

Problem-solving activities: ideas for the classroom

This resource was developed by teachers within the Royal Society Schools Network



Maths Game Being Played By Children in the Classroom
Istock image 481625182. Credit: davidf

KS1 / KS2

Introduction

33 schools from the Royal Society Schools Network were chosen to take part in a problem-solving club pilot scheme, with the aim to set up a new mathematics or computing focused problem-solving club for their students. Each club developed its own programme of activities, and teachers were encouraged to explore opportunities to embed the problem-solving activities they ran into the curriculum.

We asked the teachers involved in the pilot to tell us about the activities that worked best in their clubs. The following are some of the main activities that were highlighted at primary level.

Curriculum key words

Each activity has a list of key words students may develop during the activity.

Curriculum links

Under each activity is a list of the areas of the curriculum it could support.

This is broken down per year where appropriate, and by statutory requirements and non-statutory guidance.

Equipment needed

Each activity uses material either readily available in most classrooms, or easy to obtain at little or no cost.

Many of the activities featured in this document have been sourced from the University of Cambridge's NRICH Roadshow. You can access them free of charge at <https://nrich.maths.org/6776>.

Activity	Description	Suitable for
Cubes	Visualising the 'faces' of cubes which can be seen when they are placed on a table and investigating how this changes when the arrangement and number of cubes are changed.	KS1
Three way mix up	Arranging 9 square tiles (3 yellow, 3 blue, 3 red) on a grid so that no two tiles of the same colour are next to each other.	KS1
Darts	Keeping score when playing a game of darts using a student friendly dartboard.	KS1
Tangram pictures	Creating pictures using tangram shapes.	KS2
Plants	An introduction to Venn diagrams and the sharing of 'properties' between multiple people.	KS2
Teacups	Arranging different coloured cups and saucers on a 6 x 6 place setting in the grid so that no column or line has a repeated colour cup or saucer.	KS2
Escape the castle	Completing a small number of short challenges, ideally covering a range of skills to gain the code to a locked box containing a prize or to collect all the pieces to a picture of something/someone.	KS2

"The children have definitely improved their collaborative skills. Initially, when given a problem all of the children would think of it as a competition and tackle the problems independently. I encouraged them to share their thoughts and ideas and eventually the children started to speak and contribute different points of view. They realised that if they worked together they would solve the problem in a way they would perhaps not have thought of." Pilot teacher

Visualising

[Cubes](https://nrich.maths.org/42) from NRICH (https://nrich.maths.org/42)

Ideal age group: KS1

Summary of activity

You need to have three cubes, all the same size with flat faces. Each cube should be a different colour. The students are asked to think of a single cube on a table, and visualise in their heads how many 'faces' (sides) of the cube they can see (Answer = 5, the 6th is on the table so not visible).

They are then asked to add a second cube, and think of all the ways that the two cubes can be placed next to each other. (Answer = one on top of the other, one to the side of the other and both on their own). Again, the students should visualise how many faces they think they can see, and then check against the actual cubes.

Discuss with the students all the different arrangements of the two cubes there might be, and if they think placing one cube on the right side of the other, or on the left side will be the same arrangement or different. Students should think of arguments for and against.

Repeat this with three cubes.

Equipment needed:

Three cubes, all the same size with flat faces.

Possible problem-solving skills, techniques and approaches

Looking for patterns eg are arrangements the same?

Making and testing hypothesis eg if a cube is on the table you will be able to see 5 sides, if it is on the table and joined to another cube you will be able to see 4 sides etc.

Checking solutions eg counting the number of sides to check your prediction is correct.

Trying different approaches eg starting with two cubes and finding different ways of arranging them or dropping the cubes on the table so they arrange themselves or getting a friend to arrange them.

Visualising eg forming a mental picture to work out the answer to the question.

Predicting eg how many sides can be seen before counting them.

Recording results eg how can you record your results to keep track of them?

Finding all possibilities eg use three cubes every time and see how many different ways you can arrange them – how many faces do you see each time?

