This article originally featured in the Spring 2022 edition (Volume 26, Number 1) of Primary Mathematics by the Mathematical Association and is available here with their kind permission.

The ECMG trajectory of early learning experiences to develop spatial reasoning

Sue Gifford

Part of the spatial reasoning trajectory for 6 and 7 year olds

Mulligan et al (2020)

'Spatial reasoning' is now part of the statutory Educational Programme for children from birth to five years in England (DfE, 2021:110) and identified by research as a key contributor to mathematical learning (Cambridge Mathematics, 2020). However, the term is unfamiliar to most early years practitioners and teachers, who were accustomed to *shape and space*. Requiring them all to suddenly teach spatial reasoning seemed a tall order to the Early Childhood Maths Group **(ECMG) (https://earlymaths.org)**

We know that one of the most useful kinds of support for practitioners is a guide to 'what to look for' in children's behaviour, showing how their skills and understanding are developing, together with ideas for 'what to plan next', including provision, interactive strategies and activities. So, we set out to produce a learning trajectory based on the best information and examples we could find from research and practice. There are other trajectories available, notably *Development matters*, (DfE, 2021), *Birth to five matters,* (Early Education, 2021), NCETM's *Early years* progressions (NCETM, 2019) and not least, Clements and Sarama's (2021) *Learning trajectories*. However, all of these have limitations, either of brevity or accessibility for the English context and none of them deal specifically with spatial reasoning. As we believe that the early years include the first school years, where spatial learning seems to have become rather neglected recently, our trajectory is for children from birth to seven years old.

A six year old's map of the route home from school via the park (Oli and Jenni Back)

Part of the spatial reasoning trajectory, tracking construction from birth to seven

The trajectory is based on a broad view of spatial reasoning from recent research. The role of children's early physical development is emphasised, including body awareness and navigating the spatial environment. It reflects new findings from research, such as the importance of supporting two year olds with jigsaws and the map-making capabilities of four year olds. We also include examples of less familiar aspects such as perspective-taking and scaling.

The trajectory is finely graded according to ages: younger babies, older babies, toddlers, 2 year olds, 3

year olds, 4 and 5 year olds and 6 & 7 year olds. This provides appropriate suggestions for those working with particular age groups, without assuming that an individual child ever conforms to a 'typical' trajectory. Most aspects can be tracked through the trajectory, although some, such as perspective-taking and scaling, are emphasised more in the later age ranges. Below is the trajectory for construction, tracked through the age ranges:

	Children are learning to..	Adults might..	The environment might include..
Younger babies	**Explore differently shaped objects and their properties through** seeing and feeling/ mouthing	Encourage babies' explorations of the characteristics of objects, *e.g. by rolling a ball to them.*	Interestingly shaped objects *e.g. vegetables, spoons, corks, pinecones, balls*
Older babies	**Begin to put objects** inside others and take them out again	Talk about the properties of shapes, e.*g. flat, round, curvy, bumpy.*	Blocks and boxes to build with
Toddlers	**Begin to explore stacking** objects with flat surfaces together, e.g. stacking blocks and cups	Play alongside children building their own structures, building your own structures and providing a commentary or building together.	A range of construction materials, *e.g. wooden blocks, packaging.* Storage with photos to show where things are kept.
2 year olds	**Make simple constructions** with blocks, combining identical shapes to make walls, towers, etc.	When building, talk about the shape of the blocks you are selecting and why.	A variety of construction materials for indoor and outdoor play.
3 year olds	**Create** arches and enclosures when building, using trial and improvement to select blocks	Sensitively support and challenge experienced builders to make specific structures e.g. bridges and rooms. Offer choices *(Would you like one of these or one of these next?).*	Large and small blocks and boxes available for construction both indoors and outdoors, *e.g. for making entrances, bridges, walls and dens.*
4 and 5 year olds	**Build complex compositions** including repeated units, (such as arches made of three blocks), corners (pieces at right angles) and ramps. Selects shapes to solve a problem **Plan mentally** by visualising what they will build and selecting blocks needed	Challenge children to make more complex constructions (perhaps in story contexts), *e.g. with towers or arches, a window or a staircase.*	A wide range of materials for construction indoors and outdoors including unit blocks and a range of recycled materials which provide real life examples of shapes *e.g. kitchen roll tubes, cube tissue boxes, party hats, tyres, drainpipes, planks, canes and connectors etc.*
6 and 7 year olds	**Relate 2D and 3D** in making models from photos and plans (2D-3D) and do drawings of 3D models and arrangements (3D-2D).	Support children to build more complex constructions, using exploded model diagrams, e.g. 	Images of constructions made with blocks (including exploded models) for children to discuss, compare and improve upon. Consider a 'Lego club' with family members or older children.

Learning Trajectory for Construction, ECMG

We have separated spatial reasoning into 'spatial relations' and 'objects and images', (roughly corresponding to 'space' and 'shape', coloured blue and green respectively on the online format). However, separating these proved tricky: for instance, construction is about identifying shape properties, but we included it in 'spatial relations' because it also involves fitting shapes together by turning or flipping. We also gave up trying to pigeonhole scaling and included it in both sections.

