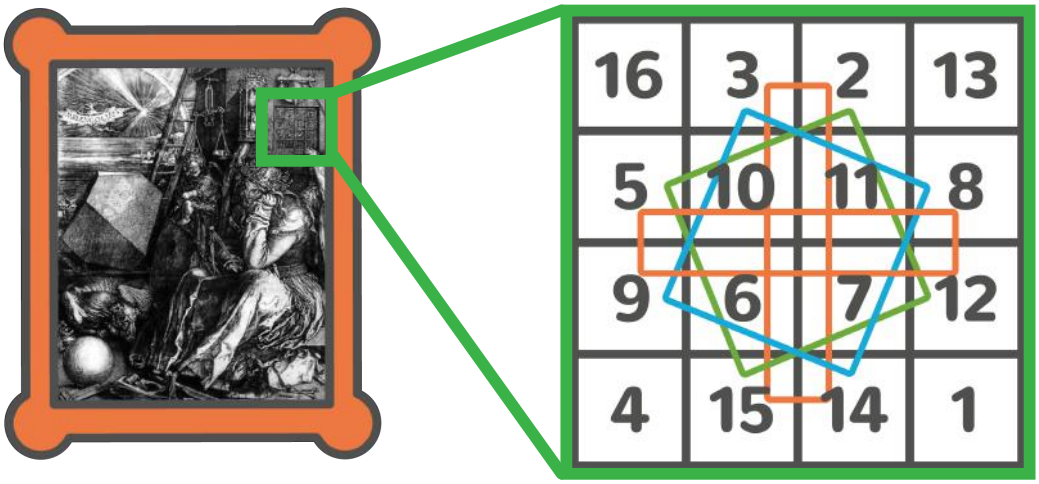
The Gnomon Magic Square

- The numbers used are 1 - 16
- The sum of 1 to 16 is 136
- The magic number is 34
- The numbers in the 4 corners add up to 34
- The 4 centre numbers add up to 34
- The sum of the 4 quadrants is 34

How else can you make 34 using a Gnomon Magic Square? There is a hint in the diagram...



This particular magic square is famous. Albrecht Durer incorporated the magic square into his copperplate engraving. Even the year of the engraving (1514) is included. This magic square has the additional property that the sums in any of the four quadrants, as well as the sum of the middle four numbers, are all 34. It is known as a Gnomon Magic Square.

http://mathworld.wolfram.com/DuerersMagicSquare.html

Some variants of magic squares:

- **'un-magic' squares** using digits 1 – 9 the sum of the rows, columns and diagonals must be different.
- **'prime' squares** – using digits 1 – 9 all the rows and columns must add up to prime numbers. Is it possible to have the diagonal as well?

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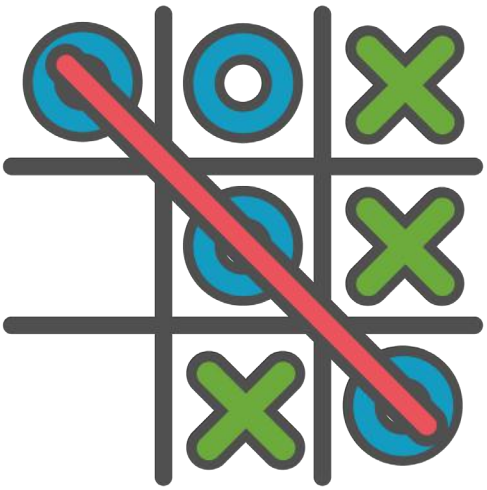
The winning strategy revealed

Winning in Sum to 15 is the same as finding a straight line in a 3x3 grid, which makes our game equivalent to tic-tac-toe. They are two representations of the same game. Sum to 15 is noughts and crosses in disguise. Who'd have thought it?!



So, what's the answer to our original question? Is there a strategy for winning in Sum to 15? Well, you probably know that tic-tac-toe has no guaranteed strategy – if both players know the handful of combinations in the game and each play a 'perfect' strategy, neither will win. So, there is no guaranteed strategy for Sum to 15 either.

Perhaps we can make the game a bit more interesting...

Try some of tic-tac-toe variants below:

Dotty Six (Nrich)
https://nrich.maths.org/7337

Traffic lights (Nrich)
https://nrich.maths.org/1181

Tic-tac-toe
https://nrich.maths.org/538

The Ultimate Tic-tac-toe
https://mathwithbaddrawings.com/2013/06/16/ultimate-Tic-tac-toe/

Ultimate Tic-tac-toe blank template is also available with this download.

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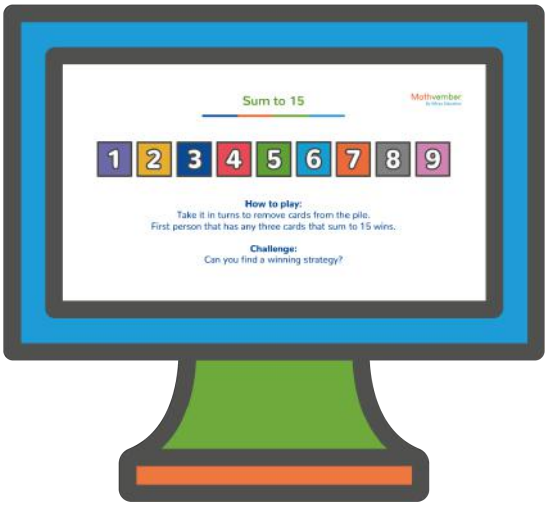
Practical tips for the classroom

The classroom environment needs to be considered as well. Bringing the magic into the classroom could involve having a designated area that celebrates problem solving. This could be, sticking with our magical theme, by setting up the Magician's Workshop with stage effects, props and tricks. This maths area can be integrated into the lesson as a space to work in or used as a continuous learning space. Ensure that:

- A range of resources are accessible and available
- Mathematical language on display is changed frequently – also try words of the week
- Pose questions to make students think
- Get students to pose questions and display them
- Be interactive – provide an opportunity to respond to a problem of the day
(sign up for our Mathvember problems at www.mathvember.com)
- Make space to practise and explore



You can hopefully see why we choose this rich problem. We started with a simple game of addition and ending up in the realm of tic-tac-toe, a game without numbers! We found a surprising connection between two very different looking ideas by navigating the mystery of magic squares. Maths is all about finding these hidden connections.

Have fun making maths magical in the classroom!

Find out more at www.mathvember.com

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