YOUNG MINDS BIG MATHS №1

Ramp play

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Child-led exploration of maths through ramp play in early years settings

About this book

Children are often drawn to roll things down ramps. This book will help you to see the rich and varied mathematics they might encounter during their ramp play, and so to support and extend their mathematical explorations.

We've organised it into loose mathematical themes, so that similar ideas are together. (Of course, these ideas could also arise from, or lead to, other kinds of play.) This isn't intended as a step-by-step guide to ramps, but rather to equip you to support the children in your setting as they ask their own mathematical questions and make their own discoveries.

We'd love to hear about ramp play in your setting, and how you've used this book. You can give feedback and download the book as a free pdf from the website, **youngmindsbigmaths.co.uk**, or share your own ramp play stories with the hashtag **#YMBMrampplay**.

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Ramp play

This book started from observations of children's play, and the discussions they prompted between early years practitioners and university mathematicians.

The pictures, stories and quotes come from many different children, all aged 3 or 4, over three years, as they engaged in ramp play throughout their time in nursery. Some children played with the ramps most days for weeks at a time, while others dipped in and out.

As the children played in a purposeful way, they encountered many important mathematical ideas, extending well beyond the early years curriculum.

Practitioner reflections

In the green boxes, the practitioners who led the ramps project reflect on the children's play in the light of their wider experience.

The maths inside

In the blue boxes, university mathematicians discuss the deep mathematical ideas that the children are encountering.

Mathematical development

In the yellow boxes, we focus on the children's mathematical thinking and development.

Mathematical language

In the red boxes, we provide words – some familiar, some more technical – you might use with the children as they explore the ideas.

How can practitioners support ramp play?

Provide materials – offer a variety of versatile objects and materials to use in ramp play.

Observe – recognise and acknowledge children's ideas.

Introduce new vocabulary – use words when they become relevant to the children's explorations.

Encourage inquiry by asking open-ended questions, for example, 'what do you think will happen if we change the height of the ramp?'

Scaffold learning – extend children's interests from prior learning and introduce challenges to deepen their learning.

A focus on **building ramps**

The children tested out their ideas by independently designing, building and adapting ramps. They were given autonomy to adapt and re-adapt their structures, enabling them to solve problems and deepen their understanding.

‘I put a wooden plank on this. Only put one end up like this.’

‘It just dropped – it didn’t work.’

MATHEMATICAL DEVELOPMENT

Building ramps

Building a ramp requires a huge amount of mathematical thought. Objects must be put in the right position relative to one another (one end must be higher), and everything must remain stable even when something travels down it.

On this page we see a barrier made of blocks to keep the pumpkin on track.

To the right the girl has bent up the outer edge of her ramp, to guide a rolling object round the curve and stop it falling off.

Mathematical language

On, next to, beside, between, behind, above, below, high, low, over, under, position, balance, stable, long, short, wide, narrow.

‘Can I make a ramp with this cardboard?’

Children can set themselves their own challenges. Their own motivations give them a ‘can-do’ attitude.

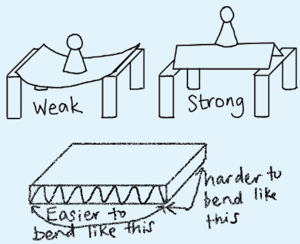
This child has envisioned a ramp, and a curved ramp at that. She shows an awareness of different shapes, different slopes and properties of materials, making use of the bendiness of cardboard. She selects items by their shape and then uses tools to achieve her intended outcome.

THE MATHS INSIDE

Corrugated cardboard

If you have bent something one way, it’s then much harder to bend it the other way. This extra strength is used for making bridges. Corrugated cardboard has a middle layer which is already bent back and forth: you can see this ‘wiggly’ layer at the edge. So, it’s easy to make a new bend parallel to the wiggle ridges, but harder to make one across the wiggles.

It’s useful to think about this when building with cardboard: do you want it to bend, or stay flat?



Practitioner reflections

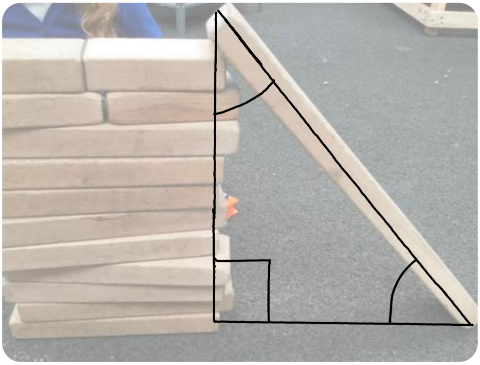
Cardboard is a material rich in possibilities for open-ended play. Having a range of cardboard that children can manipulate and construct with allows children to create arches, ramps and enclosures. Using trial and error they can adapt their shapes to fit together and function as planned, practising a key aspect of spatial reasoning.

A focus on **slopes and angles**

'I can see an angle in there. See that bit there, that's an angle.'

Angles are not something that practitioners often find themselves discussing with young children. However, we have been amazed at how naturally children can explore and think about the many aspects of angles.

We heard children daily describing the angles they could see as they constructed their ramps, and especially the angles at the top and bottom of their ramps. Before long, angles were being talked about at home and in school and this mathematical language became fully embedded and embraced.



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Angles in ramps

A straight ramp is the long side of a right-angled triangle. The support (vertical side) and the floor (horizontal side) meet in a right angle (see p8). Sometimes (like in the photo to the right, where the ramp isn't resting on the floor) you might have to imagine a side.

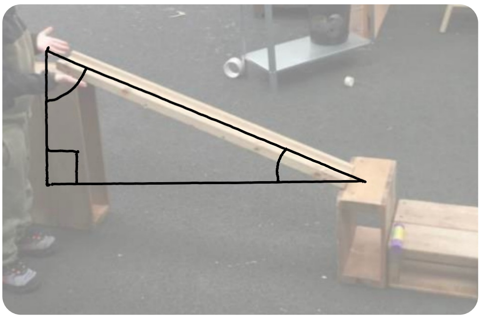
Mathematicians would usually talk about the angle between the floor and the ramp, but we found that the children tended to focus on the 'top' angle, between the ramp and the support. Either is fine!