Spatial relations:

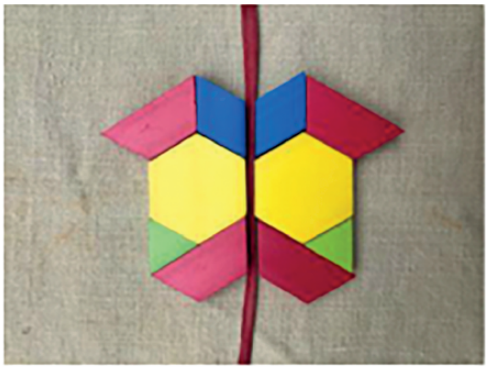
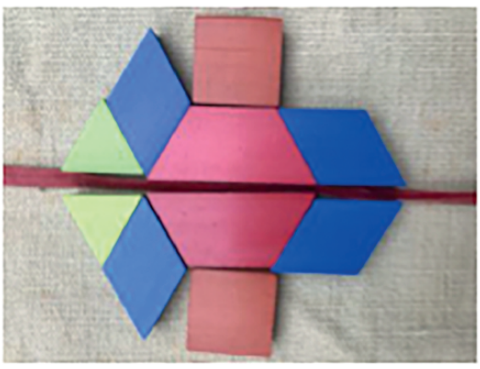
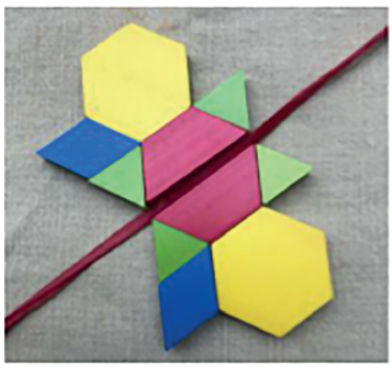
- **language of position - *Where?*** in relation to one or two things e.g. next to, between; relative to the viewer, *e.g. in front of, behind*
- **distance - *How far away?*** Length and area, *e.g. near, in the middle*
- **direction - *Which way?*** Moving around, *e.g. up/down, forwards/backwards, left, right*
- **changed orientation - *Which way up (or round)?*** *Upside down, back to front, tipped over, this way up*
- **composing -** fitting together 2D and 3D shapes, using interrelationships between properties *e.g. with jigsaw puzzle pieces, pattern blocks, nesting containers and construction.*
- **movement and rotation -** *e.g. turning, sliding or flipping a shape or jigsaw puzzle piece to fit or match*
- **symmetry recognition -** in 2D and 3D, reflecting, pattern making, block-building
- **perspective-taking -** appearance from different viewpoints
  - * visibility (what can be seen, e.g. hidden or partially visible)
  - * size and distance (how things far away look smaller)
  - * position (where objects are in relation to each other, e.g. things behind each other appear to overlap)
  - * appearance (e.g. how circles can look like ovals from certain viewpoints)
- **scaling -** zooming in and out, e.g. small-world play and map-making
- **navigation -** *e.g. way finding and routes*

Objects and images

- **identifying - What?** 2D and 3D including the shape of everyday objects such as cups, clothes, jigsaw pieces, leaves and clouds, *eg. circle, rectangle, triangle, heart-shaped; cuboid, cone, ball, roof-shaped.*
- **properties -** including:
  - * size, e.g. big, tall, wide
  - * sides, faces, edges, lines; *e.g. straight/ curved, wiggly, zig-zag*
  - * corners and angles *e.g. points, vertices, right angle, square corner, sharp*
- **cutting and decomposing shapes** to make new shapes, parts within wholes, bending and folding *(e.g. making cylinders with paper strips, unfolding boxes to make nets and then refolding, halving shapes, creating symmetries)*
- **structure -** symmetry, cross-sections, 2D to 3D
- **scaling -** identifying the same item in different sizes, enlarging and shrinking

These aspects provide a much broader view of maths than that traditionally included in *shape and space*, linking with *pattern and measures* as well as many other aspects of the curriculum, such as physical development, art and geography. In our trajectory There are three columns in each age range, headed, *Children are learning to…, Adults might…,* and *The environment might include….* These include examples of children's behaviour, supportive teaching strategies and provision.

We found that identifying a spatial reasoning trajectory suggests giving young children access to an excitingly rich mathematical education. It also suggests that many more spatial activities and experiences remain to be identified, supported and celebrated, as contributing to young children's mathematical development.

Clements . D.H. & Sarama, J. (2021). Learning and teaching early math: the learning trajectories approach 3rd edition. Abingdon: Routledge and ***https://www.learningtrajectories.org***

DfE (2021) Statutory Framework for the early years foundation stage ***https://www.gov.uk/government/publications/early-years-foundation-stage-framework--2***

DfE (2021) Development Matters ***https://www.gov.uk/government/publications/development-matters--2***

Early Education (2021) Birth to 5 Matters ***https://www.birthto5matters.org.uk/***

Mulligan, J., Oslington, O., & English, L. (2020) Supporting early mathematical development through a pattern and structure intervention program. ZDM, 52, 663-676.

NCETM (2019) Early years materials ***https://www.ncetm.org.uk/in-the-classroom/early-years/***

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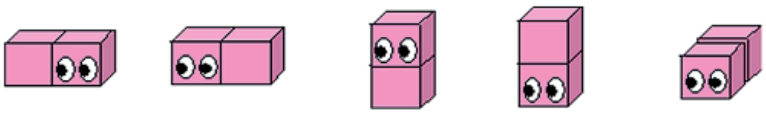
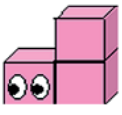
Wag Worms

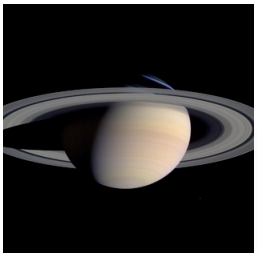
When intergalactic Wag Worms are born they look just like a cube. 

Each year they grow another cube in any direction (except on their faces, of course). So a two-year-old Wag Worm might look like any of these:



So one shape a three-year-old Worm can be is this:





Can you find all the shapes a three-year-old Wag Worm could be?

Image of Saturn: NASA / Wikimedia Commons

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