Primary Magazine
Issue 34

National Centre for Excellence in the Teaching of Mathematics

Welcome to the 34th issue of the Primary Magazine. Our little bit of history article focuses on the Ancient Egyptians, we look at the art of Matisse and focus on woolly things! Our CPD opportunity explores proof in the primary classroom and our ICT article explores the use of digital cameras in mathematics. *It's in the News!* features zoos.

Contents

Editor's extras

In this issue, we highlight the last three of the case studies from our National Priority Project (NPP): 'Maximising opportunities for mathematical learning across the primary curriculum'. We also tell you about another successful NPP and point you to a variety of research articles and intervention materials.

It's in the News!

Towards the end of 2010, a documentary about London Zoo was aired on television. This was repeated at the beginning of 2011. One of the highlights of the series was the zoo's breeding programme for 'silverback' gorillas. Zoos are those places that are either loved or hated. *It's in the News!* explores the pros and cons of these establishments and, of course, offers plenty of links to mathematics.

The Art of Mathematics

In this issue, we look at the art of Henri Émile-Benoît Matisse, a French artist born on 31 December 1869 in France. He was first inspired by the world of art at 21 when he suffered appendicitis, his mother bought him a set of paints to help his convalescence. I wonder if she knew at the time what this would lead to!

Focus on…

We focus on knitting the mathematical way. You may be surprised at the mathematics involved in knitting. So get that wool out and see what you can make happen!

A little bit of history

In this issue, we are going cross-curricular once again and looking at some of the ways that you can link mathematics into a topic on the Ancient Egyptians. If you are looking at this period of history, you might like to try out some of the ideas.

Maths to share – CPD for your school

One of our roles as teachers is to encourage the children we work with to think mathematically, and to enjoy the process of problem solving. In this issue, we consider proof, an area of mathematics which will enable them to think like mathematicians and become effective problem solvers.

ICT in the classroom

We consider the use of digital cameras to consolidate the children's understanding of mathematical concepts and to develop reasoning skills. We have some great ideas, including a scavenger hunt.

Editor's extras

"I'd like to read some research but I don't know where to start." (Mathematics teacher)

In the last issue, we had an article Teachers reading research, aimed at inspiring you to look into research, with examples from the General Teaching Council (GTC) web page, Research for teachers. In this issue, we have more suggestions from the web resources of the British Society for Research into the Learning of Mathematics (BSRLM). We highlight some papers that may be of interest to you.

In Issues 32 and 33 we highlighted four of the case studies from our National Priority Project: Maximising opportunities for mathematical learning across the primary curriculum. You may remember that the main aim of the project was to:

Engage teachers and their pupils in exciting projects involving mathematics in real life and across the curriculum in order to enhance and deepen the mathematics they are taught in the discrete maths lessons, so raising attainment and enjoyment.

In this issue, we feature the remaining three schools who took part in this successful project:

- Sir James Wolfe Primary School, Greenwich, who made links with art
- Tudor Primary School, Suffolk, who made links with science
- Holy Trinity C of E Primary School, who made links with RE.

We hope you enjoy reading about what they did and are inspired to give mathematics across the curriculum a go at your school.

You may have heard of the Pearson Primary Policy Watch. Pearson have written documents which are intended to alert busy colleagues to the national developments in education. They can all be found on the Edexcel website.

And finally...
Have you seen Google's new art project? It has recently been launched and is a little like their 'Street View', but instead of streets it shows the inside of art galleries. Fantastic for making up more art and mathematics links!!

It's in the News!

Recently, a documentary was broadcast featuring London Zoo, in Regent's Park, and its 'country home' at Whipsnade. One of the highlights of the series was the work involving a breeding programme for 'silverback' gorillas. Zoos are places that are either loved or hated. Many, such as the zoo featured on the programme, do good work breeding animals in captivity for conservation purposes and keeping endangered species in a safe environment. Some people feel it is wrong to keep animals in captivity. Whichever camp you are in, zoos also provide great opportunities for mathematics work!

Before you use the slides you might find it helpful to look at the following websites for further information:

- Born Free Foundation zoo check
- itv.com
- Wikipedia - zoo, and list of zoos worldwide

This resource provides ideas that you can adapt to fit your classroom and your learners as appropriate. As always, we would be extremely grateful if you could give us some feedback on how you have used it, if it has worked well and how it can be improved.