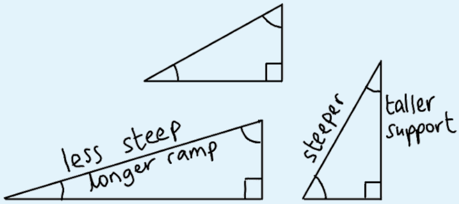
THE MATHS INSIDE

What is an angle?

When two lines meet, they make an **angle**. The size of the angle is about how far around we have to go from one line to the other. Below, the angle on the right is bigger than the one on the left.

We put a little curved line in the angle (or make a square for a right angle, see p8), to show that we're interested in it.





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Changing the slope

The sides and angles of a triangle are all connected, and we saw this when the children changed their ramps.

If we use the same plank to make a steeper ramp, the vertical side of the triangle gets longer (we need a taller support) and the horizontal side gets shorter.

Alternatively, we could rest a longer plank on the same support, to get a less steep ramp.

In either case, the angles also change (this is what 'trigonometry' is all about). The children usually noticed that the angle at the top gets smaller when you make the ramp steeper.

'It's gone little up the top now when I move the ramp up, the acute angle that's just small.'

Practitioner reflections

When exploring angles with children, gradually introduce the new words into the conversation. Encourage the use of these words across many different contexts, so children can link their ramp play with the rest of their world.

With time and opportunities, they will develop fluency in the subject language, using it to express and debate many ideas.

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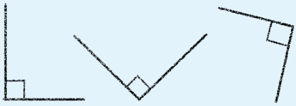
Comparing angles

The most familiar angle, easy to find in the real world, is the **right angle**. The corners of most windows, doors, and pieces of paper are right angles. Squares and rectangles have right-angled corners:



Angles smaller (sharper, ‘pointier’) than a right angle are called **acute**:

Angles larger (blunter) than a right angle are called **obtuse:**

We can compare angles by fitting them on top of each other. It is less easy, but interesting, to find acute or obtuse angles in the real world. A ramp triangle (like on p6) has one right angle and two acute angles.

‘I know, we can make an acute angle too, look, like this with the sticks.’

MATHEMATICAL DEVELOPMENT

Angles: the lengths don’t matter

The size of an angle is about how sharp or blunt it is: the lengths of its two lines don’t matter.

We can have same-sized angles with different lengths of line:

Or different-sized angles with the same length of line:

Many children don’t understand this until they are at secondary school.

‘Well, I don’t see a right angle; it’s more like an acute angle.’

THE MATHS INSIDE

3D or 2D?

In this section we've been talking about a ramp as part of a triangle, but really the ramp set-up is 3D and a triangle is 2D.

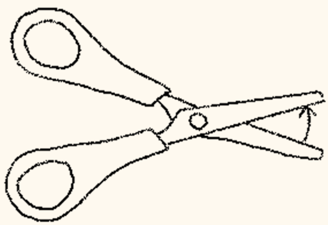
Of course, a photo of the ramp is 2D, and if it's taken from the right direction we can see the triangle clearly. Most ramps are the same all the way across, so this doesn't really lose any information.

We'll think like this again later when we focus on the object being sent down the ramp.

MATHEMATICAL DEVELOPMENT

Changing angles

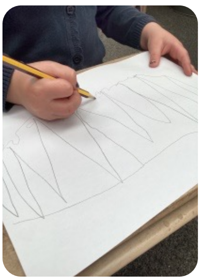
To see how the size of the angle can change with the same length of lines, it is interesting to look at things that can change angles, like books, doors, scissors, folded card, pairs of sticks or even legs.



This idea, that an angle can describe turning, rather than a (fixed) corner, is quite advanced, and often difficult even for much older children.

'I'm laying them [the planks] down. The point is at the top: sometimes it's a little point but if I move the planks out it goes bigger. I can make it go bigger and smaller by moving the planks in and out. Watch me do it!'

'This is the design of how I want to make the angles work.'



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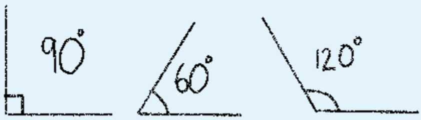
Numbers for angles

At school, and in science and engineering, angles are measured in degrees (written with a little circle). A right angle is 90°, so for example a 60° angle is acute, and a 120° angle is obtuse.



These numbers are larger than most 3- or 4-year-olds have met, so mostly children will just describe angles as right, acute or obtuse, or compare them as larger or smaller. But a keen child might be intrigued by such big numbers, and try measuring angles with a protractor.

Some girls find another way to talk about angles using numbers.

‘I can make a whole cake with all the slices.’

‘Three slices is half a cake.’

Practitioner reflections

By drawing diagrams children can explore shape, position, orientation and number. This helps them to make personal sense of mathematical concepts, in this case slopes.

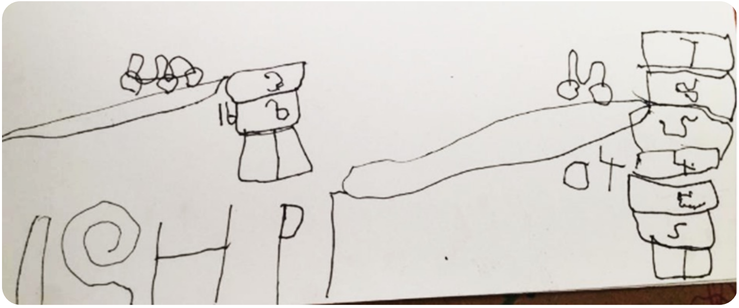
THE MATHS INSIDE

Diagrams

Mathematicians often draw diagrams when they’re trying to solve problems. Sometimes (like with the girl on the next page) it might represent a plan, sometimes it might clarify an idea (we’ve done this a lot in this section), or sometimes it might show a mathematical object. We were excited to see that the children often want to represent their ideas this way too.

Mathematical language

Angle, right angle, acute, obtuse, triangle, tilt, flat, steep, vertical, horizontal, lower than, higher than, longer than, shorter than.



