Loughborough University

MATHEMATICS EDUCATION NETWORK

Supporting spatial reasoning in the early years

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More than just numbers

- I will explore research into the significance of young children's spatial reasoning, and
- begin to think about how to what this looks like in Early Years settings and classrooms.

Spatial play

- Early years educators know how mathematically rich spatial play can be.

- Research shows that it is young children's spatial rather than their numerical abilities that predict their overall, later mathematics achievement.

image: @earlymaths.org

Lowrie et al (2018) describe spatial thinking as:

- **awareness** of space i.e. distance and dimensions
- **representations,** mental and graphical
- **reasoning** i.e. interpreting and making decisions

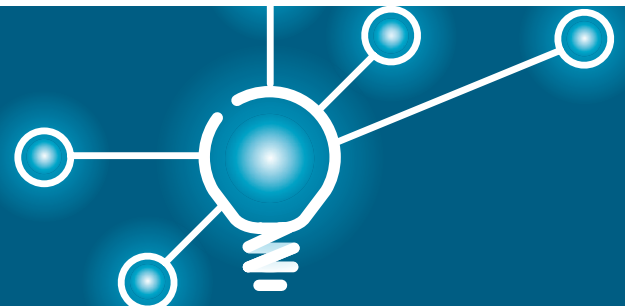
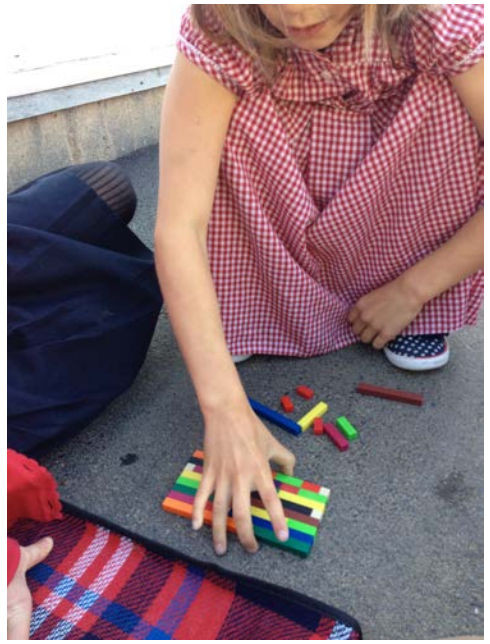


image: Coop Academy, Oakwood

- *Spatial reasoning is how we understand how things (including ourselves) move and interact in relation to the physical space around them.*
- *Children engage spatially all the time, from a baby reaching for a toy to a 6-year-old judging how much paper to cut out to successfully wrap a present. There is an increasing body of research supporting the importance of early spatial reasoning in predicting later and wider mathematical achievement.*

(Cheng & Mix 2014, Clements et al 2015)

Williams, H.J., (2020)
https://famly.co/blog/the-child/helen-williams-spatial-reasoning/



Spatial reasoning includes:

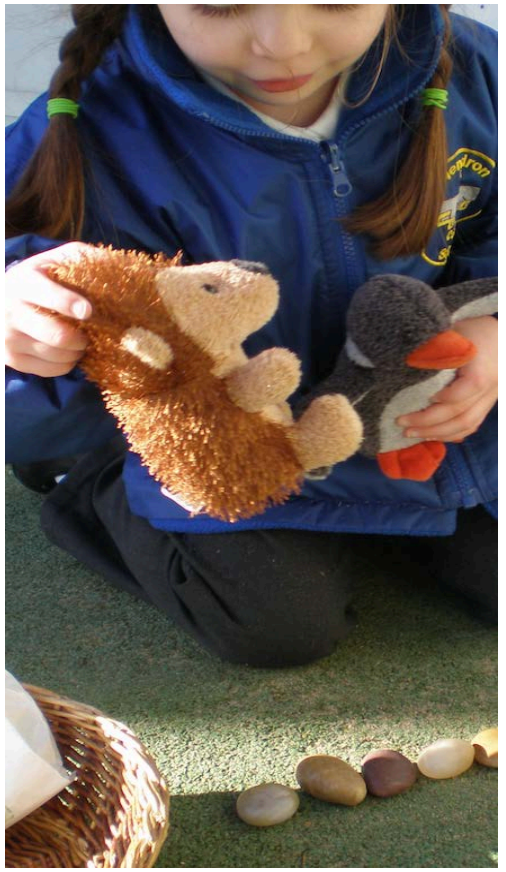
- interpreting **appearances**: *deducing the shape and size of objects*
- awareness of **relationships** and variations: *different kinds of positions, directions or orientations*
- **language**: *hearing, describing, directing*
- **manipulating** mentally: *memory, prediction*
- **generalising** and decision making: *abstracting relationships and rules*

- **representations**: *visualising mentally understanding perspective and movements, rading models and diagrams*

Early Childhood Mathematics Group (2020)
https://earlymaths.org

Early predictors of mathematical attainment:

- parents' education, home learning
- an autumn birthday
- a balance of adult- and child-led activities
- early-number sense
- pattern awareness
- **spatial reasoning** (Verdine et al 2017, Schroeter 2017, Cheng and Mix 2014)



Key experiences

Jigsaw play: relationships, visualisation, language (Levine et al 2012, Riberio et al 2020)

Construction, rotation, using barriers: visualisation spatial representations, language (Gura 1992, Casey et al 2008)

https://earlymath.erikson.edu

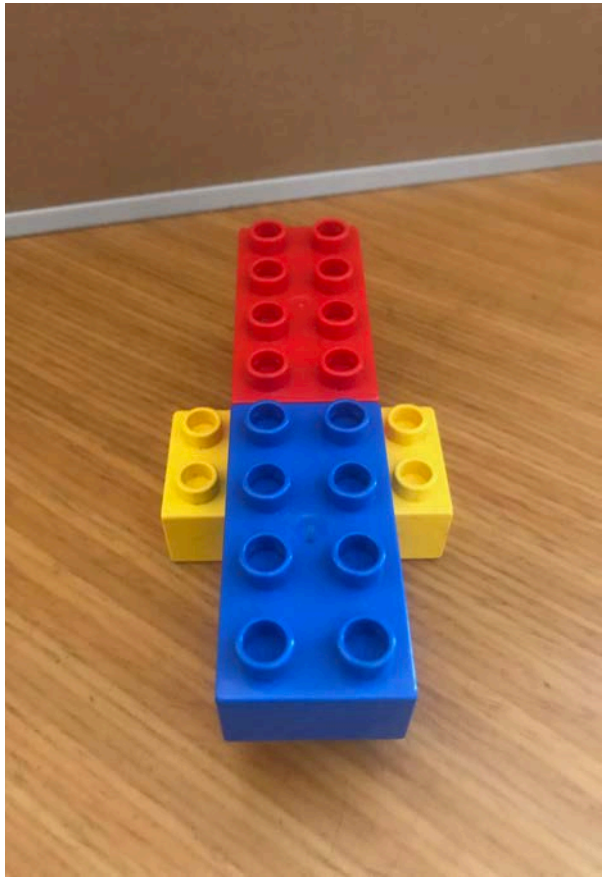
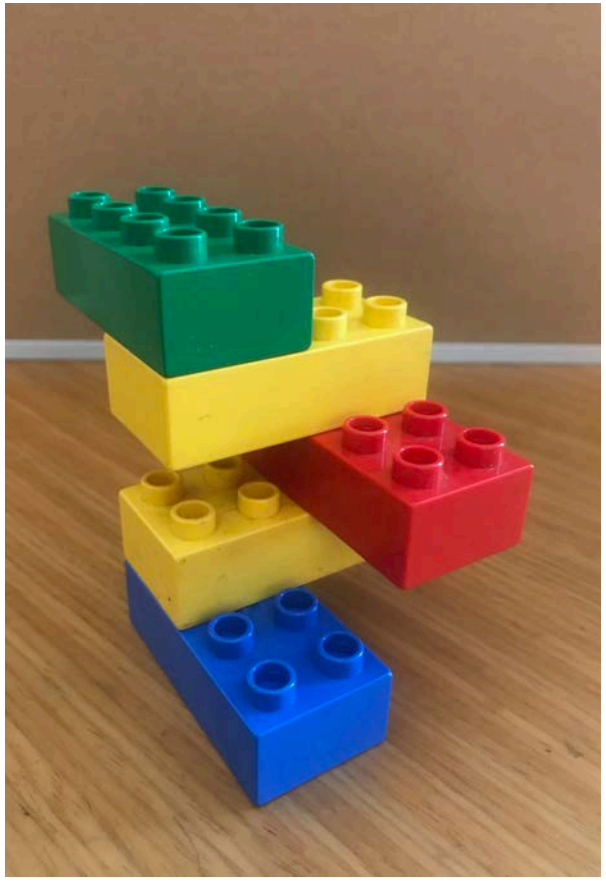
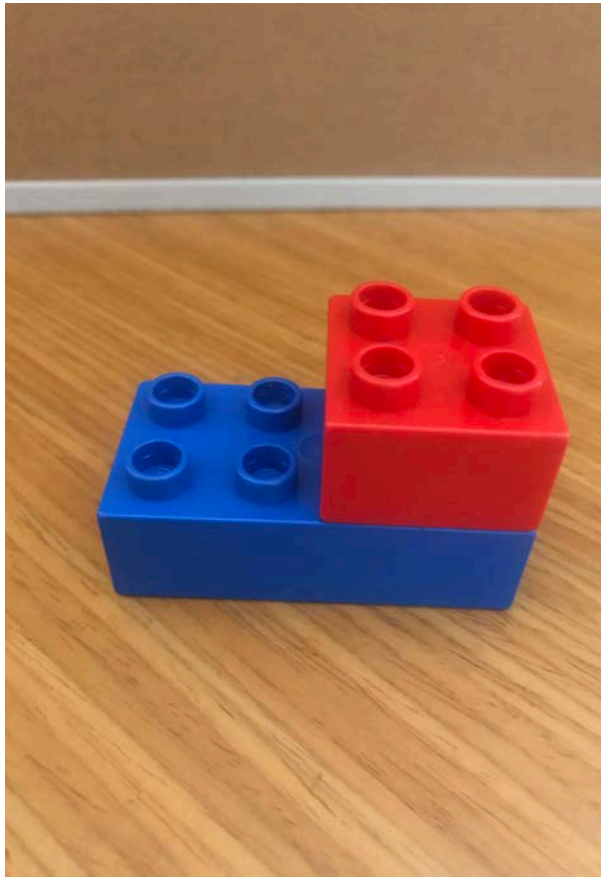
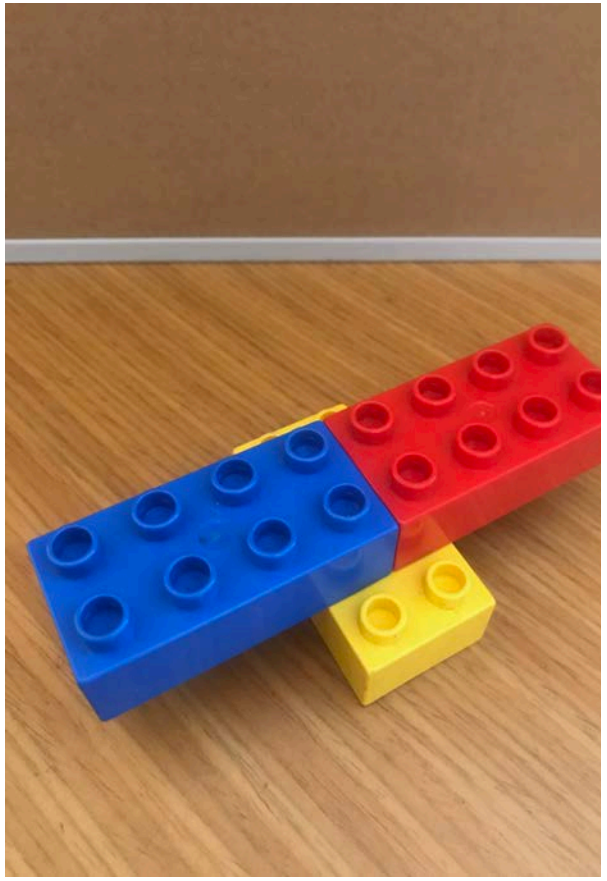
Combining and positioning shapes: relationships, visualisation (Shroeter 2017, Lowrie et al 2018)