Download this *It's in the News!* resource - in PowerPoint format.

Download this *It's in the News!* resource - in PDF format.

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National Centre for Excellence in the Teaching of Mathematics

The Art of Mathematics
Henri Émile-Benoît Matisse

Henri Émile-Benoît Matisse was born on 31 December 1869 in Northern France. He grew up in Picardy, where his parents had a flower business. When he was 18, he went to Paris to study law. Once qualified, he returned home as a court administrator. At 21, he became ill and needed his appendix removed. While he was recovering, his mother bought him a set of paints to help his convalescence. He later described this time as ‘a kind of paradise’. Three years later, he went to Paris to study art at the popular Académie Julian. Matisse had a daughter, Marguerite, with model Caroline Joblau in 1894, but it was Amélie Noellie Parayre that he married in 1898. They had two sons together, Jean in 1899 and Pierre in 1900. Marguerite and Amélie often acted as models for Matisse. After 41 years of marriage, he separated from his wife.

At first, Matisse painted still life and traditional landscapes, but later John Peter Russell introduced him to Impressionism and his style changed completely. Matisse was one of the three artists (Picasso and Duchamp being the other two) who were responsible for significant developments in painting and sculpture. They used bright, expressive colours. When Matisse and a group of artists exhibited their work in Paris in 1905, their painting style shocked the art world. A critic labelled them *fauves*, which means wild beasts, so the style of painting became known as Fauvism. Matisse liked to paint the human body and domestic households. He had three favourite props which can be spotted in many of his paintings – a bird cage, a pewter jug and a Chinese vase. When depicting the human body, he used solid colour in the background and a different solid colour for the body, often creating a silhouette-like effect. Soon after he separated from his wife, Matisse became very ill with intestinal cancer and was confined to a wheelchair. Unable to stand to paint he began what he called ‘painting with scissors’. His cut paper collages, known as *gouaches découpés*, were usually large and colourful. Although often quite simple works, his eye for colour and geometry ensured that his work was both playful and powerful. The Snail, created in 1953, the year before he died, is one of his most famous and instantly recognised pieces. Find out more about *The Snail* from the Tate website.

Matisse died of a heart attack on 3 November 1954, aged 84. Although better known as an artist, Matisse was also a sculptor, draughtsman, book illustrator, and a graphic artist. He is one of the leading artists of the 20th Century.

You might like to begin your exploration of Matisse with Raoudi, his Schnauzer dog. Find out about Matisse’s favourite props – a bird cage, a pewter jug and a Chinese vase – and spot them in his paintings.

Explore *The Snail*. Which geometric shapes can you see? Instead of using quadrilaterals and 'near' quadrilaterals, ask the children to create a picture using circles and 'near' circles, or another geometric shape. Which creatures might the chosen shapes best represent? The Snail is a very large work of art, almost three metres square. Estimate how big each shape needs to be to create the correct effect. Make a large copy to actually measure and compare with the estimates, then make, say, one tenth scale models of the original.

Use handprints in bright colour to create an image very similar to Matisse's paintings of leaves.

Year 2 children at Bignold Primary School, Norwich, looked at Blue Nude II.

They then took photographs of each other in a chosen pose and turned the photograph into shapes. They then enlarged the shapes and painted them blue, to display with Blue Nude II.

The NCETM microsite [Maximising opportunities for mathematical learning across the primary curriculum] shows how teachers and children at Sir James Wolfe School explored their teaching and learning of mathematics through a cross-curricular approach. Year 5 focused on Matisse, as well as other artists. Their mind map has lots of useful ideas. For example:

- Locate France on a map. How far is it from your school to Paris where Matisse lived (extend to converting miles to km and vice versa)?
- How long would it take to travel to Paris (if I get the Eurostar at 07:12 and it takes 4 ½ hours until arrival at the hotel, what time do I check in etc.)?
- How much would it cost us to get to France (one person, whole class trip etc.)?
- What currency do they use in France?
- How do we know how much things cost in £ from €? Use line graphs to find conversions and calculate conversions from decimal values.

You could use *The Snail* to explore tangrams – for example, identify shapes, calculate area and perimeter. Can we make a copy of *The Snail* by replicating the shapes (including measuring perimeter and angles)?

