Early mathematics: Predictors and priorities from research

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What research tells us
What predicts maths success?

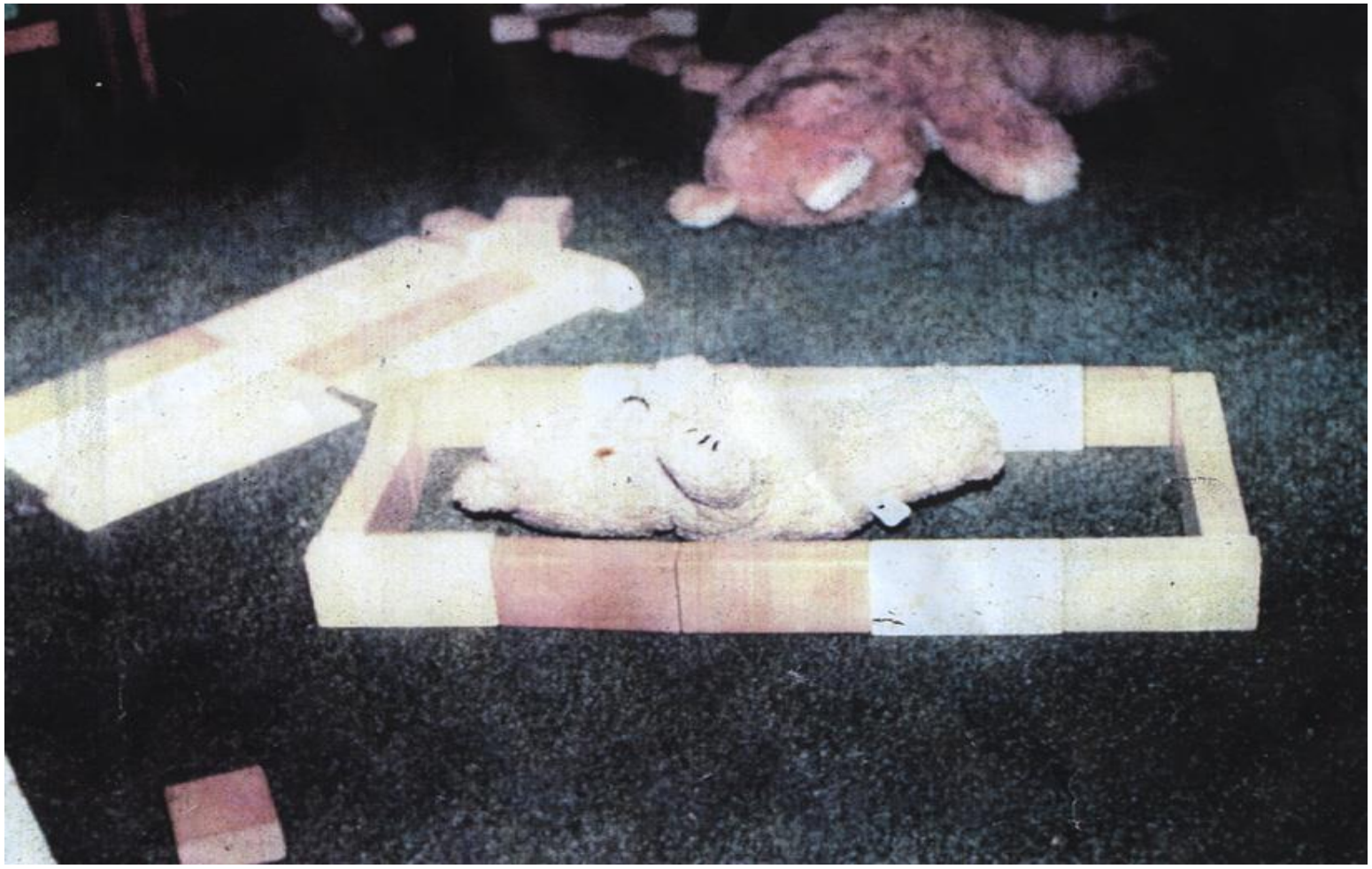
in the early years:

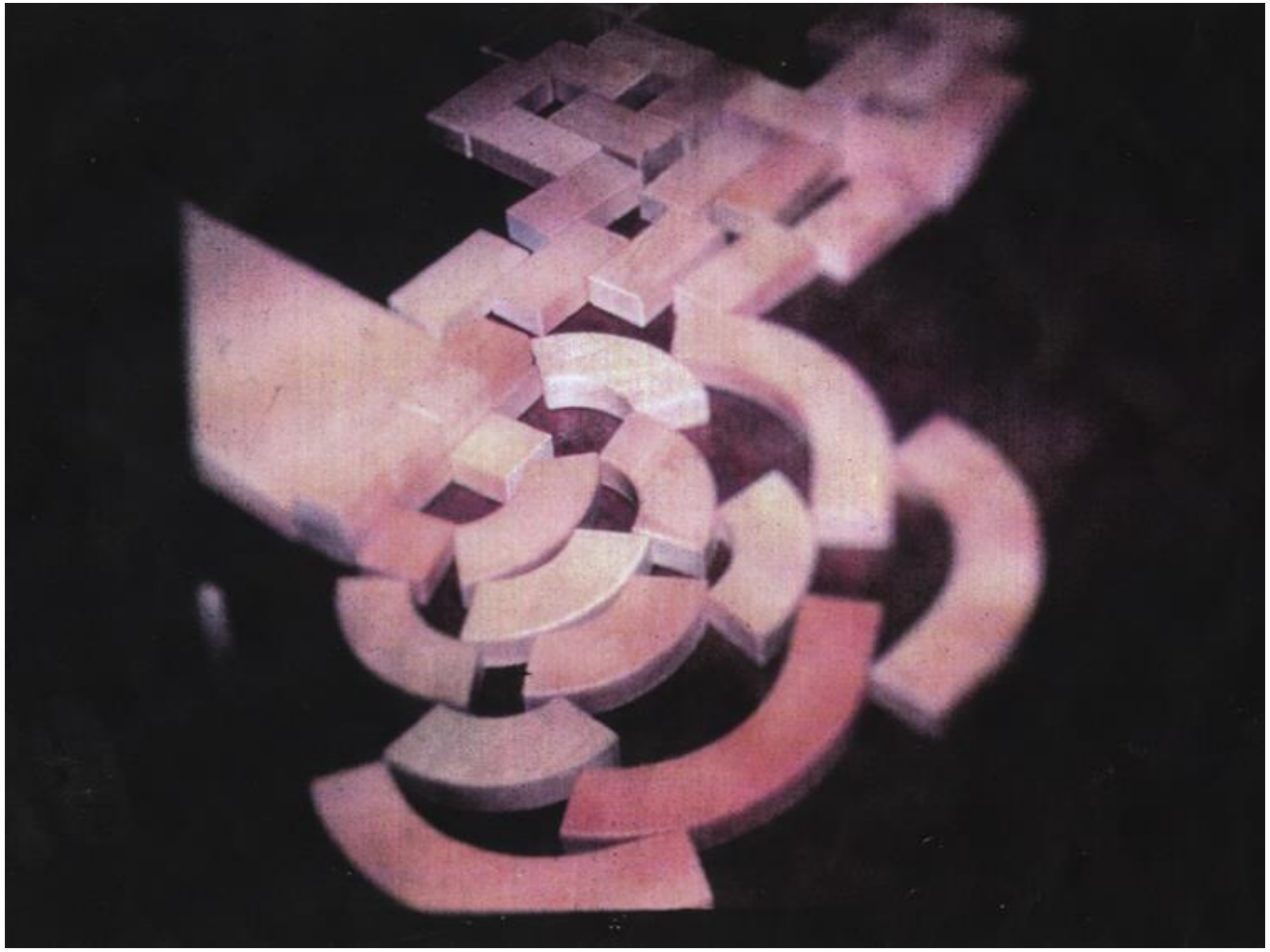
- parents' education and home learning (EIF 2018)
- a balance of adult and child-led activities (Ofsted 2018)
- early number sense (Nunes & Bryant 2009)

at primary school:

- mathematical reasoning (Nunes, Bryant et al 2012)
- a growth mindset (Dweck 2006, PISA 2012)
- an autumn birthday (DfE)

Child-led activities





mathematical reasoning

Adult initiated: *Faster than Usain Bolt*

If you go slower you'll get a bigger number.