Mapping: instructions, remembering &creating routes, representations, visualisation, language (Pruden et al 2011)

Memory games: memory, visualisation, language (Pruden et al 2011

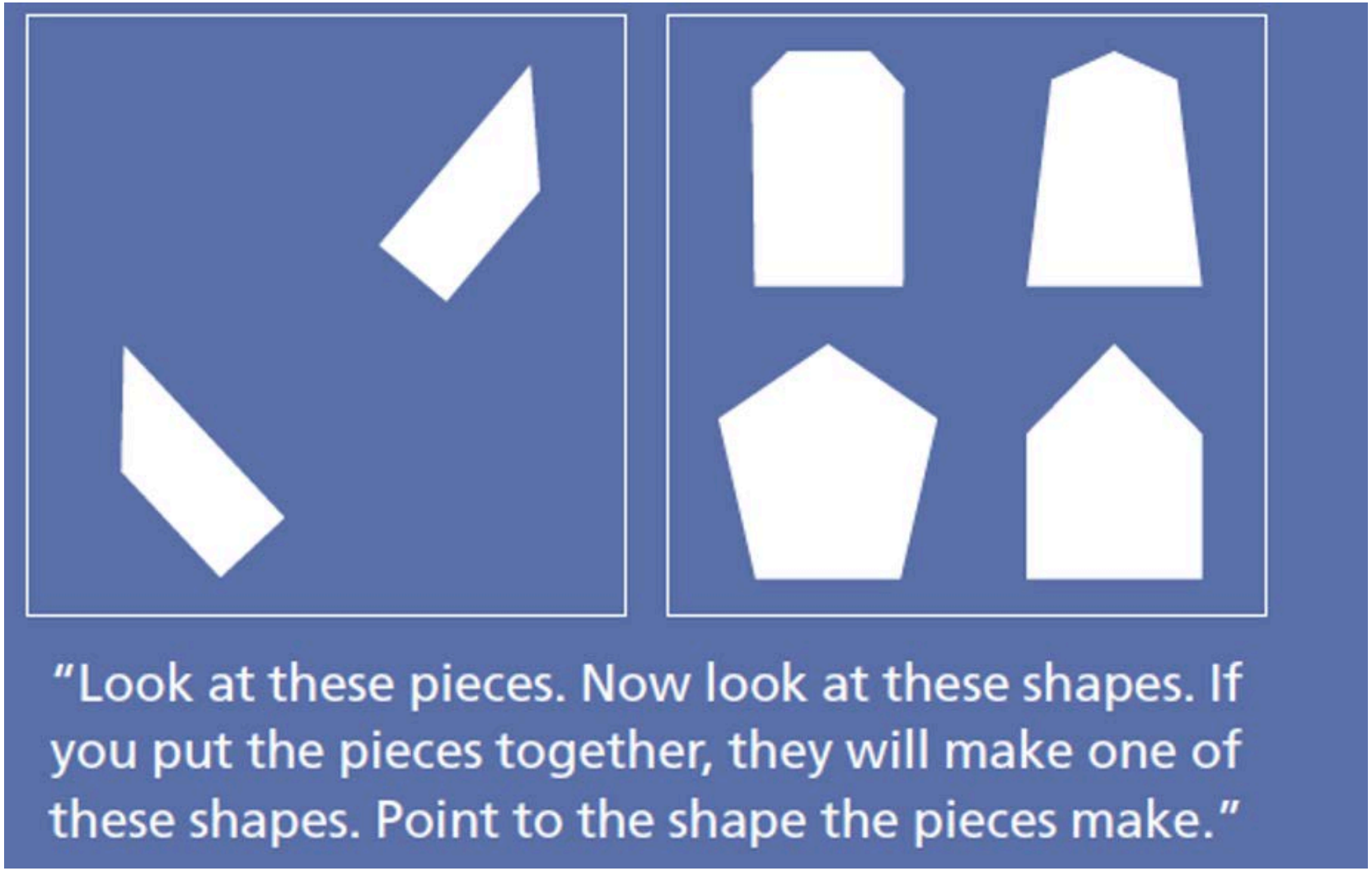
Combining and visualising how shapes fit together