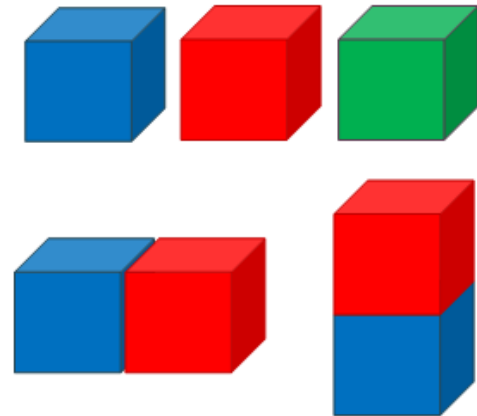


Image 1: Two block patterns

Why this activity works well

At the highest level, students can work systematically to count the faces they can see on different arrangements of three cubes. Everyone can get involved at some level.

“The low entry high ceiling meant that students of different levels were engaged.”

The students were able to come up with creative solutions. It progressed to half covering faces with other cubes and also to making generalisations about which kind of arrangements revealed more faces.

The range of solutions allowed the students to make decisions based on their thinking and reasoning in a group. This was useful for developing communication skills.

Curriculum links

Links to the national curriculum

- Year 1 statutory requirements: Pupils should be taught to recognise and name common 2D and 3D shapes... including squares....including cubes... describe position, direction and movement.
- Year 1 non-statutory guidance: Pupils handle common 2D and 3D shapes, naming these and related everyday objects fluently. They recognise these shapes in different orientations...use the language of position, direction and motion.
- Year 2 statutory requirements: Pupils should be taught to: identify and describe the properties of 3D shapes, including the number of faces... identify the shapes on the surface of 3D shapes... arrange combinations of mathematical objects in patterns and sequences.
- Year 2 non-statutory guidance: Pupils handle and name a wide variety of common 2D and 3D shapes... use vocabulary precisely such as sides, edges, vertices, faces.

Develops vocabulary

Left	Near
Right	Close
On top of	Up
In front of	Down
Above	Forwards
Between	Backwards
Face	Side
Edge	Square
	Cube

Finding patterns

'Three way mix up' from NRICH (<https://nrich.maths.org/177>)

Ideal age group: KS1

Summary of activity

The students are given three square blue tiles, three square yellow tiles and three square red tiles. They have to put them together to make a square (3 x 3 grid), so that no two tiles of the same colour are beside each other.

The students are challenged to find a different way of ordering the tiles from the example given (image 2). They are then challenged to find all the ways this is possible.

There are several variations of this game, several can also be found on the NRICH website including; Mismatched socks and the Ladybird game.

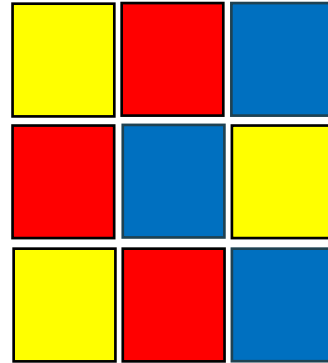


Image 2: The example given for students to work from

Equipment needed:

Three square blue tiles, three square yellow tiles and three square red tiles.

Possible problem-solving skills, techniques and approaches

Working systematically eg start with the same colour square in the corner. Looking for patterns eg symmetry or using the same colour square twice in each row.

Making and testing hypothesis eg you can put the same colour square in the opposite two corners of the top row and the middle square of the bottom row each time.

Checking solutions eg checking that no same coloured squares are next to each other.

Trying different approaches eg trying to work from different starting points or finding different patterns.

Decomposition eg breaking the problem down to solve each row rather than looking at the grid as a whole.

Finding all possibilities eg working systematically to check that each possibility has been discovered.

Persevering eg keep trying different approaches if at first you don't succeed. Try to come up with strategies that help to solve the problem.

Recording results eg what is the best way to record results? Is it necessary to colour in each square or is there a more efficient way to record the results?