If you go faster you'll get a <u>smaller</u> number.

Mastery: generalising mathematical relationships

Class teacher: Georgina Harries, Marlborough Primary School, Falmouth**.**

Researcher: Dr Helen Williams

What research tells us:
How to produce children with maths difficulties

Anxiety blocks working memory space

-acceleration rather than understanding

-anxious teachers and parents create anxiety

Fixed mindsets

- ‘no good at maths’
- ability grouping (Bradbury, NEU, 2017)

national education union

UCL Institute of Education

Grouping in Early Years and Key Stage 1

“A Necessary Evil”?

Predictors

Children's understanding of number during preschool is consistently associated with their mathematical achievement in primary and secondary school.

Mathematical achievement in turn is consistently found to be the strongest predictor of children's overall school achievement and their success in entering the workforce.

The ages of 3 to 5 are therefore considered an ideal time to rectify income-related learning gaps in children's understanding of numbers.

(Early Intervention Foundation 2018)

Mathematical predictors for 5 year olds: the evidence

- **counting out** a number from a larger group (EIF, 2018)
- **understanding numerals** as cardinal numbers (EIF, 2018)
- **comparing numerals** ordinally (Lyons et al, 2014)
- **patterning** eg visual sequences (Rittle Johnson,2016; EIF)
- **spatial thinking** (Verdine et al, 2017; Young et al, 2018)

Pattern awareness

There is emerging evidence to suggest that preschool children's patterning ability – that is, the ability to recognise predictable patterns in stimuli – also supports numerical awareness.

(EIF, 2018:140)

Spatial awareness

There exists a distinct cognitive factor that could be called 'spatial ability' .. forming and manipulating visual-spatial mental images

Mix & Cheng (2012)

Improving spatial experiences prior to school entry is likely to increase children's readiness for school.

Optimizing spatial performance may be an underutilized route to improving mathematics achievement. (Verdine et al, 2017: 93,102)

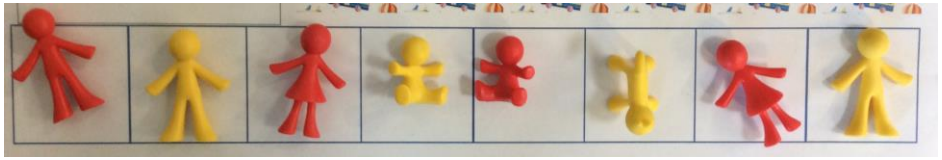
Ball skills predict maths:

'Interceptive timing' Giles et al. (2018)

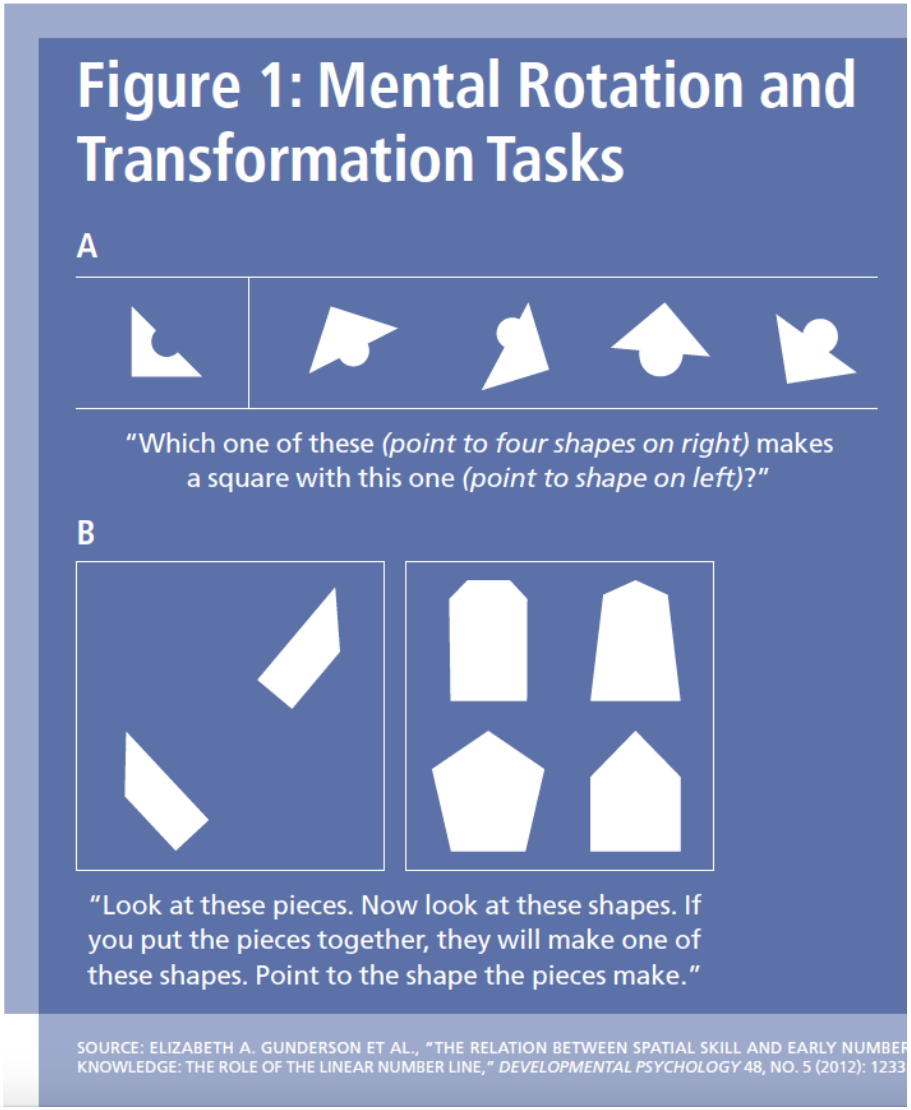
Better hand-eye coordination could lead to improved grades at school, study finds CREDIT: SHAPECHARGE

Repeating patterns:

AB, ABC, ABB



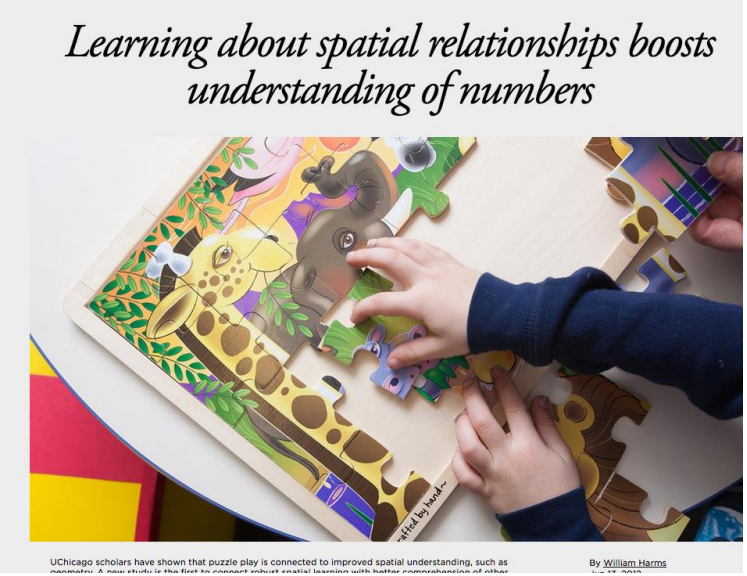
Identifying the unit of repeat: *What is my pattern?*