- use vocabulary associated with shape.
- sort and classify shapes, angles etc.
- extension: ratio and proportion – scaling up image of *The Snail* to make a larger version for display.
- symmetry: use paper-cutting techniques to create symmetrical patterns, extend to two lines of symmetry and/or rotational symmetry where appropriate.

Further information from:

- The Artchive

- Guggenheim Museum
- WebMuseum, Paris
- Pompidou Centre
- Wikipedia.

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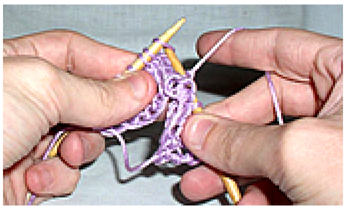
Page header - Henri Matisse photograph from the New York Public Library's Digital Library in the public domain



Focus on…Mathematical Knitting

Mathematics is not usually something associated with knitting, or indeed any textile art for that matter. However, a wide range of mathematical concepts have been used as an inspiration for a range of fibre arts, including quilt making, knitting, cross-stitch, crochet, embroidery and weaving. It is almost impossible to take part in any of these craft activities without using some mathematics: simple counting, repeating patterns and sequences, using symmetrical images… even exploring hyperbolic space!

Dr Daina Taimina is a Latvian mathematician, now an associate professor at Cornell University, New York. She is best known for using crochet to produce objects that illustrate hyperbolic space. Where a sphere has a constant positive curvature (it curves inwards), and a flat table has zero curvature, hyperbolic geometry has negative curvature (curves outwards), similar to a ruffled lettuce leaf or a sea slug. Although the notion of hyperbolic space is extremely complex, Dr Taimina found creating it remarkably simple. She started with a line of crochet, and then for each subsequent line, she increased the number of stitches. For example, adding an extra stitch in the second line for every five stitches in the first. The number of stitches increases at an exponential rate, and the material quickly starts to fold in interesting ways. In the last ten years, Dr Taimina has made over 100 examples of hyperbolic crochet. Her most ambitious model used over three and a half miles of thread! Read more about Dr Taimina's creations in this article from The Times, or even have a look at her Facebook page!

Hyperbolic crotchet photograph by Margaret Wertheim

Creating hyperbolic models may be beyond the reach of the pupils in your class, but there are other ways in which they can explore textile art as well as learning some mathematics. Jenni Stather, a teacher in Newham, 'brings numeracy to life', by sharing her love of knitting with pupils in Key Stage 2. They develop skills of estimation and prediction whilst exploring accurate measurement of time and length. This Teachers TV clip, which she produced, lasts nearly 14 minutes, and includes some inspirational ideas that you can use in the classroom.

Joanna Lewis explores some simple (and some not so simple!) plaiting and weaving that can be carried out in the primary classroom. Show the pupils how to plait with three strands. Does this work with five strands? Can they use the same method with an even number of strands? What might they change in their method to create a braid with an even number of strands? Does the bottom of the braid look the same after moving each strand? How many moves will it take for it to look the same again? What if there is more than one strand of a particular colour? Is there a link between this and the number of strands? Encourage pupils to increase the number of strands and invent their own 'rules' for a new braid. Joanna suggests ways in which pupils might record their ideas, and challenge each other to follow new patterns.

Introduce yourself and the children in your class to the idea of 'Finger Knitting', where needles are not required! Pupils will be engaged in following patterns and counting stitches, as well as measuring the length of their quickly-produced creations. There are many sets of easy-to-follow, online instructions, supported by images or video clips. In the Learning Maths Outside the Classroom microsite, one school discusses their activities for 'Maths Week', and having learnt to finger-knit, the children decided to see if they could knit their way around the school. A remarkable, self-initiated activity encouraging pupils to follow a line of enquiry and practise those using and applying skills!

There are many people out there busily combining the craft world with that of mathematics. Pat Ashforth and Steve Plummer consider themselves 'Matheknitticians', and host the Woolly Thoughts website, where they demonstrate their creations and make patterns available for others to knit their mathematical designs. 'Tilting at Windmills' is a popular design used by many schools through the 'Afghans in Schools' project. The teaching materials are available for download.