(Verdine et al 2017)

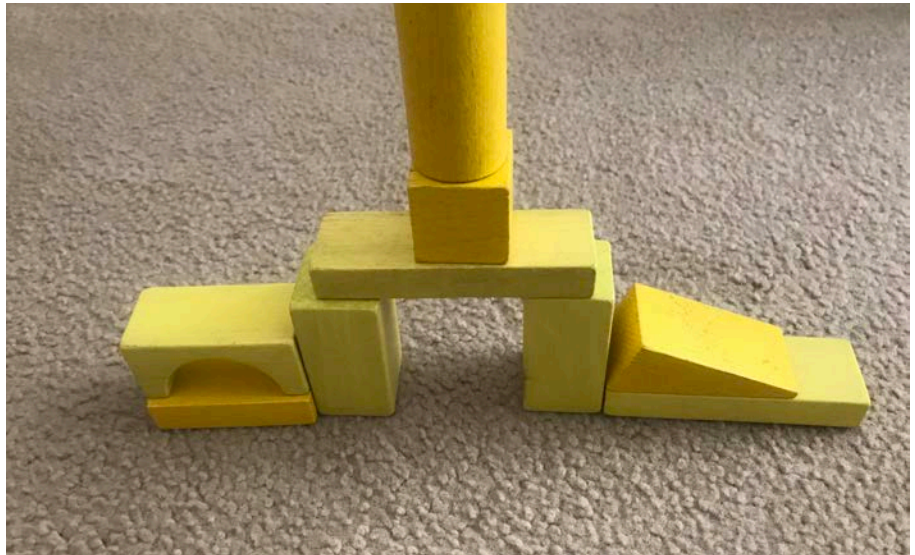
Visualisation

(Gunderson et al 2012)