'The low ramp has 3 bricks, and the big ramp has 7 blocks. It had a point at the top. The low ramp had a little point.'

While a group of children are exploring the idea of slopes, one child takes herself away to capture her thoughts using mathematical graphics.

Her drawing above shows two ramps, each supported by a different number of blocks. After drawing this plan, she goes on to build the ramps shown to the right. She is keen to talk about the heights and angles of the two ramps.

MATHEMATICAL DEVELOPMENT

An ambitious technical drawing

In her plan (in the photo above), the girl has labelled the blocks with quite recognisable numbers, in the right order. Once the ramps were made, she used the yellow ruler to find the height in centimetres. She added these two-digit numbers to her diagrams, although she doesn't yet know about the places for tens and ones, and writes 04 for 40.

In her diagram, neither ramp reaches ground level, and both have the same slope. Children of this age (and older) find it much harder to draw sloping lines than vertical or horizontal ones. The top of the taller ramp is drawn 5 blocks up, not 7; the tall ramp in the photo is actually 10 blocks up. She says the lower ramp has a little point at the top, though in fact it's a larger angle. Perhaps she means that it is lower down, or less pointy?

Although she can't yet get everything right, the work and thought that she has put into planning and recording her constructions is remarkable.

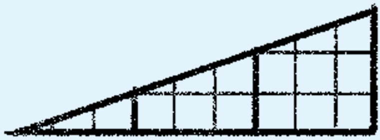
'The biggest ramp was the biggest number. Four and a zero, it was high up, an acute angle.'

THE MATHS INSIDE

Numbers for steepness

In the picture, the slope goes:

- 1 square up for 3 along, or
- 2 squares up for 6 along, or
- 3 squares up for 9 along.



Any one of these tells you how steep the ramp is. They could also describe ramps of three different sizes but with the same slope.

(Older children are taught that 1 to 3, 2 to 6, and 3 to 9 are all the same 'ratio'.)

The children balance a wooden plank across some blocks and immediately begin moving objects along. The practitioner prompts them to consider the slope of the plank, by asking gentle questions like
'What do you think will happen if we raise this end?'
'Can you make it go slower? How?'
As the children tilt the plank at various angles, there are lots of thoughtful conversations. The children experiment by resting the plank on lots of different supports at different heights.

A focus on **speed and distance**

Children often explored the connection between ramps and speed. As they sent an object down a ramp they would often comment on its speed.

With children who had been engaged in ramp play for some time, the practitioners could pose questions like:

'Does the height of a ramp affect speed?'

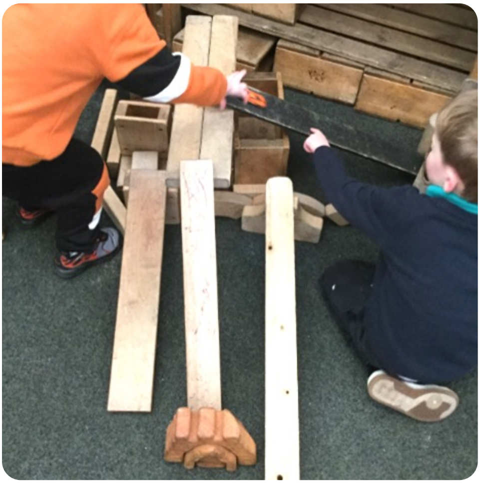
'Does the length of the ramp make a difference to the speed?'

Extending their discoveries, children investigated the effect on speed as the features of the ramp changed.

Practitioner reflections

For children to be able to explore the concept of speed fully they need access to a range of objects and materials (see p34 for some ideas).

Children often compare the speeds of objects as they go down ramps, noticing which travel faster or slower, and discussing why. This is a natural opportunity for the use of mathematical language.



↑ **'The black ramp is high like I did before so that's why they are going fast.'**

'Watch this car – the really long one is slow for me as well at the end like his, but I can make the car go faster if I lift it up, so it goes steep.'

THE MATHS INSIDE

Mathematical models

Models are simplified versions of reality. We're used to physical models, like a scale model of a building or a model railway. However, a **mathematical model** captures how **variables** (numbers that describe the situation) relate to one another.

We all build models in our head – if you're planning a car journey you estimate your travel time by combining the relevant variables: distance, speed limit, time of day (rush hour?). Your satnav does this more precisely, by using more variables and complicated equations.

In the same way, the children are thinking mathematically about variables like the length and ramp angle to predict the speed of travel.

MATHEMATICAL DEVELOPMENT

From seeing to certainty

Much of maths (and science) is about finding patterns, or relationships, in what happens. For example, at first a child might just say:

That ramp is steep. The car is going down fast.

But after plenty more ramp play, they might make a general statement:

When the ramp is steep, the car goes fast.

They might use their experience to make predictions:

If the ramp is steep, then the car will go fast.

Or to explain events:

The car went fast because the ramp is steep.

Words like **'if … then'** and **'because'** are the crucial links in logical (and mathematical, or scientific) argument. They can even be used to build up a longer argument: If I make this end higher, so the ramp is steeper, then the car will go faster, and because of that it will go further across the floor.

There are examples of these sorts of reasoning statement throughout the book.

'This is just a little one. The car hasn't gone really fast, just a little bit fast.'

'It's gone faster now. That's because I moved it – I moved it up.'

‘I’ve made this ramp a flat one. It’s long but when I put my car on it, I have to push it to make it go. I can make the ramp like a hill and my car will go down itself.’

THE MATHS INSIDE

The flat ramp

Mathematicians love thinking about what happens **in the limit**, when you push an idea as far as it will go.

In this case, the ‘flat ramp’ is the limit as the ramp gets less and less steep. The ramp triangle has collapsed into a horizontal line!

We weren’t really sure if it was a ramp or not, and we nicknamed it the ‘zero ramp’.

‘I was right, look! It’s going itself down the hill!’

‘When it’s a really little acute angle the cars are even faster.’

MATHEMATICAL DEVELOPMENT

Watch this!