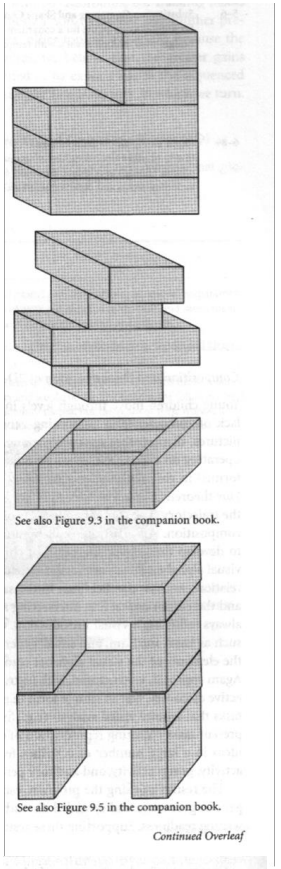
5 year olds' spatial reasoning predicts number line knowledge

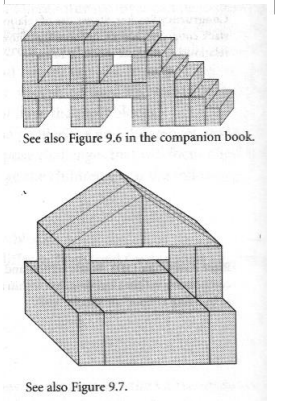
Gunderson et al (2012)

What helps to develop spatial reasoning?



http://news.uchicago.edu/story/learning-about-spatial-relationships-boosts-understanding-numbers





Erikson Early Mathematics Collaborative: *Composing shapes with child 12*

Number ELG

Children at the expected level of development will:

- Have a deep understanding of number to 10, including the composition of each number;
- Subitise (recognise quantities without counting) up to 5;
- Automatically recall (without reference to rhymes, counting or other aides) number bonds up to 5 (including subtraction facts) and some number bonds to 10, including double facts.

Learning number facts to solve problems

- *Young children will typically use a variety of basic strategies when first learning arithmetic, such as counting with their fingers. Over time, children should be able to solve basic arithmetic problems automatically from memory. Progress in using more efficient strategies is likely to be non-linear and gradual.*

- *A child's ability to accurately compare the magnitude of numbers is related to their success in learning arithmetic. Young children use their understanding of magnitude to make sense of arithmetic problems and to check if their answers are correct.*

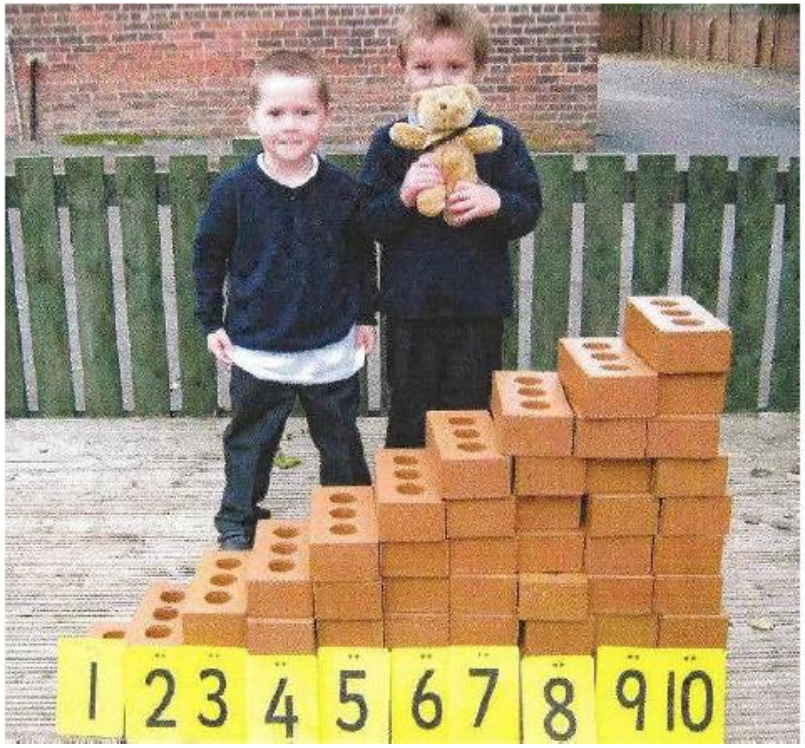
DEANS (2019:14)

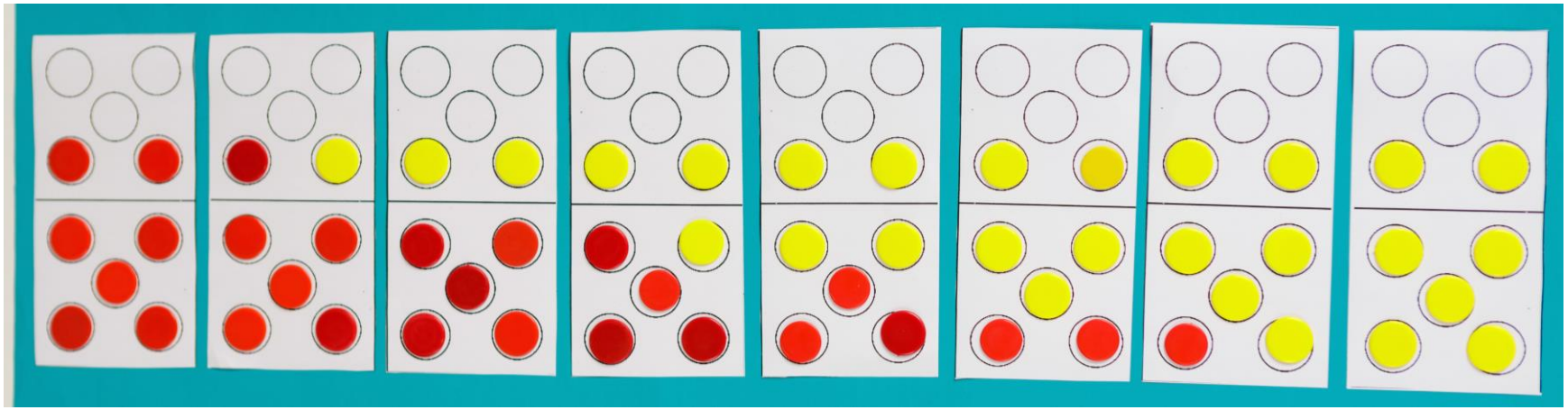
Numerical Patterns ELG

Children at the expected level of development will:

- Count confidently beyond 20, recognising the pattern of the counting system;
- Compare sets of objects up to 10 in different contexts, considering size and difference;
- Explore and represent patterns within numbers up to 10, including evens and odds, double facts and how quantities can be distributed equally.

Numerical patterns





Griffiths et al, 2016: *Making Numbers*

Exploring patterns within numbers

Griffiths et al (2016) *Making numbers*

Key aspects missing from the proposed Goals

- Cardinal counting eg *Give me 5*
- Understanding number symbols
- Problem solving
- Shape, space and measures
- Patterning
- Communicating mathematically

Consultation deadline 31st Jan
www.education.gov.uk/consultations

Number sense: a feeling for numbers

'Five is a number which is medium small'

Counting

Cardinality

Comparison

Composition

NCETM: *Main areas of early years maths*

Number sense
a feeling for numbers

Counting -sequence & synchronisity

Cardinality - *the eightness of 8*

Comparison - relative size

Composition- *numbers hidden inside numbers*

Counting: It takes 4 years to learn to count verbally to 20

So children need a lot of counting opportunities!