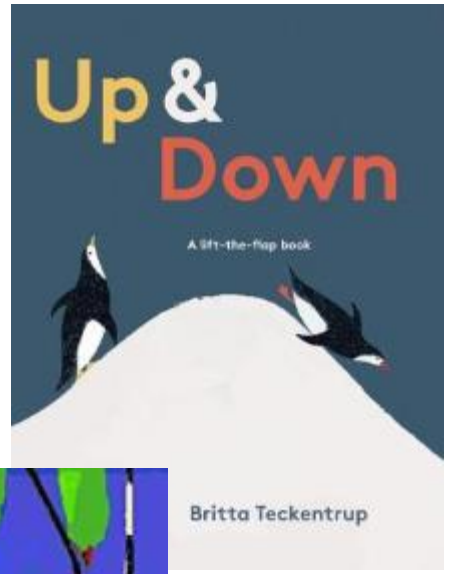


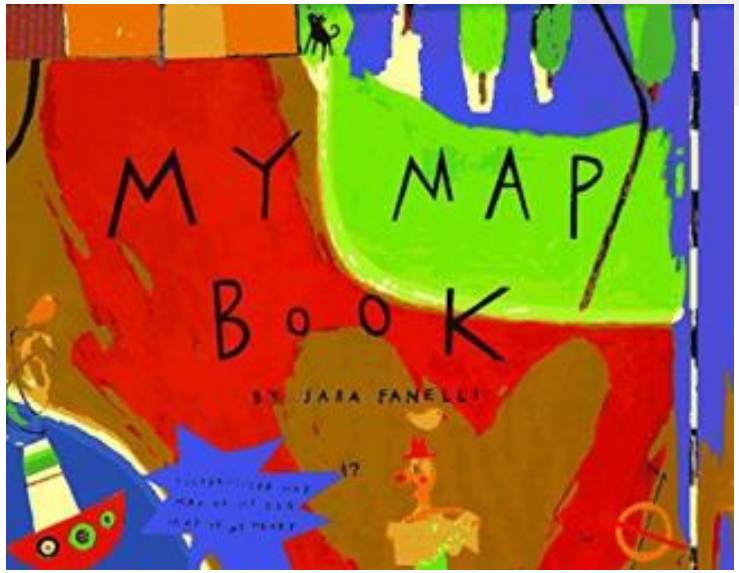
Barrier games

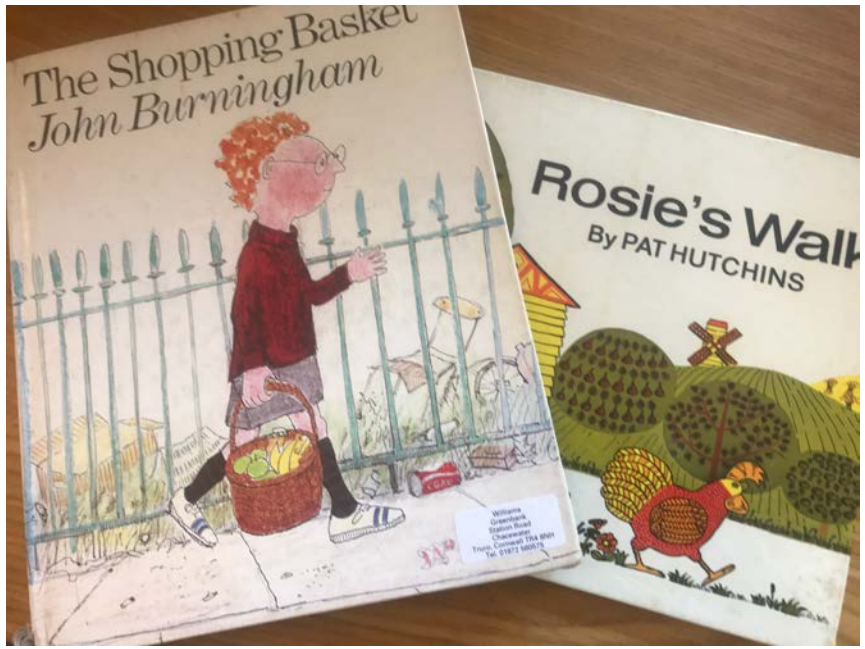
Make it the same

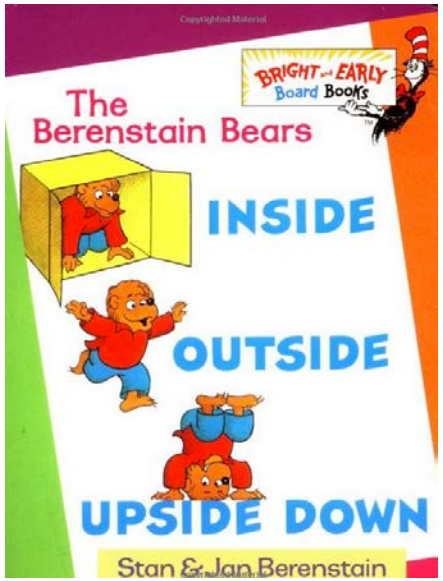


Picture books and mapping









Block play

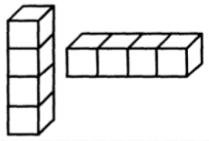
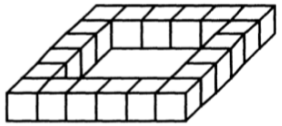
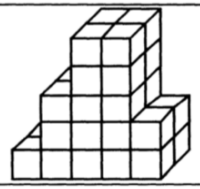
- Remains on the periphery of the curriculum
- There is evidence that gender differences in spatial skills begin early (4/5 years)
- Gender differences are not consistent when examining ***competency*** rather than ***preference***

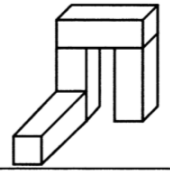
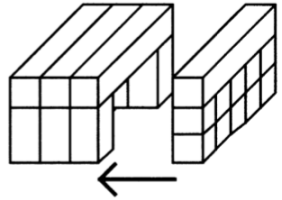
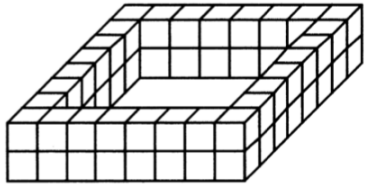
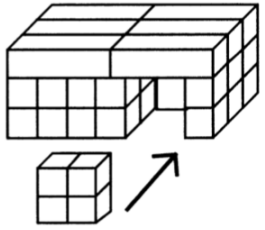
Image: Froebel block play project (Gura 1992)