After using their reasoning skills to understand the connection between how the ramp is set up, and how fast or far the object travels, the children would often exclaim ‘**Watch this!**’ **‘Look!’**

They are confident in their understanding, and they want to share it with someone. Especially if they have had the freedom to ask their own questions, they feel an ownership over their discoveries.

THE MATHS INSIDE

The ‘infinity’ ramp

Taking ideas ‘to the limit’ again, the opposite to the ‘zero ramp’ would be the ‘infinity ramp’: as steep as possible, with the triangle collapsed into a **vertical** line. Anything sent down it would be simply falling.

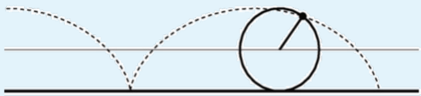
This boy’s ramp is almost vertical. An object goes down very fast, but almost all its motion is vertical, so it lands at the bottom with a crash and doesn’t travel far on the ground.

So, speed on the ramp is important for distance on the ground, but it’s not the only factor.

THE MATHS INSIDE

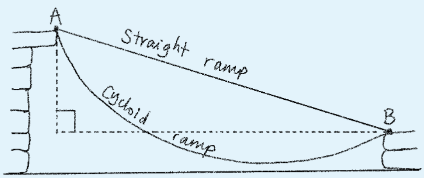
The perfect ramp

In 1696, the Swiss mathematician Johann Bernoulli posed a question to the mathematical community. He wondered what ramp shape would allow an object to get from one point to another in the shortest time. The next year, English mathematician Isaac Newton responded with the answer: the shape is part of a curve called a cycloid, which is the shape traced by a point on a circle as it rolls along.



The shape was given the name **brachistochrone curve**, which means ‘shortest time’.

We think it would be possible, with something flexible like cardboard, to create a ramp of this sort of shape, so you can test Newton’s theory!



‘When it goes really fast it crashes at the bottom!’

One child asks:

‘Does the highness of the ramp make it go far away or not?’

This wonderful question opens a new avenue for children to explore. The higher the start of the ramp, the steeper the ramp is and the further (the children propose) an object will travel after rolling down the ramp.

The children spend some time testing this theory before another child poses a further question:

‘How do we know how far it goes?’

Then, extending their learning, they feel the need to measure and record the distance travelled. The children choose their own units of measurement, using numbers to label the distances. One child uses her footsteps to measure the distance the car has travelled, and she tells the group:

‘I am the measurer cos it’s my shoes, not yours. Your shoes are different.’

Practitioner reflections

It is crucial to ensure we give children time, time to explore, make decisions informed by their reasoning, and explain their thinking.

Investigating distances in the real world requires measurement and prompts comparisons.

THE MATHS INSIDE

What to measure?

The children were interested in how fast the objects were travelling down the ramp, but this is really hard to measure, or even compare – everything is over in a matter of moments.

We suggested instead thinking about how far the objects travelled along the floor, since the final resting position is much easier to measure. This isn’t directly related to speed – an object could go very fast down the ramp but stop quickly at the bottom because of a thick carpet, for example – but it gives the children an easier way to measure and compare ramps.

Mathematical language

Fast(er), slow(er), long(er), short(er), high(er), low(er), motion, movement, increase, decrease.

A focus on measuring and recording

During their ramp play the children were rolling many different items and making lots of comparisons when one child asked a question:

'How far does the car go?'

We discussed this question together and the children decided to use long paper to mark the distances. Recording this measurement became a big part of children's everyday explorations with ramps. This linked ramp play to early data handling skills.

Practitioner reflections

Through ramp play children can be encouraged to record their observations, and to interpret and analyse this data. Children can share their findings and interpretations with those around them. This in turn encourages others to conduct their own ramp experiments. All the data they have gathered becomes available for the learning community, leading to rich discussions among the children.

THE MATHS INSIDE

A desire for data

After a while, the children weren't satisfied by describing what was happening and making verbal comparisons: they wanted precise measurements.

Data is the name for observations like this. Often data is numbers (distances, times, counts etc) but it can be other things (colours, type of animal, place). Statisticians use data to answer questions.

MATHEMATICAL DEVELOPMENT

How to measure?

Lots of the ways the children find to record the distances travelled might seem a bit questionable to an adult – using a shoe or handmade ruler as a unit of measurement, or having the number get smaller as the car travels further.

Educators can introduce standard units (eg centimetres) and tools (eg a tape measure), if it feels appropriate.

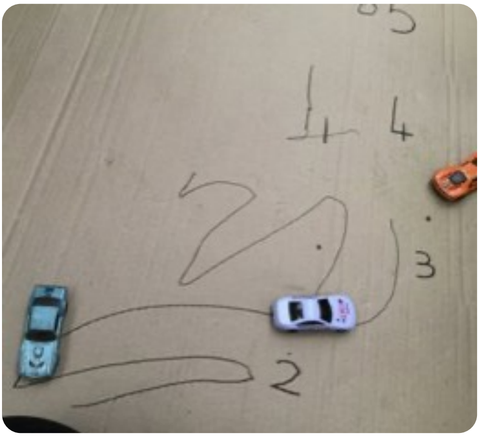
But using their own methods, the children are already thinking mathematically, finding ways to be precise and working together to gather data so that they can answer their own questions.

MATHEMATICAL DEVELOPMENT

Writing numbers

This is a challenge for the children, but they often take it on. Here, their numbers are recognisable (in the bottom photo the 3 has more curves than the 2) but not quite standard. To help all the children learn the correct form, the practitioner has written the number clearly beside the child's attempt.

But it's very important that the child's attempts are also still on the paper, valued and respected. The practitioner could say **'This is how I write a 2'**, or **'The 2 up on the wall there looks like this'**.



The children write numbers on cardboard, so that they can then record how far each car travelled.

'This car went far on the shiny ramp – all the way to 4.'

Mathematical language

Measure, record, track, distance, observe, data, information, variation.

Practitioner reflections

When children are motivated to write things down, they expand their repertoire of communication skills. This is especially valuable learning for the children who wouldn't readily turn to written communication during their play.

In this context, writing has real meaning and purpose for the children, and they see that it can also be mathematical.

