Spatial abilities and Mathematics; from the lab to the classroom

Prof. Emily Farran
University of Surrey
10th July 2025

Spatial Abilities

Spatial abilities provide one with the ability to:

- Understand the location and shape of objects and the relations between them.
- Visualise: mentally represent and manipulate objects (including parts and wholes)
- Use tools to spatialise thought (e.g. language, graphs, maps)

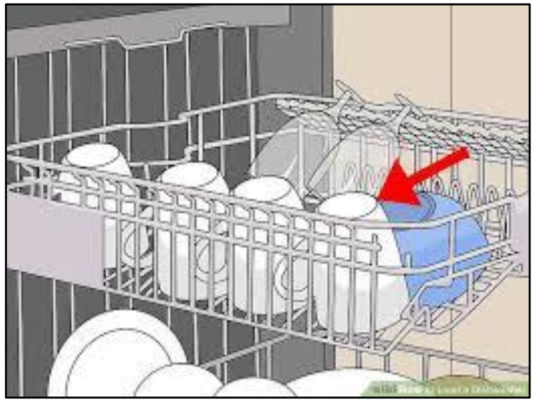


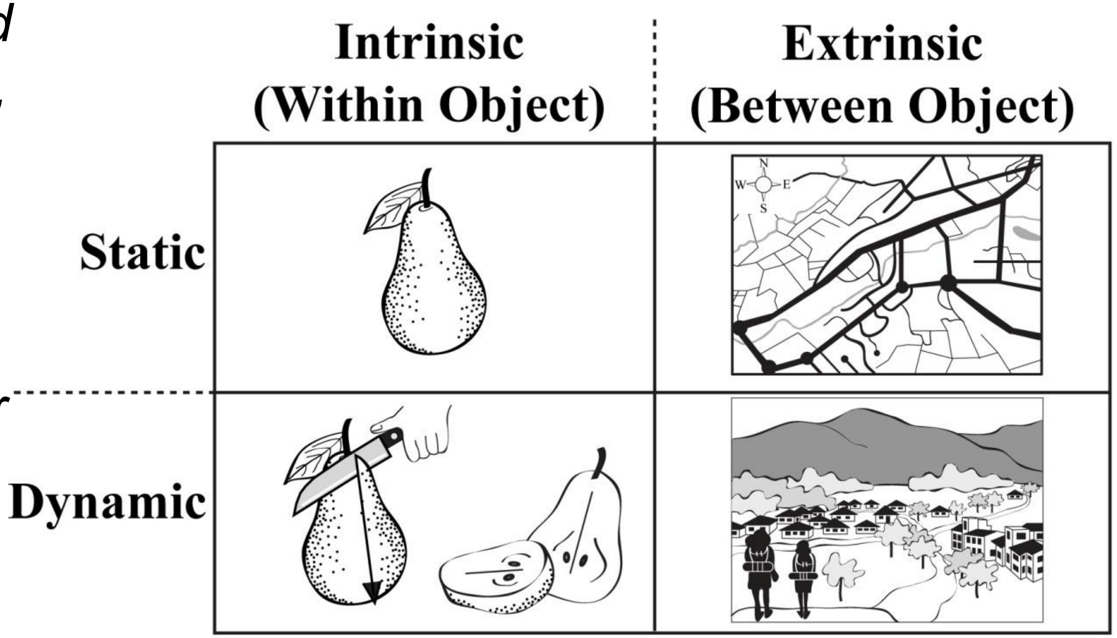
photo by Alan Levine

e.farran@surrey.ac.uk

Defining spatial abilities

" Any kind of action in a spatial world is in some sense spatial functioning, and hence can sensibly be called spatial cognition".

Intrinsic: the structure of objects, their parts and the relationship between these parts.
Extrinsic: the location of an object, relationships between objects, the position of objects viewed from different perspectives.



(Uttal et al., 2013; Newcombe & Shipley, 2013)