Developing counting with cardinality takes a long time

- **number sequence**
  - forwards and back
  - numbers to 20- takes 4 years
  - crossing boundaries 29/30
- **one number one object** - rhythm & synchronisity
- **keeping track** - being systematic
- **cardinal principle** - last number is 'how many'

Spotting number patterns

Key assessment:

Counting out a number from a larger group

Can you get me 9?

Young-Loveridge (1991)

The cardinal principle - last number you say is the number of the group

When do children use counting because they really want to find *'How many'?*

- getting a number of things *'Give me nine'*

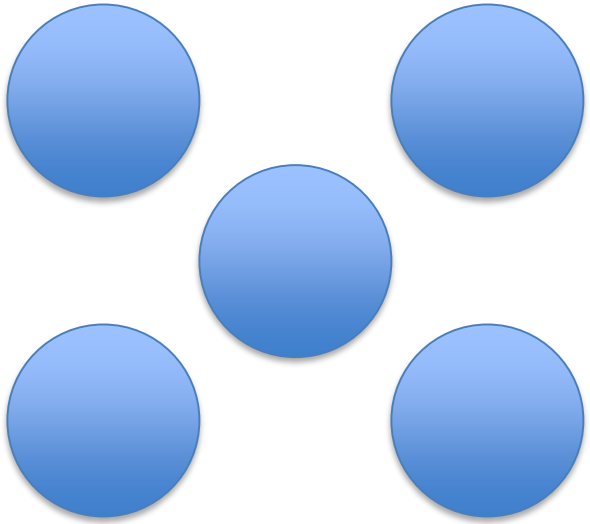
- counting to share and compare

- counting to check

Cardinality: ‘how manyness’

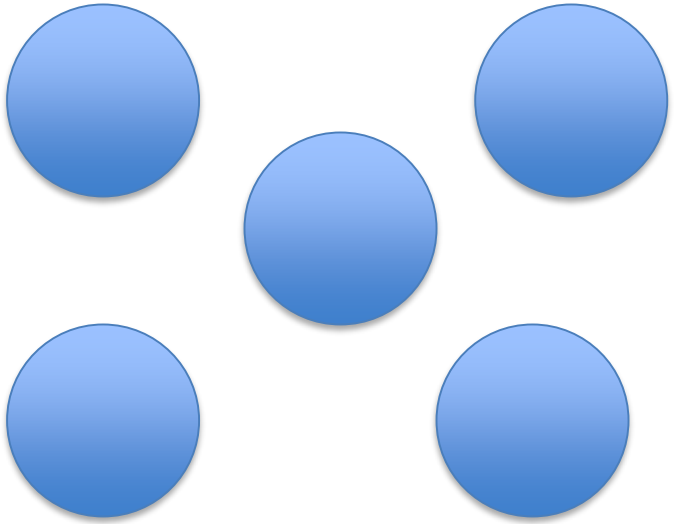
the number of things represented by the number

5



All-at-once finger numbers

Subitising



How do you develop subitising?

Do it huge – and outdoors!

Understanding number symbols

How do we know that children see numerals as number concepts?

When do children see everyday numerals with cardinal meanings?

(referring to a number of things)

Numerals referring to numbers of objects are rare!

Cardinal and ordinal numbers

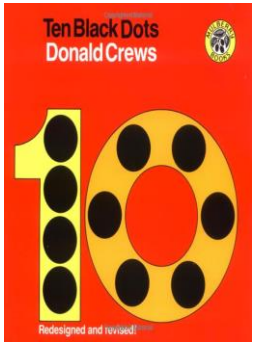
The cardinal meaning of numerals

When do children see number symbols linked to numbers of things in your setting ?

The cardinal meaning of numerals:

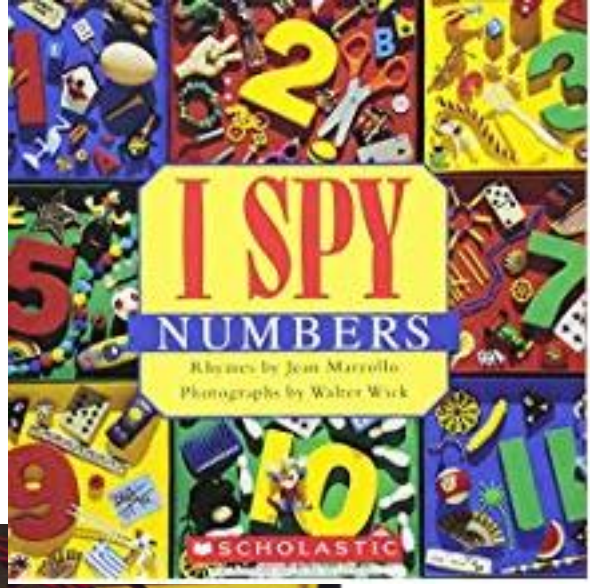
When do children see number symbols linked to numbers of things in school?

- tidy up labels
- recipes (with pictures)
- number books and rhymes
- numeral dice for games
- scoring goals etc
- others?



I spy numbers

Marzollo & Wick



Numberblocks CBeebies BBC

Counting jumps

Individual spinner on lanyard

How might you record scores of outdoor target games?

Troon Nursery School, Cornwall

Comparison: relative size

- comparing two numbers
- estimating *'about how many?'*
- predicting adding /taking 1

Comparing numbers

Which is bigger 5 or 8?

'Which is bigger, 5 or 4?'

5/6 yrs:

High SES - 96%

Low SES -18%

Gersten et al (2005)

Key to number sense
'Five is a number which is medium small'

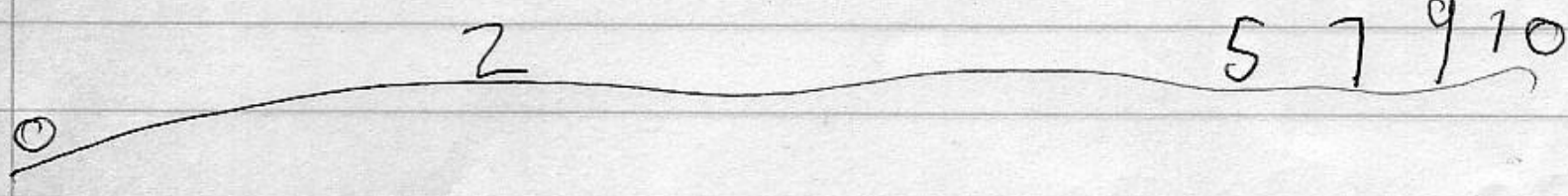
Children need to link:

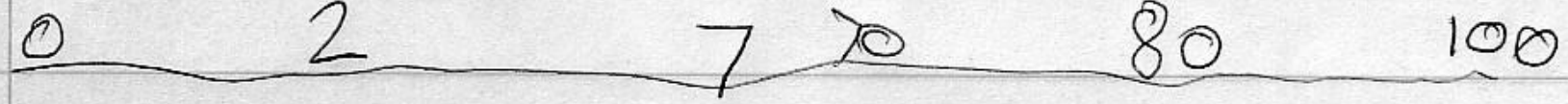
- counting order
- cardinality - the size of numbers

The voting station

Nrich

4 more people to vote: what might happen?


0
2
5
7
9
10


0
2
7
80
100

Number Board Game

The Estimation Station

https://nrich.maths.org/content/id/13339/Estimation%20Station.pdf

A handful: how many have you got?