“I want to make a ruler!”

One child sends a car down a ramp. He has made a ‘ruler’ to measure the distance the car travels on the floor once it reaches the bottom of the ramp. But the ruler isn’t long enough; the car has gone much further. He realises he’ll need to measure the distance in rulers!

Another child is watching closely and steps in with a piece of wood. Silently he places it at the end of the ruler to mark the position so that the first child knows where to place the ruler the next time.

“Ruler, wood, ruler, wood.”

A sequence emerges, with the boys counting aloud each time the wood jumps over the ruler, to see how many rulers the car has travelled. Soon, this turns into a game that many friends want to join.

Practitioner reflections

As a result of their problem-solving during ramp play, the children encountered a repeating pattern. Their chanting of the sequence was both meaningful and playful, as they enjoyed the pattern together.

When a generally abstract mathematical concept, such as repeating patterns, appears like this during play, children will not only understand it, they will also feel a certain pride of ownership: it is *their* idea!

MATHEMATICAL DEVELOPMENT

Measuring with memories

Let's say the car travels five times the length of the homemade 'ruler'. It would be easy to show this if the boy had five rulers, but he only has one, so he places it five times. Instead of counting rulers, he counts his actions of placing it, just as the girl counts her footsteps when measuring with her shoes. You might also say that he leaves behind 'memories' of a ruler, to cover the whole distance.

This is already quite an abstract idea for this age. But he also knows that the places for the ruler must fit together just right. If they overlap, or leave gaps, then he won't have a true measurement. The second boy, watching, knows this too. So he uses a stick to show the position of the end of the ruler. Then the first boy can put the start of the ruler there for the next placement. Their shared understanding, and teamwork, is very impressive.

THE MATHS INSIDE

A surprise pattern

While keeping track of how many ruler-lengths they had measured, these children notice a repeating pattern: ruler, wood, ruler, wood.

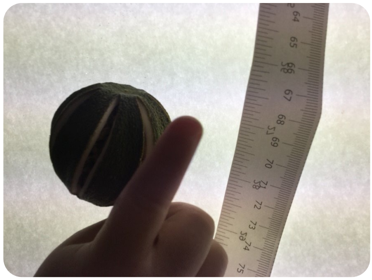
There are lots of repeating patterns that happen in daily life, for example taking turns (Molly, Isla, Molly, Isla, …) or setting a table (knife, fork, cup, knife, fork, cup, …).

MATHEMATICAL DEVELOPMENT

Working precisely

We see the children being very concerned about precision while collecting their data. For example, the same shoe must be used or else the results won't be consistent, and a boy steps in to help his friend make sure his ruler-lengths line up properly.

High-quality data is crucial when you care about the question you're investigating!

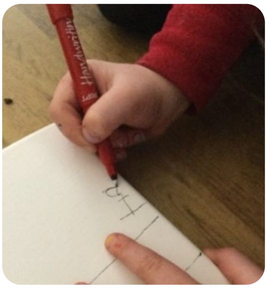


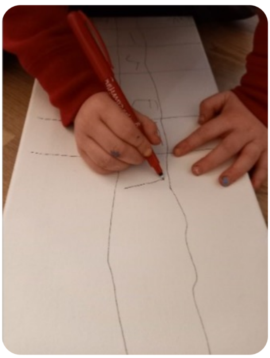
Two girls have built ramps from acrylic shapes over a lightbox. They roll a dried orange down the ramps, and begin to measure the distance using a tape measure, with help from the practitioner.

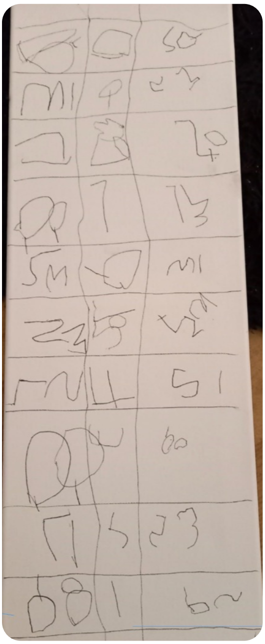
The practitioner wonders if the girls might be able to work together to record their findings. She gives them a large sheet of paper, which they decide to divide into columns using vertical lines – one column for each girl's measurements, and a central column numbering the rolls from 1 (in the bottom row) to 10.

They take turns to roll the object, measure how far it travels, and record it in the table, making observations as they do so.

'Look, 6 and 6 and then 6 and 6 again – that is two times the same!'
'Them are all big numbers, aren't they'
'It travels a long way all the time.'







THE MATHS INSIDE

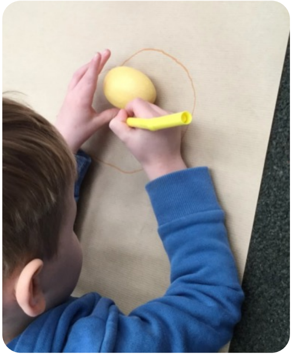
Recording data

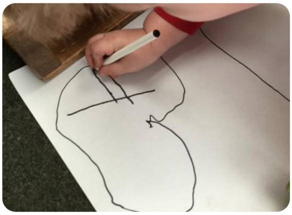
Taking measurements is one thing, but if we want to use data to learn about the world it's useful to record it in a way that lets us see it all at once. **Tables** are a great way to do this, and are used to store (almost) every dataset there is. It doesn't matter that they fill the table from bottom to top, or that the 'ID' column is in the middle – this table has all the information you would need to begin a proper statistical analysis.

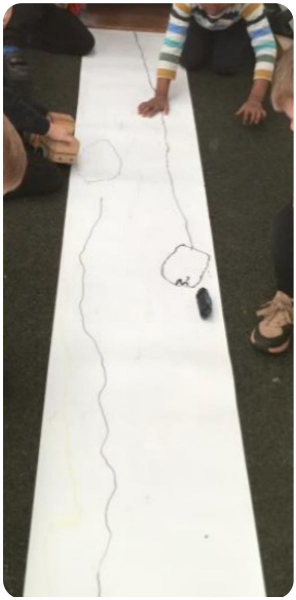
A popular system for recording the distance travelled by each object is to draw an outline of each object in its resting place. Sometimes they draw a line to the object as well.