Why this activity works well

You can make the equipment for this activity as simple or as complicated as you want, from paper cut outs to more tactile foam pieces to using translucent tiles on a light table.

“The students thought about whether there would be a systematic way of moving one tile at a time so that you could be sure you had found all of the possibilities.”

This generated quite an interesting discussion about whether rotations of the square counted as being the same or different. The second group chose to record their answers on paper.

Curriculum links

Links to the national curriculum

- Year 1 non-statutory notes and guidance: Pupils use the language of position and direction including: left and right, top, middle and bottom, on top of, above, between, up and down.
- Year 2 statutory requirements: Pupils should be taught to ... arrange combinations of mathematical objects and sequences... use mathematical vocabulary to describe position...

Develops vocabulary

Side	Edge
Square	Centre
Left	Explain
Right	Show me
Down	What comes next
Colour	Repeat
Between	Separate
Beside	Change
Next to	Symmetrical
Middle	Reflection
Find all possibilities	Pattern

Mental calculations

Darts

Ideal age group: KS1

Summary of activity

A teacher observed that dart players need good mental arithmetic to be able to count their scores as they play. Students were challenged to play a game of darts (using a student friendly board) and keep their scores as they played.

There are more sport related activities by NRICH here: <https://nrich.maths.org/olympics>

Equipment needed:

Toy dartboard or another game that uses a physical activity to provide random numbers.

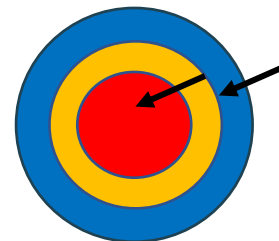


Image 3: dartboard

Possible problem-solving skills, techniques and approaches

Looking for patterns eg are there any number patterns that might help with mental calculations.

Checking solutions eg have a partner check results on a calculator. Trying different approaches, eg what strategies can you use to calculate the answers in your head?

Predicting eg which numbers on the dartboard will give you answers greater than 20?

Decomposition eg using decomposition as a strategy to carry out mental calculations.

Recording results eg how should the results be recorded?

Why this activity works well

Students could play at their own speed, and the element of competition took away from the usually mundane task of practicing addition and subtraction.

“This activity helped the children to enjoy using their mental maths and see a purpose for it.”

Curriculum links

Links to the national curriculum

- Year 1 statutory requirements: Pupils should be taught to: add... one and two digit numbers to 20, including zero... solve one-step problems that involve addition... using concrete objects and pictorial representations...
- Year 1 non-statutory notes and guidance: Pupils memorise and reason with number bonds to 10 and 20.
- Year 2 statutory requirements: Pupils should be taught to: solve problems with addition ...using concrete objects and pictorial representations... applying their increasing knowledge of mental ... methods ...recall and use addition and subtraction facts to 20 fluently, and derive and use related facts up to 100 ...add and subtract numbers ... mentally, including:
 - a two-digit number and ones;
 - a two-digit number and tens;
 - two two-digit numbers;
 - adding three one-digit numbers; and
 - show that addition of two numbers can be done in any order (commutative).
- Year 2 non-statutory notes and guidance: adding numbers in a different order to check addition.

Develops vocabulary

Add	Total
Altogether	More than
Put together	Addition

Problem-solving with shapes

'[Tangram pictures](https://nrich.maths.org/6715)' from NRICH (<https://nrich.maths.org/6715>)

Ideal age group: KS2

Summary of activity

A tangram is an ancient Chinese puzzle where you make pictures using mathematical shapes. Students are given a standard set of tangram pieces and asked to work on one or more of the activities below, dependent on their confidence:

- make any picture they choose;
- make specific pictures using the shapes; or
- make the same pictures using the least/most amount of shapes.

Equipment needed:

Simple version = print out

Hands-on version = tangram packs



Image 4: tangram pieces

Possible problem-solving skills, techniques and approaches

Working systematically eg which shapes might you start with?