The importance of spatial abilities

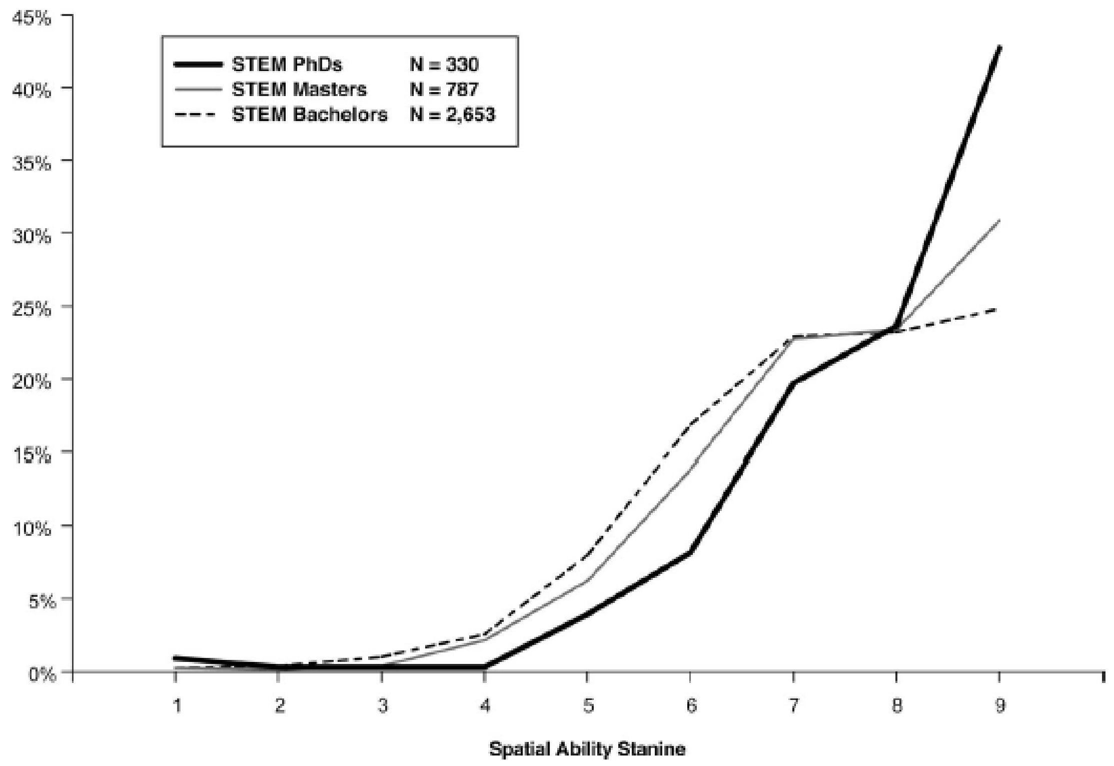


Figure 7. This figure includes the proportion of each degree group (bachelors, masters, and PHDs) as a function of spatial ability. Along the *x*-axis are the spatial ability stanines (numbered 1 through 9). STEM = science, technology, engineering, and mathematics.

Data from 400,000 randomly sampled students in the USA (Wai, Lubinski & Benbow, 2009)

The importance of spatial abilities

- £1.5bn in losses are reported per year due to STEM skills shortages (IET report 2021).

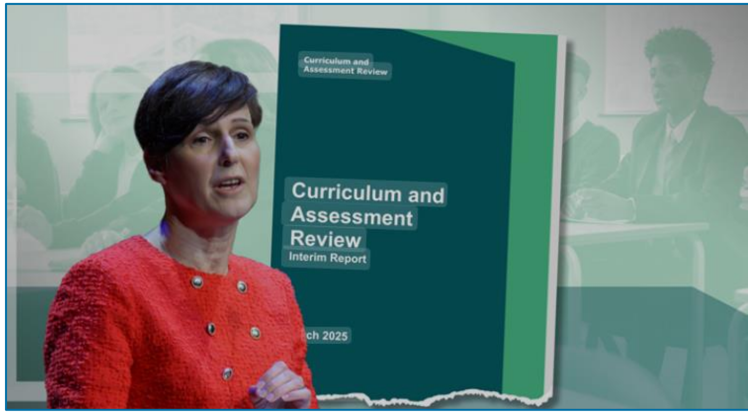
- Employment revolution has seen an increase in the use of data across careers (Royal Society, 2023).

- Reasoning and problem solving are key skills valued by employers (Maths Horizons, 2025).

- Global demand for STEM solutions (United Nations, 2018).

- Labour government missions.

Goal: Increase the number of people going into, and remaining in, STEM careers.



e.farran@surrey.ac.uk

The importance of spatial abilities

Meta-analyses - spatial training: spatial abilities are highly mall[illegible] spatial training is effective, durable, and transferable (Uttal et [illegible]g et al., 2020).

Meta-analysis - spatial-maths a[illegible]g and consistent relationship between s[illegible]cal skills. Consistent across gender and age [illegible]

Meta-analysis - [illegible]raining and mathematics: 29 studies; spatial training is effective for i[illegible]g both spatial abilities and mathematics. This is most effective when the spatial training includes physical manipulatives (Hawes et al., 2022).

“the connection between space and math may be one of the most robust and well established findings in cognitive psychology” (Mix & Cheng, 2012)

e.farran@surrey.ac.uk

The importance of spatial abilities

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the british psychological society
promoting excellence in psychology
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The developmental trajectories of spatial skills in middle childhood

Alex Hodgkiss*[1], Katie A. Gilligan-Lee[2], Michael S.C. Thomas[3], Andrew K. Tolmie[4] and Emily K. Farran[5]
[1]Department of Education, University of Oxford, UK

British Journal of Developmental Psychology (2016), 34, 555–568
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The development of spatial category representations from 4 to 7 years

Emily K. Farran* and Lauren Atkinson

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PAPER
WILEY Developmental Science

The developmental relations between spatial cognition and mathematics in primary school children

Katie A. Gilligan[1,2,3] | Alex Hodgkiss[2,3,4] | Michael S. C. Thomas[3,5] | Emily K. Farran[1,2,3]

Contents lists available at ScienceDirect
Learning and Instruction
journal homepage: www.elsevier.com/locate/learninstruc
ELSEVIER

Aged-based differences in spatial language skills from 6 to 10 years: Relations with spatial and mathematics skills