This prompts the children to think about variation (will similar objects rolled in the same way travel *exactly* the same distance?) and to compare ramp setups. Sometimes it generates friendly competition, as the children try to get their object to roll the furthest.

One boy decides to label each outline with the initial of the child who rolled it, to help keep track.







THE MATHS INSIDE

Variation

If you roll the same object down the same ramp lots of times and record the distance it rolls each time, the results will be close but not exactly the same. There are lots of reasons for this, from slight changes in how the experiment was performed to slight errors in measurement.

Statisticians call this **variation**. Even the best scientists have some variation in their measurements.

‘The rectangles are nearly next to each other!’

A focus on **comparisons and fair tests**

To build on the children's fascination with speed, we provided some equal lengths of guttering covered in different materials.

We hoped to challenge the children to consider the question

'How does the surface of a ramp affect the speed?'

The children made some hypotheses (see 'hypotheses and laws') before testing out their predictions. They used their findings to compare how different surfaces can affect the speed of objects travelling down the ramp.

Children articulated their own discoveries:

'The sparkly ones made the cars go fast but the bubble wrap was faster, I thought the bubbles would make it slow.'

THE MATHS INSIDE

Hypotheses and laws

When scientists think an idea *might* be true, but they aren't sure yet, they call it a **hypothesis**, and do more experiments, or collect more data. Sometimes, eventually, they decide it definitely *is* true, and then they might call it a **law**. But every law starts out as a hypothesis.

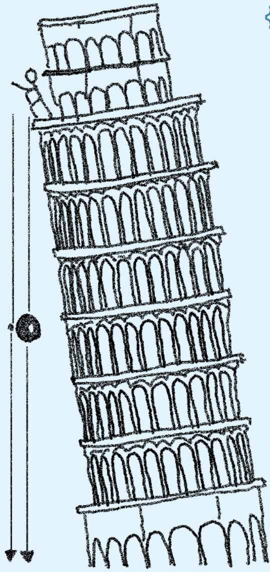
The children make lots of hypotheses: Round things roll, square things don't? Light things go down faster than heavy things? Some might be true, others might not – that doesn't matter at this stage! By making hypotheses, and then devising experiments to test them, the children are doing real science.

THE MATHS INSIDE

A famous experiment

For a long time, scientists thought that heavy objects fell faster than lighter objects. Galileo didn't agree with them, and devised an experiment to prove them wrong. In around 1589, he dropped two objects, one heavy and one light, from the top of the Leaning Tower of Pisa, and observed that both fell at exactly the same speed. Although gravity has a stronger pull on heavier objects, it takes more force to move them, and these effects cancel out. By keeping every variable apart from weight the same, Galileo showed that his hypothesis was correct.

A complication is air resistance, which causes lighter things with a big surface area (feathers, parachutes, pieces of paper etc) to fall slowly. Galileo minimised this issue by using two objects of the same shape.

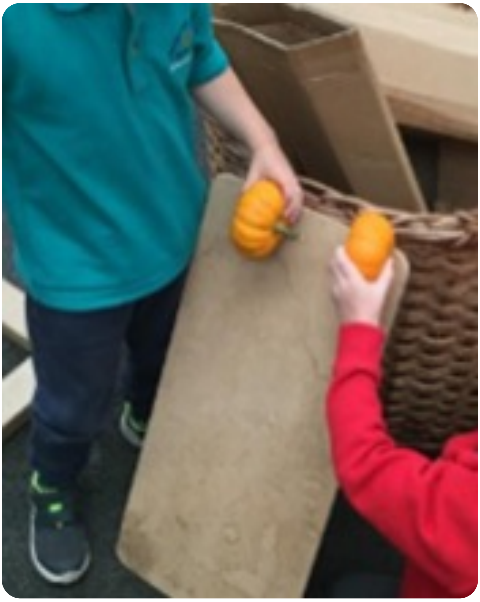


'1-2-3-4-5 *GO!*'

'Sometimes the purple was the winner, but once, the bubble wrap was the same number. Number 3 they both landed on.'

Mathematical language

Fair, unfair, change, control, same, different, identical, variable, results, compare, hypothesis, equal, cause.



Two boys are rolling small pumpkins down a ramp. They each have a pumpkin, and they want to know which will roll faster, so the challenge is to make this a fair test. The boys roll the pumpkins several times before agreeing it's not fair if they are released at different times. The answer to their problem is

'Let's ask Mrita to count down for us to go and then we can let go.'

The supporting adult joins their play, helping them to achieve 'fairness'. The boys make their predictions before proceeding with their experiment. Many conversations follow about fair tests and how can we ensure, when comparing any variables, that we conduct a fair test.

Practitioner reflections

As they investigate the effects of changing various aspects of their ramp setups, the children instinctively grasp the need for fair tests.

To make a test fair, the children must identify clearly the one variable that they are focusing on, and then vary that while keeping everything else the same. Then, when comparing their results, they can see clearly the effect of that one variable.

When tests are fair, and measurements are accurately and precisely recorded, children can draw conclusions from both differences and similarities in their data.

THE MATHS INSIDE

Fair experiments in the world

Showing beyond doubt that one thing *causes* another is not simple.

Experiments are used to approach this problem. One example is clinical trials. In a clinical trial, the people in one group are given a new treatment and those in the other (the 'control group') are given a placebo (pretend treatment). The groups should be as similar as possible. Nobody should know which group they are in, and everyone should be treated the same. This all helps make it a fair test, so that any difference in outcome must be down to the new treatment.

‘These look all different – a black one, a really long one – these two look the same size but I think this one is bigger this way [width]. I don’t know if the cars will be fast on all of these ramps.’

THE MATHS INSIDE

Choosing what to compare

There are lots of decisions to make when building and experimenting with a ramp – what the ramp is made of (and its length, width, surface etc), how high you put the top of the ramp, what object you roll down it. These are some of the **variables** (see p13). Any of these variables could affect the speed of the object, or the distance it travels along the ground.