In her article Knitting by Numbers, Lucinda Matthews shares her mathematical knitted creations. A scarf made in a pattern depicting a series of permutations possible from three coloured bands, knitted Klein bottles, and several examples of Möbius strips. Möbius strips are, it seems, quite popular with mathematical knitters and several examples can be found online. You could show the children a Möbius strip made from paper (a paper strip, twisted once on itself before the ends are joined). Let them draw a line around the centre of the strip, and watch their surprise as they realise they have to travel twice round the shape before reaching their starting point again. Ask them to predict what might happen if they cut along the line before trying it out. What happens if they cut this strip again? They should get two strips that overlap. With a new Möbius strip, cut around the strip, approximately one third in from the edge. You will travel twice around the loop and result in two separate strips, one the same length as the original band, and another twice the length. Encourage children to try different cuts, or to start with a strip twisted more than once. What happens?

Möbius strip scarf
photograph by Aine D

A final thought…
The units of measurement in textile crafts can provide an interesting, unusual starting point for unit conversion activities. Did you know:

- a 'hank' is a length of seven 'leas' or 840 yards
- a 'bundle' is usually ten pounds
- a 'lea' is a length of 80 threads or 120 yards
- 'denier' is the number that is equivalent to the weight in grams of 9 000 m of a single yarn. So, 15 denier is finer than 30 denier.
- 'tex' is the weight in grams of one kilometre of yarn?

(statistics from UK Hand Knitting Association)

So… happy knitting… and please do get in touch to share your ideas.

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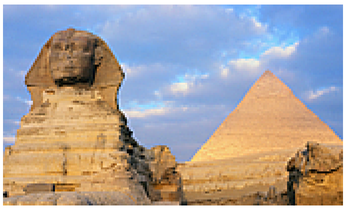

A little bit of history
The Ancient Egyptians

In this article, we are being really cross-curricular and looking at some of the ways that you can link mathematics into a topic of the Ancient Egyptians. If you are looking at this period of history, try some of the ideas. This will mean you can double up on the maths that you do during the day!

However, due to the large amount of ideas and resources, this feature can only be read directly on the portal, otherwise the interactive nature of the way they are presented will be lost.

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Page header - Sphinx and Pyramid photograph from Microsoft Clip Art used with permission of Microsoft

Maths to share – CPD for your school

Proof

One of our roles as teachers is to encourage the children we work with to think mathematically and to enjoy the process of problem solving. To do this, we need to give them plenty of opportunities to think like mathematicians. One of the best ways is to give them experiences in the concept of proof. Far too often, we ask them to accept a statement as true and don't give them a chance to develop their mathematical thinking and to prove it!

A definition of proof would be that it is a convincing demonstration that a mathematical statement is true. Proofs are often obtained from deductive reasoning, and must demonstrate that a statement is true in all cases, without a single exception. Imre Lakatos, a famous philosopher, wrote a book entitled Proofs and Refutations. He wrote this to show that informal mathematics grows by logic. It looks at the differences between counterexamples to a proof and counterexamples to a conjecture. It is worth reading. You can have a preview of it on Amazon.

This article aims to give you ideas to develop for a staff meeting, should you wish to explore the world of proof with your staff.

Starting point

Q

To begin the staff meeting, ask your colleagues what they think proof is.

- what is proof?
- write down what you think is a definition of mathematical proof
- is there a difference between an explanation and a proof?

You could share the explanations offered by the following mathematicians:

- Hersh (1997) offers this explanation:
  "A proof is a conclusive argument that convinces fellow mathematicians…"
- Haylock (2006) suggests,
  "A complete and convincing argument to support the truth of an assertion in mathematics which proceeds logically from the assumptions to the conclusion."
- Mooney et al (2009) suggest that
  "Proof is about making certain our ideas are sound" (p114).

For the National Centre's definition of proof, print out the Mathemapedia entry What is a proof? to share with colleagues.

Pose this statement and ask colleagues to attempt to prove it:

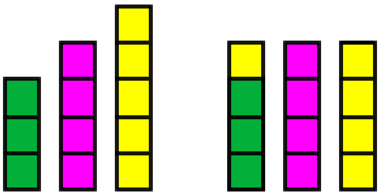
The sum of three consecutive numbers (e.g. 3, 4, 5 or 12, 13, 14) is divisible by 3.

What proof did they offer? Did they offer any?

Together, explore some of the different types of proof, outlined below, for this problem:

Visual proof

Show a model like this and ask colleagues to discuss how this proves that the sum of three consecutive numbers is divisible by three.