Casey et al (2008)

- *This study included two intervention conditions:*
- *(1) a block building intervention embedded in a story context,*
- *(2) the same block building intervention without a storytelling context.*
- *The stories used in this research were designed to engage children's motivation by providing a narrative context in which the story characters ask the students' help in solving the block building problems*

Block play trajectory (Casey et al, 2008)

Level	Description	Example
0	Random block placement	
1	1-d (1-dimensional) structures – row of single blocks, or stack of single blocks	
2	2-d structures (no internal space) – structure with no width (a wall), no height (a floor), or no length (a 2 block-wide tower)	
3	2-d structures with vertical internal space – arches	
4 *4.5:* regular/no gaps	2-d structures with horizontal internal space –enclosure only 1 block high (no height)	
5	3-d structures – 3-d piles with no internal space	

Level	Description	Example
6	3-d structures – 2-d vertical or horizontal internal space plus depth to make a 3-d structure: arch + 1 or more blocks placed in front or behind, or 2 separate walls, 2 blocks high + 1 or more blocks connecting the 2 walls *6.5:* series of arches (a tunnel)	
7	3-d horizontal enclosure: 1 block-high enclosure (or partial enclosure) + layer of roof blocks – adds height to make a 3-d structure irregular 1 block-high enclosure with roof – gaps/sloppy *7.5:* regular (no gaps) 1 block-high enclosure with roof, or series of arches (tunnel + third wall – makes a partial horizontal enclosure	
8	3-d horizontal enclosure 2 blocks high irregular 2-block high enclosure-gaps/sloppy 8.5: regular (no gaps) 2-block high horizontal enclosure	
9	3-d horizontal enclosure 2 blocks high + roof + divided internal space	

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

- "… primary children's ability to hit a moving target with a bat (tested on a virtual screen) correlated with six months advance in mathematics. (This research conducted in Bradford was aptly illustrated in the Daily Telegraph - *left*).
- 'interceptive timing' eg: predicting the trajectory and speed of a ball and moving your arm to meet it, involves 'neural circuitry' to represent time and space which overlaps with that representing number."

(Gifford, 2019)

"Better hand-eye co-ordination could lead to improved maths grades, study finds."

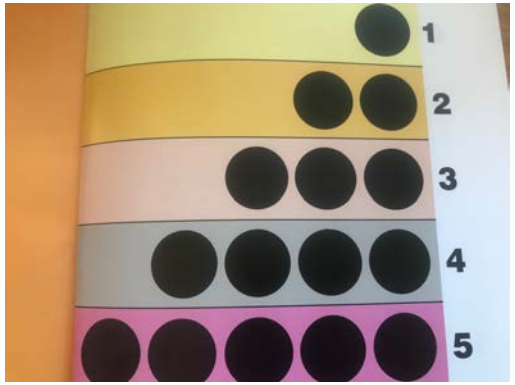
"… The neural circuitry used to build up a child's understanding of their external environment, the way they orientate themselves spatially.. is also used to process numbers and more abstract thinking."

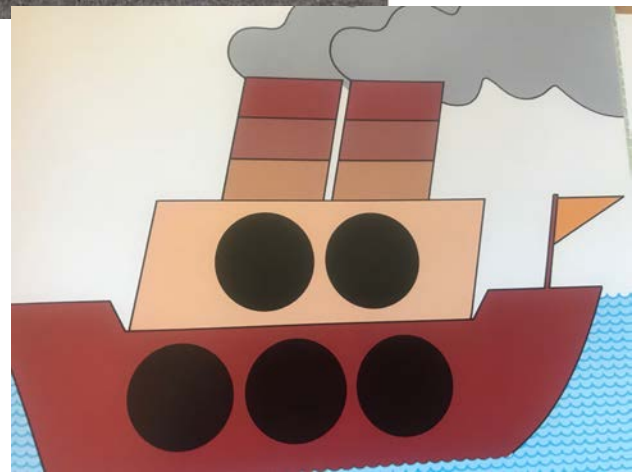
(Giles et al 2018)

What are the links to number?