If you discover that a variable is important, it might make you update your **mathematical model** of ramps!

‘It will be a race to see how things roll fast – I don’t know what will be the fastest!’

‘The big ramp will be faster, I think. It was faster because it’s high up, the car was even more faster than the other one. I know how to make it so the ramps can be high or low.’

‘If I put more blocks on it, the ramp will be high so the cars will be faster; but if I take some blocks away so the ramp is low then the car won’t go very fast.’

MATHEMATICAL DEVELOPMENT

The unpredictable!

Sometimes when scientists devise an experiment they are confident about what will happen, but not always. The children were often motivated by *not knowing* which ball would roll furthest or whether something would be fast or slow. This is a great opportunity to think about the variables (angle, length, weight of object etc), and to make hypotheses.

Don’t worry if you don’t know what will happen either – that’s part of the fun.

A focus on **moving down a ramp**

Children naturally try out their ideas, experimenting with differently shaped objects.

'My cuboid is sliding, not rolling – I think I know why – it's because it is not curved like the sphere, that is like a ball.'

The practitioners supported the children's playful explorations as they discovered how different 3D shapes move (or don't) along the ramp. Using mathematical language, the practitioner posed the wonder **'a cube has flat faces, what happens if we place it on the ramp?'**.

The children used what they knew about shape properties to predict what they thought would happen. Together, we thought about how edges, faces, and corners affect movement.

THE MATHS INSIDE

Roll, slide or stay?

If you put something on a ramp it will do one of three things: roll, slide or stay where it is. As the children experimented with different surfaces and objects, they noticed this.

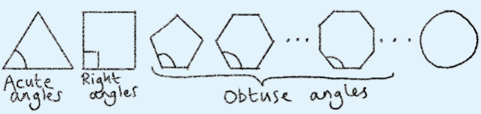
There are lots of variables that determine what will happen: the angle of the ramp, the friction of the ramp and the object, whether it is given a push, the shape, size and weight of the object. It would take quite a complicated mathematical model to predict exactly what will happen, but the children regularly use these variables in their predictions.

THE MATHS INSIDE

Angles in shapes

A **regular** shape has all angles the same, and all sides the same length. If it has more sides, the angles will be bigger.

With more and more sides, and angles closer and closer to straight, the shape looks more and more round. 'In the limit' (see p15), with infinitely many sides, it would become a circle.



'It's rough, sandpaper. The wheels will make the car go down, but if it has no wheels I'll have to push it down the sandpaper.'

‘I tried to roll the square, but it just stopped and fell over because it’s not round and it has corners. The circle rolled because it doesn’t have sides like a square.’

THE MATHS INSIDE

Staying or falling

Often, objects behave as if all their weight was at one place, in the middle. This is why, when we build with blocks, a block can stick out a certain amount – but no more! – before it falls down.

The place in the middle can be called the **centre of mass**, and what matters is whether this is supported or not. This idea is useful when we think about rolling.

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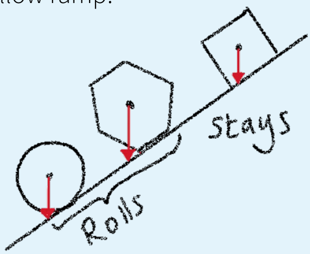
Shapes on a slope

Let’s assume the shape won’t slide. If the part of the object directly below the centre of mass is resting on the ramp, it will stay. If the centre of mass is over open space, then the weight will tip the shape and it will roll. Since a circle is touching the ramp only in a very small place, it will roll for even a very shallow ramp.



As on p9, we’re looking at this from the side to make a 2D picture: the ‘circle’ could be a cylinder or a sphere, for example.

‘This wooden circle [cylinder] will go down the ramp as well because it rolls. It will be the same as the car; it will go faster if I have the ramp up very high. Look, yes! I was right – can you see it going really fast? It goes fast cos it’s got no corners on it, just round wheels and round edges.’

Mathematical language

Corner, edge, face, flat, curved, round, angle, regular, roll, slide, friction, weight, centre of mass.

THE MATHS INSIDE

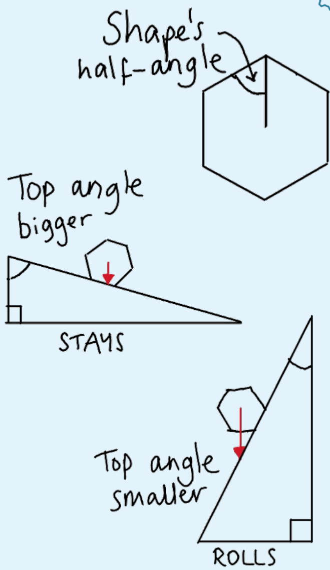
A neat angle rule

Suppose we have a regular shape on a ramp, and it doesn't slide. It turns out there's a surprisingly simple rule for whether it rolls or not. It all depends on the angles.

We compare the top angle of the ramp, and half of the shape's angle. (To show this half-angle, draw a line from the centre to a corner.)

- If the ramp's top angle is bigger, the weight is supported and the shape stays.
- If the ramp's top angle is smaller, the weight is not supported and the shape will tip and roll.

So, if your shape isn't rolling, and you want it to, you can fix this in two ways: make a steeper ramp (with a smaller top angle), or find a rounder shape (with bigger half-angles).



'I think it's because the rectangle has got right angles so that stays still easier. The circle doesn't have a right angle, so it rolls, But it is still now so it doesn't always roll.'

Practitioner reflections

Being able to hold and handle 3D shapes enables children to feel and compare their properties. Playing with shapes on ramps lets children explore how shapes behave on different slopes. This gives children a new way to look at shape properties.

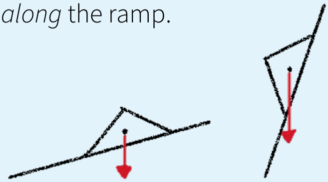
THE MATHS INSIDE

Friction: when do things slide?

Friction can slow an object as it slides down a ramp, or it can stop the object sliding at all. A rough surface on the ramp, or the object, or both, makes more friction. But the amount of friction also depends on how much the weight of the object is pressing it *onto* the ramp.