The three consecutive numbers are shown by columns of interlocking cubes. As you can see, it is possible to move a cube from the tallest to the shortest so that they are all the same height, the height of the middle cube. So the total number of cubes can be seen to be three times the middle column.

Symbolic proof

3 + 4 + 5 = (4 – 1) + 4 + (4 + 1) therefore 3 x 4

Middle number m: (m – 1) + m + (m + 1) = 3m

Inductive reasoning

1 + 2 + 3 = 6 = 2 x 3
2 + 3 + 4 = 9 = 3 x 3
3 + 4 + 5 = 12 = 4 x 3
4 + 5 + 6 = 15 = 5 x 3
5 + 6 + 7 = 18 = 6 x 3

A good start to inductive reasoning in the primary classroom is to look at a number of instances that seem to have something in common and making a general statement. As you can see above, the 'instances' all lead to the idea that multiplying the middle number in a sequence by three will give the total.

Discuss where proof is positioned in the National Curriculum. Together have a look at the National Curriculum for Mathematics Programmes of Study and see if you can chart the development of proof from the early foundations in Key Stage 1 'explain their methods and reasoning when solving problems involving number and data' to Key Stage 3 'be aware of the strength of empirical evidence and appreciate the difference between evidence and proof'.

What mathematical language did you notice is related to 'finding proof'?

Staff also need to be aware of:

Deductive Proof: reasoning based on logical step-by-step deduction or, in the case of algebra, doing some algebraic manipulation and showing a commonality. In the case above, you could find out if the totals are all multiples of three and therefore reason that all multiples of three can be made by three consecutive numbers with the multiple being the middle number.

Disproof by counter example: a specific instance that shows a generalisation to be false. As there is no counter example to the example we have looked at, we will look more closely at examples of this later.

Proof by exhaustion: a method of proving a generalisation by checking every single case to which it applies. In the example of the consecutive numbers, on proving this is true with consecutive integers, you could explore consecutive multiples of ten and one hundred, decimal numbers. Does your proof work with these?

Q Why do we need to know about proof if it is not taught explicitly in the primary age phase?

It is argued that proof should not be the preserve of mathematics at secondary school. The mathematical thinking of pupils in the primary age phase should lay the foundations for proof. This would include justifying and explaining their solutions, namely informal proofs. Indeed, proof in primary schools may take the form of explanations of number properties and patterns using diagrams and pictures. It is important that they develop the skills necessary for them to be prepared to justify in their own way and not simply follow the teacher's lead.

The use of general statements as a starting point for reasoning, explaining and justifying, is a good foundation for the understanding of proof.

You could work through some of these 'sometimes, always, never' statements with colleagues and then suggest they try them out with the children in their classes, observing closely how they explain and justify their reasoning. As you do, consider what you can do to support their understanding.

In the classroom, it would be a useful exercise to give the children opportunities to generate their own general statements based on various types of explorations of proof as set out above e.g. inductive reasoning, exhaustion. 'Sometimes' statements are a good example of finding counterexamples, as they will need to do this if the statement cannot be proved.

Year 1
All 3D shapes have at least four faces.
When you add two numbers, you can change the order of the numbers and the answer will be the same.
When you add ten to a number, the new number will be a multiple of ten.

Year 2
When you subtract two numbers, you can change the order of the numbers and the answer will be the same.
You can add nine to a number by adding ten and subtracting one.
When you fold a square in half you get a triangle.

Year 3
A hexagon always has six sides of equal length.
Any odd number is one more than an even number.
When you add two numbers together you will get an even number.

Year 4
When you multiply two numbers you will always get a bigger number.
The sum of three numbers is always odd.
Squares have two diagonals which meet at right angles.

Year 5
Multiplying a number always makes it bigger.
If you add a number to five, your answer will always be more than five.
The number of lines of reflective symmetry in a regular polygon is equal to the number of sides of the polygon.

Year 6
A square number has an even number of factors.
Dividing a whole number by half makes the answer twice as big.
When you cut off a piece of a shape you reduce its area and perimeter.

On the National Centre's microsite, What makes a good resource, you will find more 'sometimes, always, never' statements that you might wish to explore with older children.