- Estimate
- Count and label
- Order

Estimating herbs

You can pick 2 out of every 100

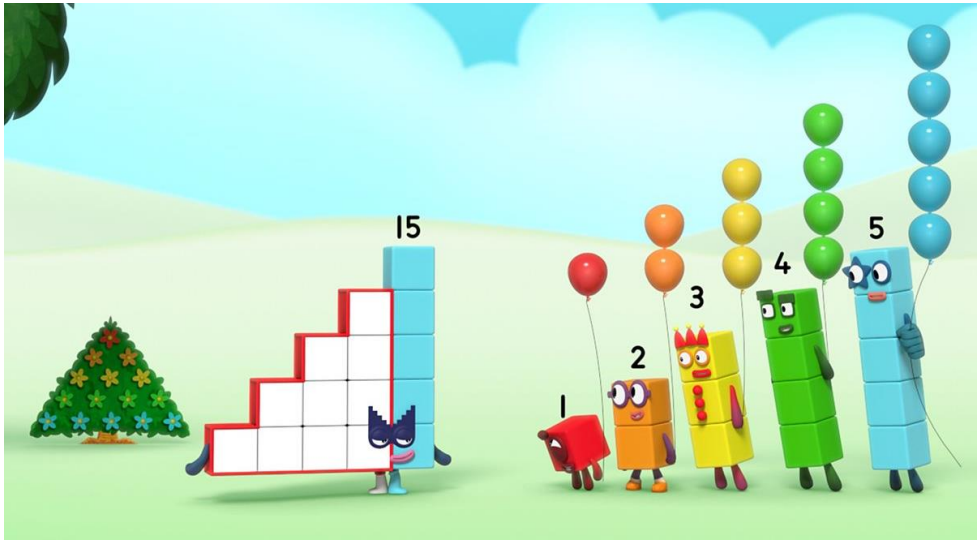
I picked 4 because I thought there were about 200!

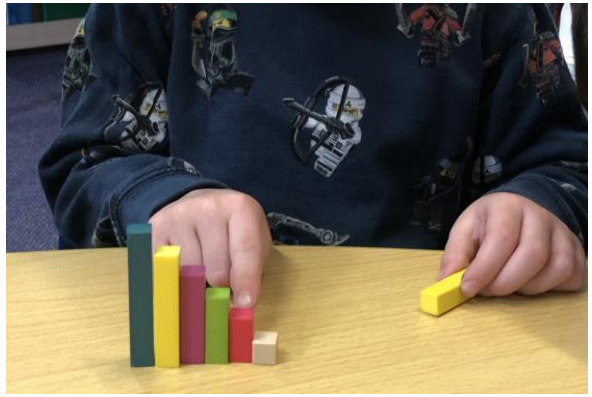
The *three-plus-one-ness* of four

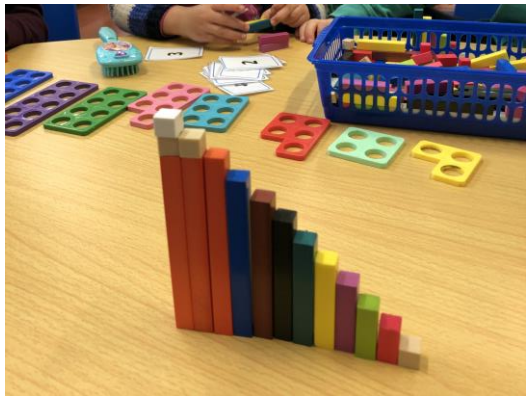
(Trundley 2008 NRICH)