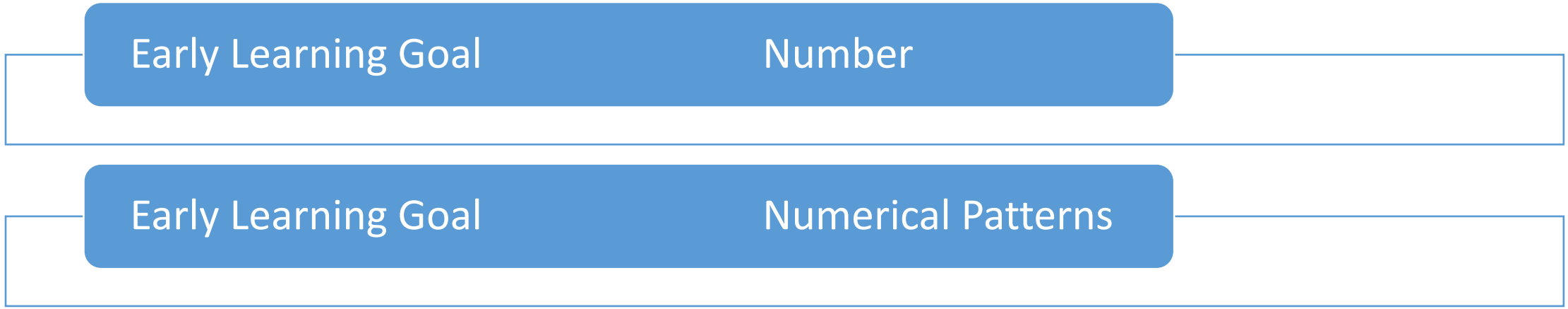
"When children come to learn about number composition, or numbers being made up of smaller numbers, spatial experiences are important because they provide memorable visual patterns and physical experiences of rearranging manipulatives (including fingers) to construct and connect images."

(Gifford 2020)





Early Years Foundation Stage (EYFS) 2021
Early Learning Goals for Mathematics



Our focus should be on …

The Educational Programme for mathematics (DfE 2020:10):

"Developing a strong grounding in number is essential so that all children develop the necessary building blocks to excel mathematically. Children should be able to count confidently, develop a deep understanding of the numbers to 10, the relationships between them and the patterns within those numbers.

By providing frequent and varied opportunities to build and apply this understanding - such as using manipulatives, including small pebbles and tens frames for organising counting - children will develop a secure base of knowledge and vocabulary from which mastery of mathematics is built.

(Contd..)

The Educational Programme for mathematics (DfE 2020:10):

In addition, it is important that the curriculum includes rich opportunities for children to develop their spatial reasoning skills across all areas of mathematics including shape, space and measures.

It is important that children develop positive attitudes and interests in mathematics, look for patterns and relationships, spot connections, 'have a go', talk to adults and peers about what they notice and not be afraid to make mistakes."

image: Bincombe Valley

The Characteristics of Effective Teaching and Learning

EYFS STATUTORY FRAMEWORK
(DfE 2017)

Characteristics of Effective Learning (CEL)

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

Ofsted Mathematics Information Pack (2013)

What am I taking away from this?

How could I take this forward?

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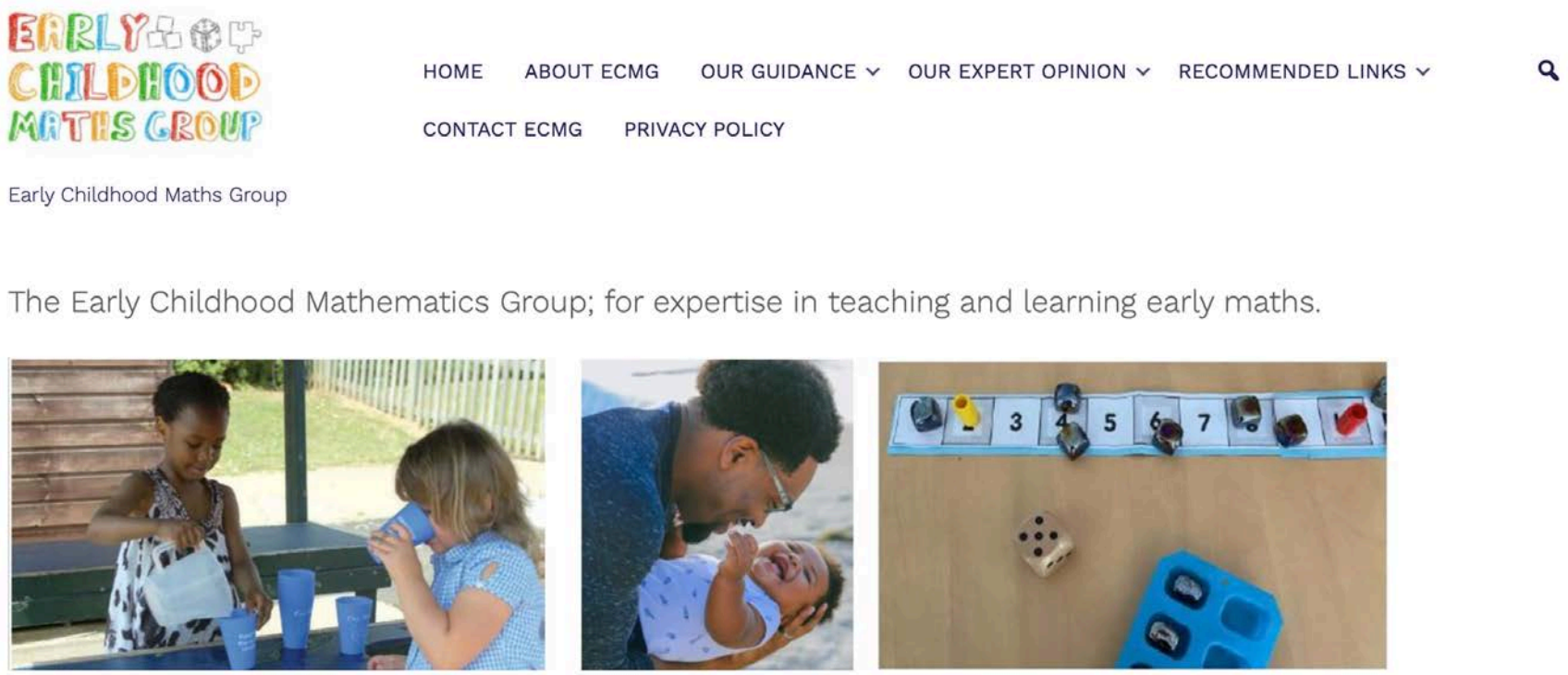
https://earlymaths.org @EChildhoodMaths
https://earlymath.erikson.edu
https://dreme.stanford.edu
https://www.learningtrajectories.org