Trying different approaches eg which shapes could be combined to make some of the other shapes (eg the two small triangles which, when combined, make the square)? Does changing the orientation of some of the shapes help?

Looking for patterns, visualising and decomposition eg which shapes might be combined to create different parts of the target image? Is it helpful to focus on one part of the image and create that before tackling the next part?

Why this activity works well

This is a good entry activity for students who may be unsure when approaching problem-solving activities. The three different types of activity build on the skills they develop, and so all ages and abilities can get involved.

“Using the shapes activity was a good way to assess how the children solved problems individually but in a way that the children thought they were having fun and were not learning.”

There are different shape Tangrams (square, egg...) and a large variety of pictures to try and make, so it is easy to link it to topics in school or the school calendar.

Curriculum links

Links to the national curriculum

- Year 3 statutory requirements: identify right angles, recognise that two right angles make a half-turn... identify whether angles are greater than or less than a right angle... identify horizontal and vertical lines.
- Year 4 statutory requirements: compare ... geometric shapes, including quadrilaterals and triangles, based on their properties and sizes ... identify acute and obtuse angles.
- Year 5 statutory requirements: know angles are measured in degrees: estimate and compare acute, obtuse and reflex angles... identify: angles at a point and one whole turn (total 360°); angles at a point on a straight line and $1/2$ a turn (total 180°) ... use the properties of rectangles to deduce related facts and find missing lengths and angles.
- Year 6 statutory requirements: compare ... geometric shapes based on their properties and sizes... recognise angles where they meet at a point, are on a straight line...

Develops an understanding of

- Spatial relationships.
- How geometric shapes can be decomposed.
- Rotation.
- Geometric properties (angle size, side length, diagonal length).
- The relationship between different pieces (eg that the two smaller triangles can be combined to make a square).

All of which would lead to improved geometric reasoning.

Develops vocabulary

Reflection	Right-angled triangle
Rotation	Parallelogram
Translation	Right-angled triangle
Right angle	Square

Using Venn diagrams to solve problems

'Plants' from NRICH (<https://nrich.maths.org/36>)

Ideal age group: KS2

Summary of activity

Students are given the following imaginary scenario. Three young people, Naomi, Alex and Chris, have been given enough money to buy 10 plants to fill their intricately shaped flowerbed. The flowerbed is laid out as three overlapping circles. They need to arrange these 10 plants so that Alex has 5 plants, Naomi has 6 plants and the Chris has 7 plants.

Their uncle Raj shows them how they can use the circles to 'share' plants, and gives an example (Image 1). This is a simple introduction to Venn diagrams and the sharing of 'properties' between multiple people.

Students in the class are encouraged to explore Venn diagrams by seeing how many other solutions they can find to sharing the 10 plants, whilst still giving each young person in the story the correct total of plants each.

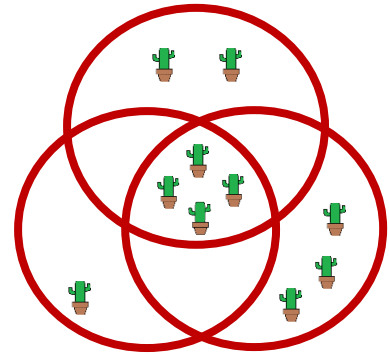


Image 5: Flowerbed solution by uncle Raj

Equipment needed:

Simple version = print out

Hands-on version = hula hoops and plants (or something to represent the plants)

Possible problem-solving skills, techniques and approaches

Working systematically eg try starting with one plant in the centre. Is it possible to make the numbers work? Then try with two...

Making and testing hypothesis eg the fewer plants in the centre, the greater the number that will have to be shared.

Checking solutions eg each time a plant is moved, ensuring that the other plants are moved to make up the correct number for each young person.

Trying different approaches eg try by decreasing the number of plants in the centre from the given example or try just having one plant in each circle where it doesn't overlap.

Abstraction eg ignoring the details of the story and focusing on the problem of maintaining the correct number of plants for each young person.