Numberblocks
Stepsquad 15

Ravenstone nursery



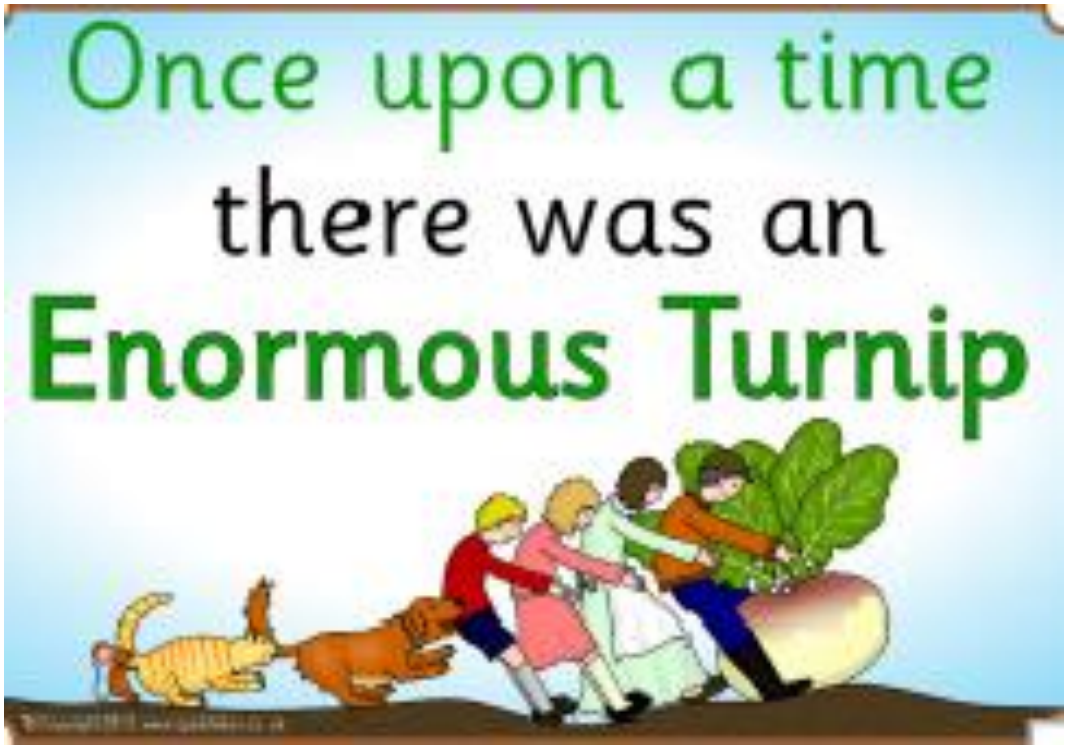


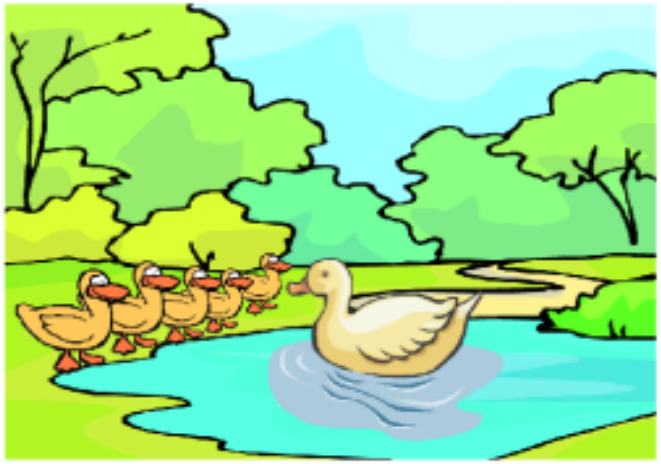


Ravenstone nursery

Huge and Outdoors

Stories and rhymes:
one more than / one less than



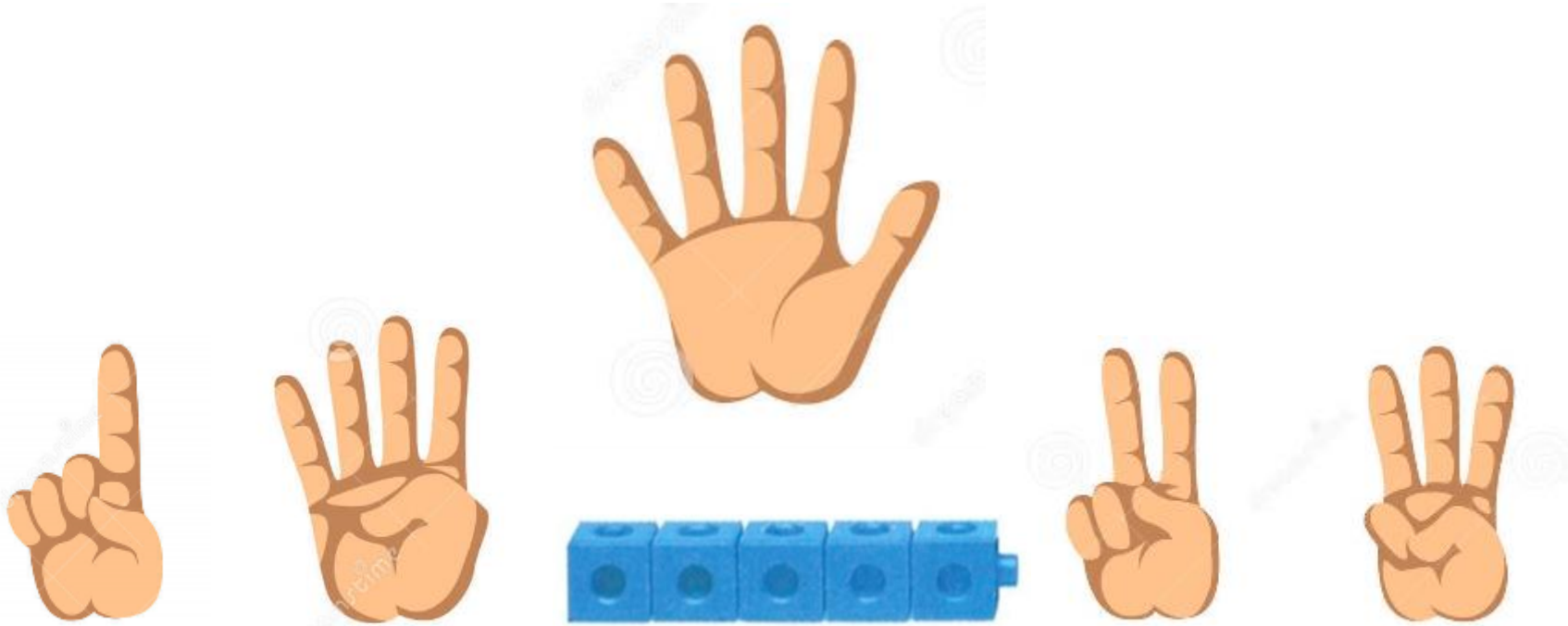


Five little ducks

Five little ducks went out one day,
Into the woods and far away.
Mother duck said, "Quack, quack, quack,"
But only four little ducks came back.

0 1 2 3 4 5

Composition



Bunny ears

Number rhymes: Frogs and logs

Composition:

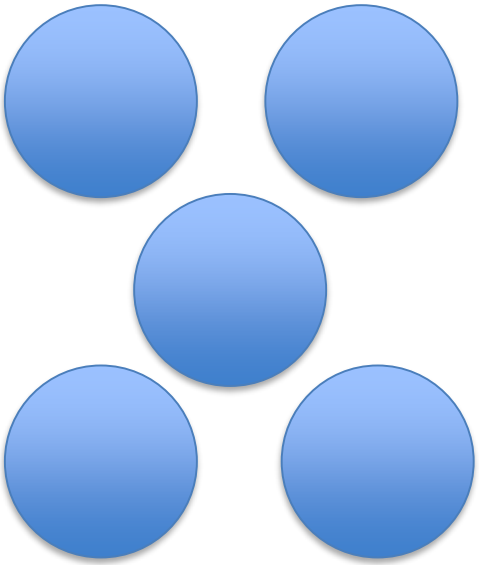
5 little speckled frogs

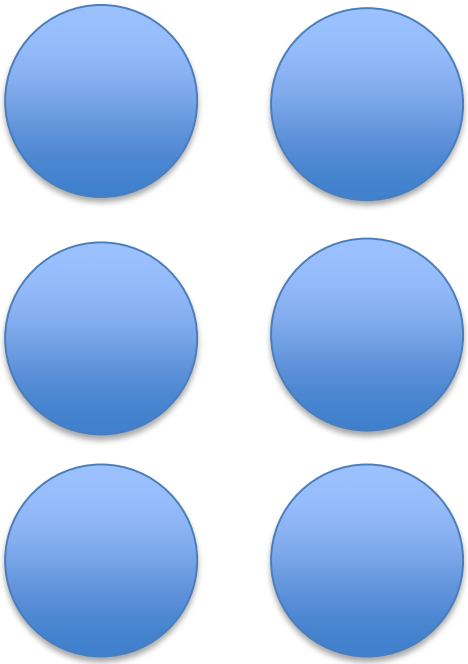
How many on the log and in the pool?

Rachel Fleming: Headington Prep 3 /4 year olds

Frog on log

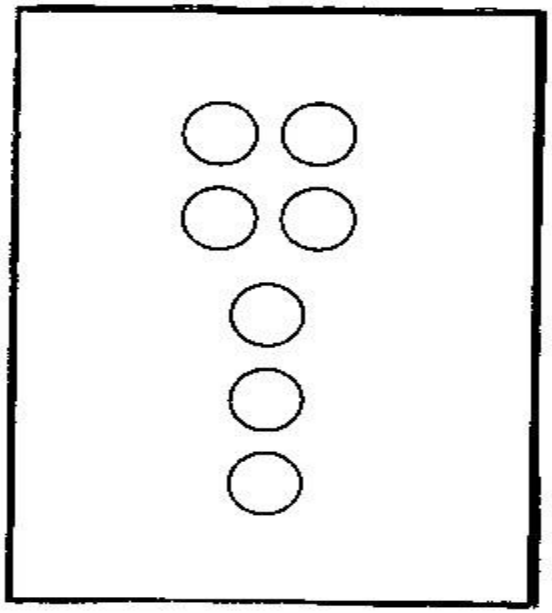
Conceptual subitising

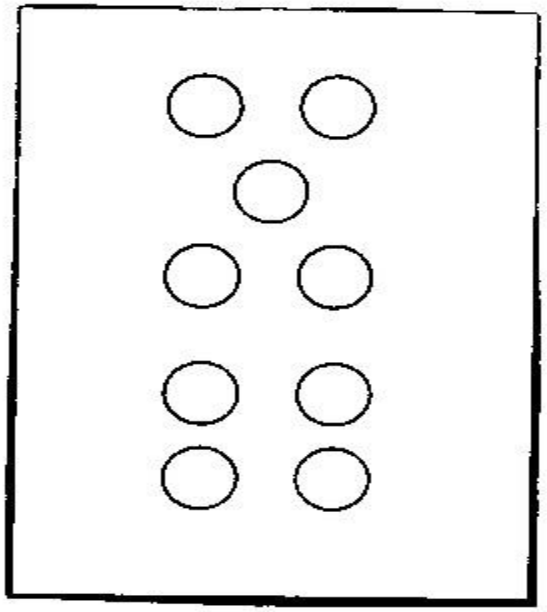




What numbers can you see hidden inside this number?