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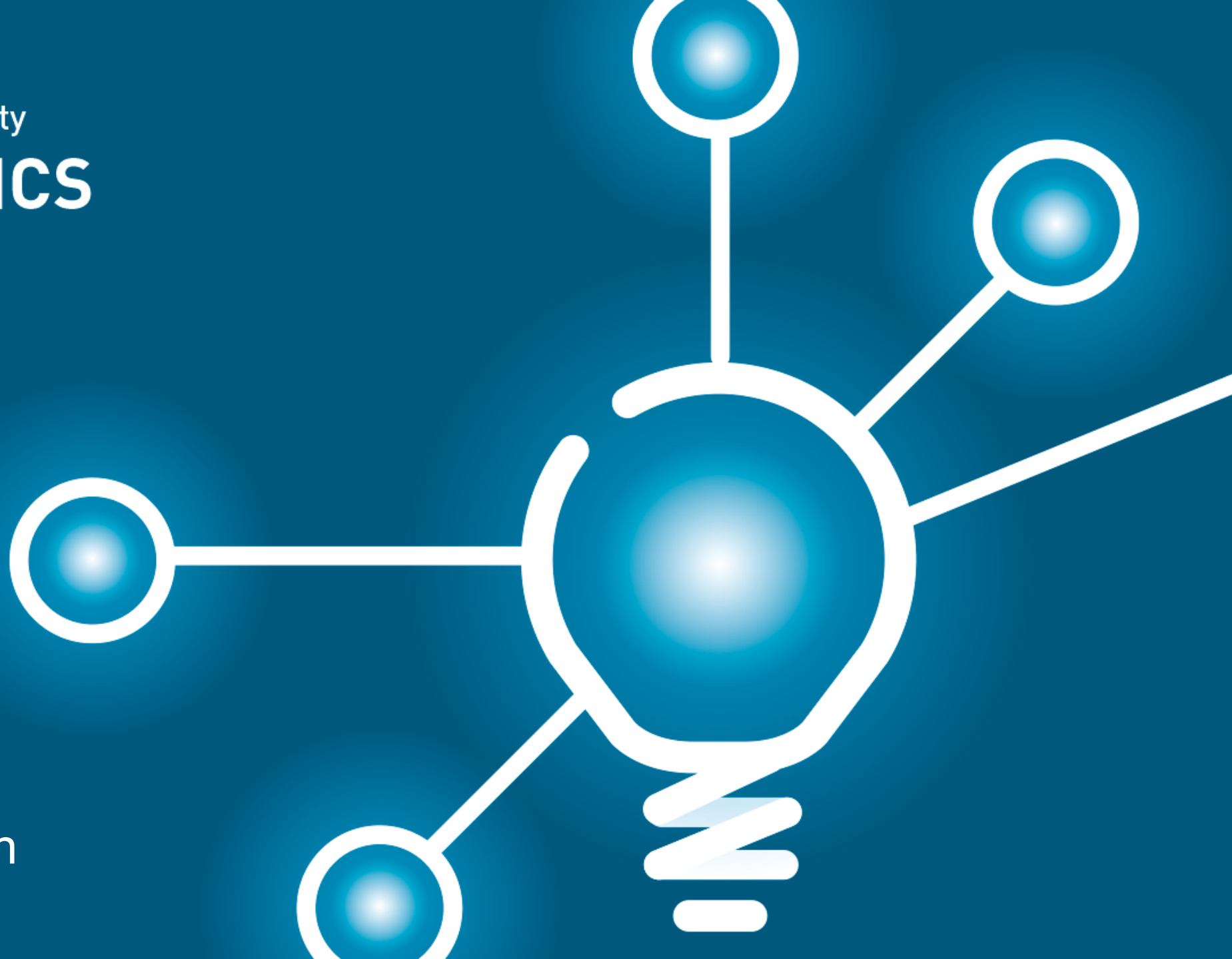

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