Persevering eg keep trying different approaches if at first you don't succeed. Try to come up with strategies that help to solve the problem.

Recording results eg what would be the best and most efficient way to record the results? Is it necessary to draw the plants each time or could they be represented some other way?

Why this activity works well

There are a number of right answers, but the students have a capacity to explore these and develop their reasoning skills. The approaches they take will differ across age groups, but due to the different ways you can reach a solution, younger students may get an answer just as fast as older students.

This activity promotes good communication as a group, encouraging students to discuss their approaches with each other (which may be different) and look for patterns to find more solutions. There is no *one* right answer, so the students can keep working on it.

“As they were actively exploring the problem it engaged all, even SEN”

The students can use print outs to draw on, move pieces around or actual hoops and plants (or plant printouts) outside – whatever works best for their own learning preference.

This activity can be focus around a number of common scenarios, so can be personalised to the school or class, linking in with a variety of topics.

Curriculum links

Links to the national curriculum

- Year 2 statutory requirements: Pupils should be taught to: solve problems with addition ...using concrete objects and pictorial representations... applying their increasing knowledge of mental ... methods ...recall and use addition and subtraction facts to 20 fluently, and derive and use related facts up to 100 ...add and subtract numbers ... mentally, including:
 - a two-digit number and ones;
 - a two-digit number and tens;
 - two two-digit numbers;
 - adding three one-digit numbers; and
 - show that addition of two numbers can be done in any order (commutative).
- Year 3 statutory requirements: solve problems, including missing number problems, using number facts, place value, and more complex addition and subtraction.
- Year 3 statutory requirements: solve one-step and two-step questions [for example, 'How many more?' and 'How many fewer?'] using information presented in scaled bar charts and pictograms and tables.

Develops an understanding of

- How a Venn Diagram can be used to organise information in a visual format to enable relationships between sets of items.

Develops vocabulary

Venn diagram

Common

Finding patterns (complex)

'Tea cups' from NRICH (<https://nrich.maths.org/32>)

Ideal age group: KS2

Summary of activity

Students are given the following imaginary scenario.

You are preparing afternoon tea for a large group of friends, and you want the table to look colourful and interesting. You have bought four sets of china for the occasion: one set has four white cups and four white saucers, the second set has four blue cups and four blue saucers, the third set has four red cups and four red saucers and the fourth set has four green cups and four green saucers.

For fun, you decide to mix up all the cups and saucers so that each place setting has a different combination of colour cup and colour saucer – no two are the same!

You want to arrange the cups and saucers for each place setting on the table in the middle, so people can easily reach them. You realise that the best way to do this is to fill a four-by-four grid (image 3).

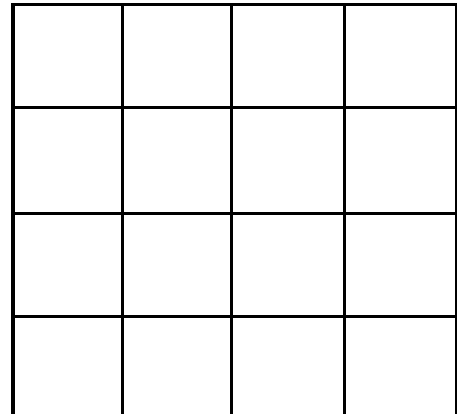


Image 6: Place setting grid

Your challenge – can you arrange the place setting in the grid so that no column or line has a repeated colour cup or saucer?

Equipment needed:

Simple version = print out

Hands-on version = actual coloured cups and saucers, as described (you could use paper versions for ease)

Possible problem-solving skills, techniques and approaches

Working systematically eg start by combining different cups and saucers then place on the grid.

Checking solutions eg checking that no same coloured saucers or cups are in the same row or column.

Trying different approaches eg trying to work from different starting points, trying to place all the cups first and then add the saucers.

Decomposition eg is there a way of breaking the problem into smaller chunks to solve it?