Subitising numbers over six

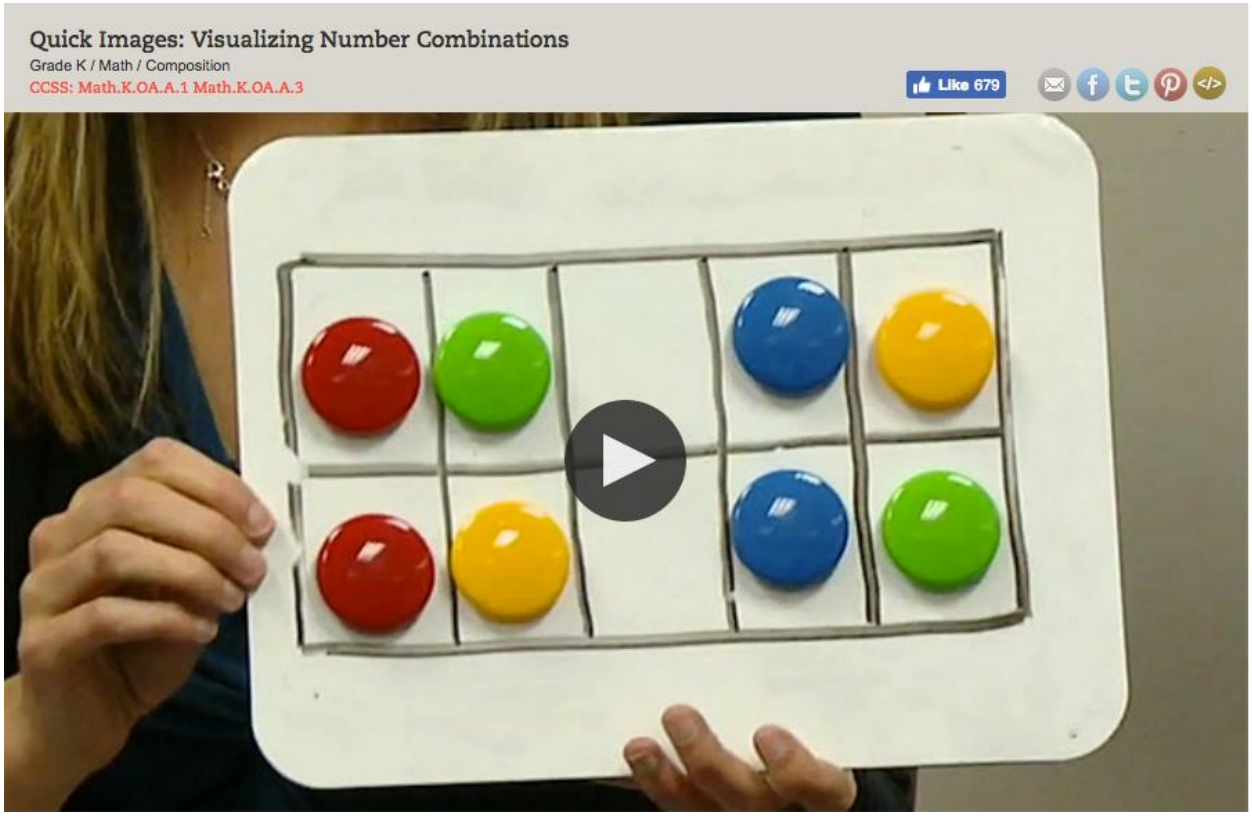




Regular arrangements: Subitising number talks

https://joelea.github.io/subitiser/

Teaching Channel: Quick Images



www.teachingchannel.org/videos/visualizing-number-combinations

Predictors of later achievement

- counting out a number from a group
- subitising
- numeral meanings
- relative number size
- predicting adding one / taking one
- number combinations
- spontaneous focusing on numerosity
- finger gnosis!
- pattern awareness
- spatial awareness

A pedagogy for number sense

- routines –register, snack time, tidying up
- games –collecting, tracks, targets, hiding
- number rhymes and picture books
- problem solving eg sharing
- playfulness- eg making mistakes
- ‘sustained shared thinking’ with adults

See NRICH for examples

Register 10 frames: using children's photos

Meadowcroft Infants

Julie Mason & Karen Henderson

Snack time

Tidy up time

NRICH Early years

Davenall, J. (2015)

http://nrich.maths.org/11528

Number games

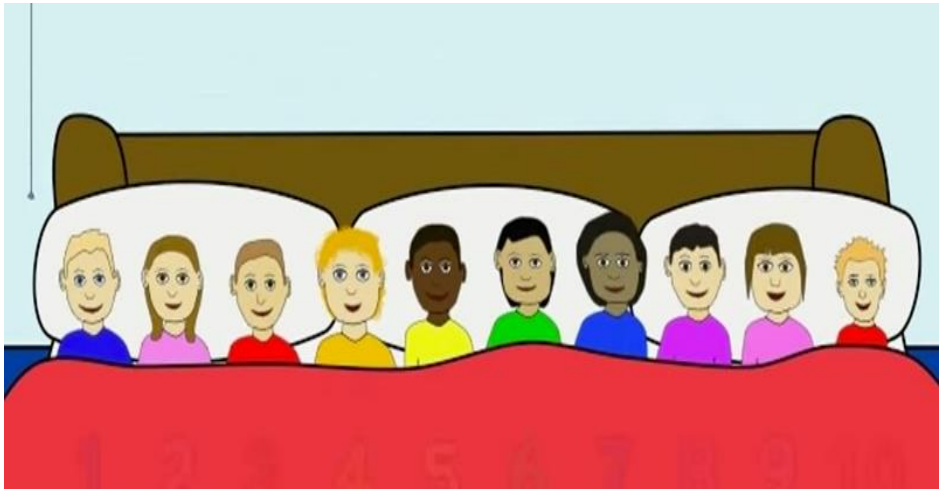
collecting games

track games

target games

hiding games

Number rhymes with props and people



Link with:

- fingers
- number symbols and staircase patterns
- 10, 9, 8, …
- predicting adding and subtracting

http://www.foundationyears.org.uk/maths-resources/

Developing mastery

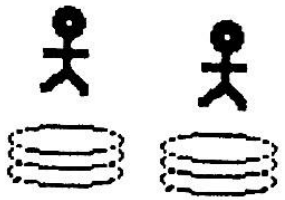
The Characteristics of Effective Mathematical Learning

How to provide mathematical opportunities for these?

Characteristics of Effective learning	
Playing and exploring – engagement	**Finding out and exploring**
	Playing with what they know
	Being willing to 'have a go'
Active learning – motivation	**Being involved and concentrating**
	Keeping trying
	Enjoying achieving what they set out to do
Creating and thinking critically – thinking	**Having their own ideas** • Thinking of ideas • Finding ways to solve problems • Finding new ways to do things
	Making links • Making links and noticing patterns in their experience • Making predictions • Testing their ideas • Developing ideas of grouping, sequences, cause and effect
	Choosing ways to do things • Planning, making decisions about how to approach a task, solve a problem and reach a goal • Checking how well their activities are going • Changing strategy as needed • Reviewing how well the approach worked

Sharing problems

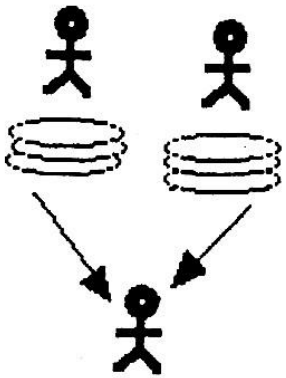
Should pirate panda keep all the money for himself?



6 crackers shared evenly between 2 dolls.

Fig. 1.