During the initial stages of learning about proof, logical reasoning should be used to convince a friend of the solution. Effective questions can support children's development in explaining, reasoning and justifying.
These prompting and probing questions are from the National Strategies' Mathematical Vocabulary Booklet:

- how did you get your answer?
- can you describe your method/pattern/rule to us all?
- can you explain why it works?
- what could you try next?
- would it work with different numbers?
- what if you had started with… rather than…?
- what if you could only use…?
- is it a reasonable answer/result? What makes you say so?
- how did you check it?

Why not provide prompt cards so that children can support each other?

Problem solving is at the heart of mathematics. Proof is important at all stages of mathematics education. It includes developing techniques that are used to convince others that mathematical ideas are valid. Early foundation for proof in primary school should mean that pupils are encouraged to explain and justify their reasoning.

Take a look at the fascinating online discussion about proof that took place in 2008, Teaching and learning mathematical proof: Discussion.

Also the Maths Knowledge Network: Starting point proof.

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ICT in the Classroom – Digital cameras and mathematics outside the classroom

In Issue 26 of the Primary Magazine, we challenged you to find 10 things to photograph over the summer holidays in a mathematical scavenger hunt:

Mathematical Scavenger Hunt

- parallel lines
- a right angle
- a picture to go with the number '5'
- an object where you can see one line of symmetry
- an object with rotational symmetry
- a repeating pattern
- an object that weighs more than a ruler, but less than a shoe
- an object approximately one metre tall
- a ratio of 3 to 1
- a picture that shows that 2 x 3 = 6

This time we explore the possibilities of children using digital cameras in a similar way, as a vehicle to consolidate their understanding of mathematical concepts and develop reasoning skills. Collecting mathematical photographs outside the classroom incorporates physical activity, unusual locations, and images 'owned' by pupils, which should support memory recall of the mathematics involved. It gives children opportunities to use and discuss mathematical vocabulary purposefully.

On a mathematical scavenger hunt, children can be challenged to collect pictures to go with any strand of mathematics that is relevant to their learning. The example here is of a hunt that covers a variety of strands at different levels, and could be used a 'one-off' reinforcement or enrichment activity, or where the focus is on developing reasoning. A scavenger hunt on a particular mathematical area is very useful for starting a unit of work as it lends itself to reviewing previous learning and informal assessment, and provides pictures that can be referred to throughout the unit.

Give scavenger hunt lists to small groups or pairs of children and allow some time before they start collecting photographs for them to discuss where they might find matching images, and clarify any unfamiliar language. With younger children give the list verbally, one or two items at a time.

For some pictures, you might ask children to include some way of proving that the photograph matches the statement on the hunt. For example, "An object approximately one metre tall" might not look one metre tall in the picture, so the group will have to either justify why it does match the criteria, or photograph something next to the object to get a sense of scale.

Some practical considerations before starting the scavenger hunt outside of the classroom

Ensure all children and additional adults know about keeping safe, consideration for others around the school, time limits, how to work the cameras.

These pictures were all taken by groups of children to match items on the Scavenger Hunt example above.

Match each picture to one or more of the items on the scavenger hunt list. Consider what you could say to prove that the picture matches the item.

Once children have collected their pictures, upload them to be displayed on an interactive whiteboard. Each group can challenge the others to decide which statement they were matching. They discuss and decide which list item is depicted in the photo and why. Probably, some of the images will fulfil the criteria for more than one statement and this will allow children to debate different mathematical aspects of the picture, and the IWB enables the pictures to be annotated to support the argument. Reasoning can be a difficult task for children and you may want to display some choices of sentence stems to assist them in putting their thoughts into words, such as:

> "I think ... because ..."
> "I know ... so I know that ..."
> "I (dis)agree because ..."
> "It reminded me of ... so ..."

Reflection and CPD

The recently published report Mathematics and Digital Technologies - New Beginnings included in its analysis the assertions that the primary mathematics teacher should be able to use digital technologies to:

> *create, collect and use mathematical photographs and videos by storing them in IWB files for efficient use in lessons*

and:

take learners outside to investigate contexts outside the classroom in which mathematical learning can take place, as well as collect evidence that can be used back in the classroom to help solve a particular problem or to create a mathematics trail for parents or other learners.

Consider how these aspects of the use of digital technologies in mathematics lessons might impact on children's learning and appreciation of the subject. Discuss with a colleague how this could be developed in your setting. You could make a plan to trial developing the use of mathematical photographs, or the outside area, and assess the outcomes.

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