Abstraction eg deciding which information from the story is relevant for solving the problem and which parts can be ignored.

Persevering eg keep trying different approaches if at first you don't succeed. Try to come up with strategies that help to solve the problem.

Recording results eg What is the best and most efficient way to record results?

Why this activity works well

The principle is building on the 'three way mix up' activity, putting it in a real-world context with more variability. If needed, the students can use actual cups and saucers, rather than just working it out on paper.

Students had to have good attention to detail to find the solution, and they needed to work strategically and systematically. Whilst finding combinations was easy, arranging them wasn't.

"This was a good one for realising the need to work strategically and systematically"

The activity promoted good listening skills, and working as a team was important.

Curriculum links

Links to the national curriculum

- Year 2 statutory requirements: Pupils should be taught to ... arrange combinations of mathematical objects and sequences... use mathematical vocabulary to describe position...
- Year 2 statutory requirements: Pupils should be taught to: solve problems with addition ...using concrete objects and pictorial representations... applying their increasing knowledge of mental ... methods ...recall and use addition and subtraction facts to 20 fluently.
- Year 3 non-statutory: Pupils solve simple problems in contexts, ... and correspondence problems in which m objects are connected to n objects (for example, 3 hats and 4 coats, how many different outfits?; 12 sweets shared equally between 4 children; 4 cakes shared equally between 8 children).
- Year 4 statutory requirements: solve problems involving multiplying and adding, correspondence problems such as n objects are connected to m objects.

Develops an understanding of

- Strengths and weaknesses of different approaches.

Develops vocabulary

Combination

Adjacent

Escape box

'[escape the castle](https://nrich.maths.org/7501)' from NRICH (<https://nrich.maths.org/7501>)

Ideal age group: KS2

Summary of activity

The Escape box brings together a small number of short challenges, ideally covering a range of skills, which the students have to complete. The desired outcome is to complete all the challenges and either gain the code to a locked box with a prize inside, or collect all the pieces to a picture of something/someone they really like.

The challenges could be number or word based, and ideally link to an actual locked box with a combination lock so that, when a group thinks they have the answer, they can try and input the code.

Examples of challenges are:

- Simple or advanced arithmetic;
- Cracking a simple code;
- A sequencing activity.

The prize can be something small like a bar of chocolate or a voucher for 5 minutes reading time etc. or something a bit bigger dependent on budget and the need for additional motivation.

Equipment needed:

Simple version = print out of a favourite picture, cut into pieces. The list of questions

Hands-on version = A box with fitting to take a padlock, and a combination padlock. A small prize. The list of questions

Possible problem-solving skills, techniques and approaches

Any of the following skills, techniques and approaches could be developed depending on the challenges used to provide the key to the box:

Working systematically.

Looking for patterns.

Making and testing hypothesis.

Checking solutions.

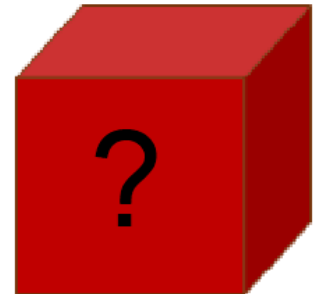


Image 7: Escape box

Trying different approaches.

Visualising.

Predicting.

Generalising.

Abstraction.

Working logically.

Decomposition.

Finding all possibilities.

Persevering.

Recording results.

Why this activity works well

The competition element is a great motivator and utilises 'learning by playing'.

“By cutting up an image of a favourite character or other loved image, students are encouraged to answer puzzles as the reward is another section of the image and they all want to complete the picture.”

The activities can be suited to the topics being taught that term, and geared to different ability levels if needed. Having smaller challenges focuses the student's concentration, and allows them to practice and explore a wider range of skills that just focusing on one particular type of task.

Curriculum links

Links to the national curriculum

- Will be dependent on the types of problem used to gain entrance to the box but there is scope to match these to any of the objectives.

Develops vocabulary

Again this will depend on the type of problem.