The arrival of a third doll who must get an even share, before any crackers are eaten, creates a problem:



Then a third doll arrives

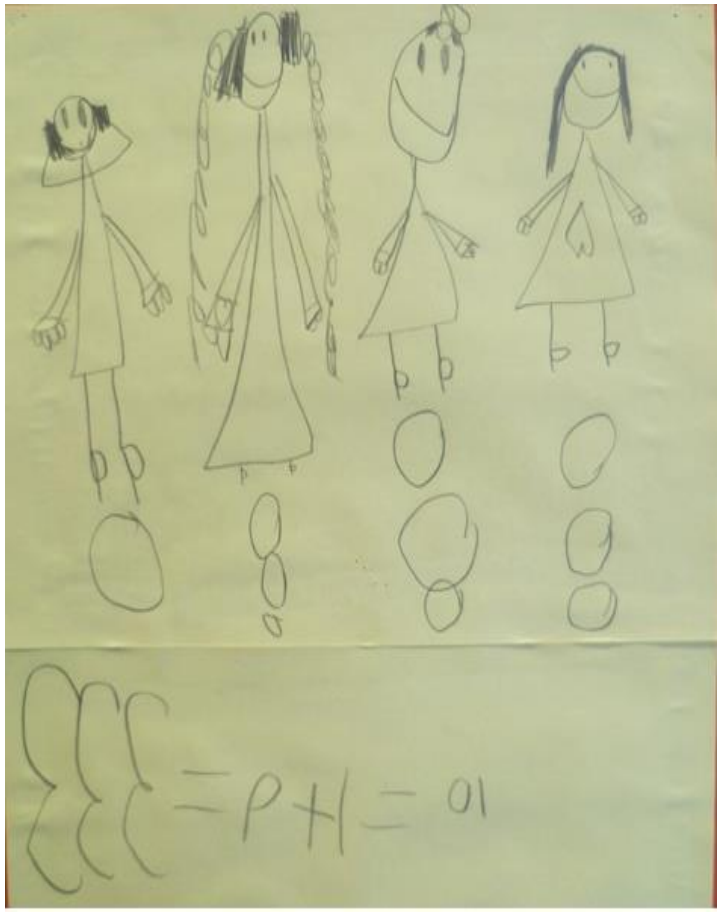
Fig. 2.

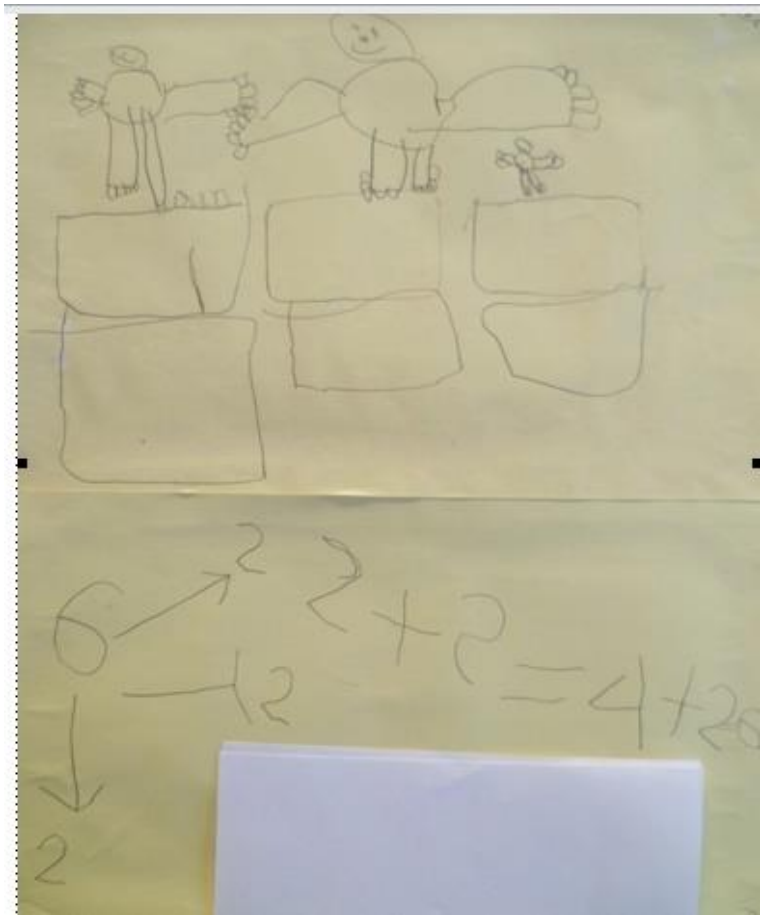
https://www.youtube.com/watch?v=1zguAec3AaE

Whole class problem solving

Sharing biscuits

Davenall, J. (2015)





Children making sense of symbols

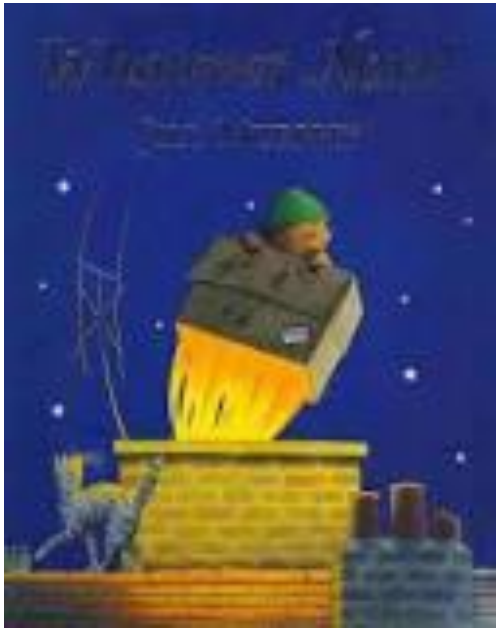
Davenall, J. (2015) NRICH Early years

The tiger who came to tea

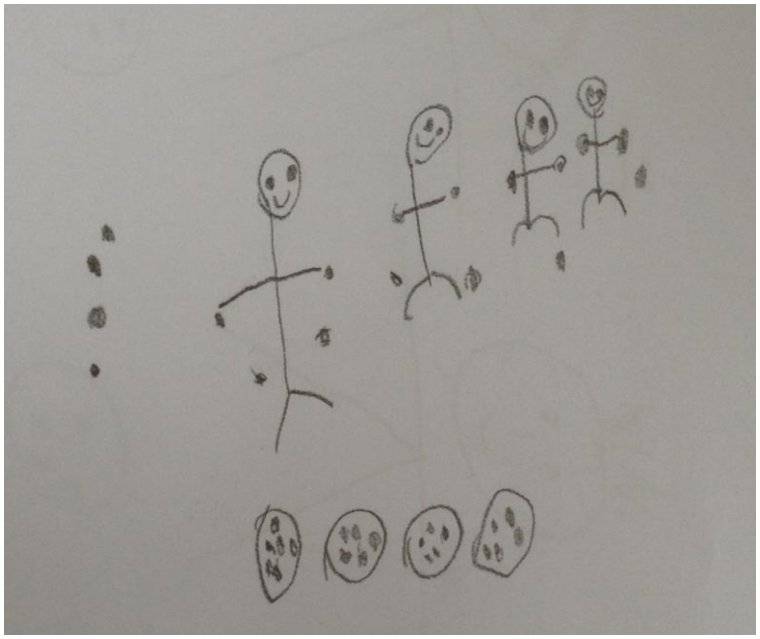
Caroline Mitchell
Staines Prep

Sophie and her mummy shared the cakes..

…And then the tiger came…



After reading *Whatever Next*
the children enjoyed a picnic
on the moon in the role play area.
Baby Bear invited 3 friends to join
him. And then another one came…



Holy Trinity Pewley Down (Sheena Preston)

The remainder: taking turns