On a shallow ramp, the object's weight pushes mostly *onto* the ramp. But on a steeper ramp, the object's weight is pushing mostly *along* the ramp.

That's why, as the children notice, if you make the same ramp steeper, the same object is more likely to slide, or slides faster.



It was not long before the children were experimenting with anything and everything: cars, balls, wheels, blocks, shells, stones and even water.

Ramp play was running through both indoor and outdoor environments, so the children had access to a wide range of versatile objects to use in their experiments.

One question that especially interested them was how size affects the outcome:

"This is a tiny stone, I wonder what will happen." – "What do you think will happen?" – **"I think it will slide and then it might fall off the end cos it's tiny."**

Another question was **"Will my tiny stone need a tiny ramp?"**.

Together, we were able to match objects to differently sized ramps to see whether bigger objects needed bigger ramps, using problem-solving to address the children's queries.

Practitioner reflections

Our enquiry-led approach to learning allowed children to pose their own wonders as they built on their previous learning in a fluid and natural way.

Getting started

Children are thinking mathematically when they:

- Talk about **properties** like distance, size, weight, shape, angle, slope, time, speed. They might comment: 'This is a long one!', or compare: 'This one is longer than that one', or even want to measure: 'How long is it?'
- Use **spatial language**: 'The ramp is on top of the crate and it goes under the bridge.'
- Make **predictions**: 'This one will go fast.'
- **Make connections** between the properties above: 'The big ball went faster than the small one.'
- Talk about **cause and effect**: 'It stopped because the ramp was too flat.'

When to join the mathematical conversation

- **Observe and listen** to the children's play. Look for moments when they are
  — repeating a process;
  — showing curiosity or frustration;
  — talking about how or why things are happening.
- **Follow their interests**; build questions around what they are doing.
- **Pause after asking**; give children time to think and respond.
- **Avoid over-questioning**; don't interrupt the children's flow of play too often.
- **Find a good balance** between their independence and your interest.

How to offer materials

- As far as possible, key materials should be openly available, so that children can find and take what they want independently.
- To start things off, you might set up a simple ramp, to captivate children's attention and stir their curiosity.
- Offer a new resource at the right moment, for example when children are absorbed in play, but encounter a problem or limitation.

What might you say?

You could give some running commentary (with pauses for reflection) to introduce mathematical language. But mostly you will be asking questions.

Avoid the kind of question that tests knowledge, and has just one correct answer. Instead, ask open-ended questions which:

- **model wonder and curiosity**: ‘Hmm, that’s interesting, I wonder why it wobbled like that.’
- **support children to identify problems or find solutions**: ‘Is the cardboard not strong enough? What else could we use?’
- **guide mathematical thinking**: ‘Have you thought about the height of this ramp? Would changing that make a difference?’
- **encourage collaboration**: ‘How did your friend’s ramp work?’ ‘Can you explain to your friend how you built this ramp?’ ‘Could you work together to build a steeper ramp?’

How to start a question

Here are some phrases that start good questions:

- **How could you …**
  … stop it falling off?
  … measure how far it went?
- **What else …**
  … could you send down the ramp?
  … might help it go faster?
- **Why do you think …**
  … this one sticks but that one slides?
  … the cars are going faster now?
- **What would you …**
  … do differently next time?
  … keep the same next time?

Final reflections

Supporting children’s learning is about offering the right things at the right time. Follow the children’s lead, step in with purpose, and allow space and time for trial and discovery.

Practitioners need to listen to the child’s voice and through this, children will feel respected, take ownership of their learning and develop a positive can-do attitude to maths.

Resources

Here are some lists of materials that might be useful as you enable ramp play. You might well think of other things you already have that would work well!

Ramps

Guttering / drainpipes

Planks of wood

Cardboard

Laminate flooring boards

Decking boards

Sheets of Perspex

Transparent tubes (to see movement inside)

Materials to change the surface of the ramp (sandpaper, hessian, various fabrics, bubble wrap etc)

Supports

Wooden blocks (big or small)

Furniture (eg table edge)

Stacks of tyres

Cable reels

Cardboard boxes

Tree stumps

Objects to roll (or slide!)

Toy cars / trains

Balls

Pumpkins (or other firm, round vegetables)

Wooden shapes (cylinders will roll, but it is interesting to see what other shapes do)

Natural objects (stones, pinecones, acorns …)

Measuring and recording

Measuring tools

Long sheets of paper

Stopwatches

Clipboards

Whiteboards / chalkboards

Young Minds Big Maths

Young Minds Big Maths began in September 2020 as a collaboration between Houghton Community Nursery and the Department of Mathematical Sciences at Durham University.

Houghton Community Nursery is a local-authority-maintained setting in Sunderland, UK. Each year they welcome around a hundred 3- and 4-year-olds, with a staff to child ratio of 1:13. The location has below average participation in higher education, both now and in the previous generation, and Sunderland is in the most income-deprived 10% of English local authorities.

Practitioners at the nursery reached out to the mathematicians, seeking support to broaden and deepen their approach to maths. In regular online meetings, practitioners reported on the interests and activities of the children, and the mathematicians discussed maths underlying, or related to, the children's play.

The impact on staff's confidence has been huge. Practitioners are now able to support the children to explore deep mathematical ideas and concepts. This is child-led mathematics that is creative, engaging and accessible for both children and practitioners.

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We also thank everyone else, from both Durham University and Early Years settings, who participated in YMBM discussions from 2021 to 2024. You have all helped to inspire this booklet.

Finally, we thank ESRC IAA for the generous funding that has made this book possible.

Ramp play

We hope that this booklet will show you the rich potential of following children's interests, and the importance of willing staff who scaffold and extend the children's mathematical explorations.

Ramps are a valuable resource in early years settings, for fostering curiosity and deep engagement in play. The open-ended nature of ramp play encourages collaboration, communication, and creativity. It can unlock children's mathematical thinking, so that they come to view themselves as capable and creative young mathematicians.

#YMBMrampplay
youngmindsbigmaths.co.uk

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