Katie A. Gilligan-Lee[a,*], Alex Hodgkiss[d], Michael S.C. Thomas[b,c], Pari K. Patel[a], Emily K. Farran[a,b]

British Journal of Educational Psychology (2018)
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Spatial cognition and science achievement: The contribution of intrinsic and extrinsic spatial skills from 7 to 11 years

Alex Hodgkiss[1]*, Katie A. Gilligan[1], Andrew K. Tolmie[1], Michael S. C. Thomas[2] and Emily K. Farran[1]
[1]UCL Institute of Education, University of London, UK
[2]Birkbeck College, London, UK

Journal of *Intelligence*
MDPI

...ilding Numeracy Skills: Associations between DUPLO® ...ock Construction and Numeracy in Early Childhood

...A. Gilligan-Lee[1,2,*], Elian Fink[3], Lewis Jerrom[4], Megan P. Davies[4], Caoimhe Dempsey[5], ...e Hughes[5] and Emily K. Farran[2,4]

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The contribution of spatial ability to mathematics achievement in middle childhood

Katie A. Gilligan*, Eirini Flouri, Emily K. Farran
Department of Psychology and Human Development, UCL Institute of Education, University College London, 25, Woburn Square, London WC1H 0AA, UK

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SPECIAL ISSUE ARTICLE
Developmental Science WILEY

First demonstration of effective spatial training for near transfer to spatial performance and far transfer to a range of mathematics skills at 8 years

Katie A. Gilligan[1,2] | Michael S. C. Thomas[3] | Emily K. Farran[1,2]

DOI: 10.1111/cdev.13963
REGISTERED REPORT
CHILD DEVELOPMENT

Hands-On: Investigating the role of physical manipulatives in spatial training

Katie A. Gilligan-Lee[1,2,3] | Zachary C. K. Hawes[4] | Ashley Y. Williams[2] | Emily K. Farran[2,3] | Kelly S. Mix[5]

Spatial ability as a gateway to STEM success

Original Research
Written by: Emily Farran
Published on: May 16, 2019

MIND, BRAIN, AND EDUCATION
EDUCATION

Reimagining Mathematics: The Role of Mental Imagery in Explaining Mathematical Calculation Skills in Childhood

Kathryn E. Bates[1], Katie Gilligan-Lee[2], and Emily K. Farran[3]

e.farran@surrey.ac.uk

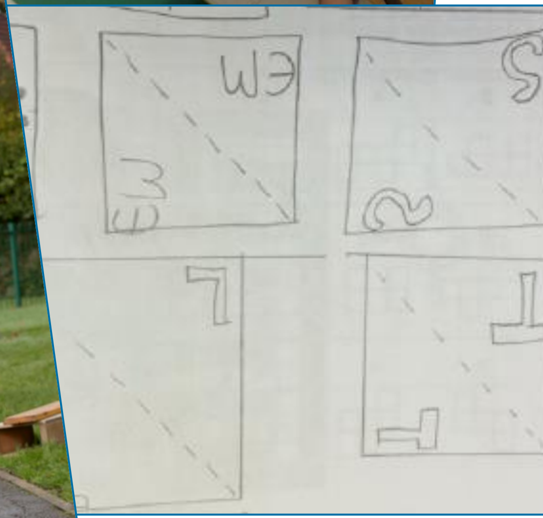
The importance of spatial abilities

» Strong spatial abilities:

  - more likely to be interested in science and maths
  - more likely to choose degrees in STEM subjects
  - more likely to be good at STEM research / STEM careers

- Spatial abilities can be trained

  "...would early attention to developing children's spatial thinking increase their achievement in math and science and even nudge them towards STEM careers? Recent research on teaching spatial thinking suggests the answer may be yes" (Newcombe, 2010)



e.farran@surrey.ac.uk

Spatial reasoning and the mathematics curriculum

- EYFS 2021: Shape, Space and Measure early learning goal removed.
- Geometry is often not prioritised (Ofsted, 2023).
- Geometry is underspecified; lacks visualisation, a key aspect of spatial reasoning.

Recent Policy documents:

- Ofsted 2024 Best start in life. Part 3: *“Understanding both number and spatial reasoning is crucial to later achievement”*
- Royal Society Mathematical Futures (2024): *“there should be greater emphasis on conceptual understanding and a stronger focus on spatial reasoning”*
- Maths Horizons executive overview (2025): *“[Curriculum] often neglects the purpose, progression and “habits of thinking” that underpin [content], such as spatial reasoning, argument, interpretation and critique.”*
- Maths Horizons full report (2025): *“...spatial reasoning is a powerful but under-utilised foundation for mathematical learning with broad benefits for maths, including geometry, measures, number, algebra and statistics.”*

e.farran@surrey.ac.uk

Spatial abilities and mathematics: BLOCs

https://www.surrey.ac.uk/block-construction-skills-mathematics-blocs
Funded by the Leverhulme Trust
McDougal, Silverstein, Treleaven, Jerrom, Gilligan-Lee, Gilmore & Farran (2023a) https://doi.org/10.31234/osf.io/5hvpx

Emily McDougal

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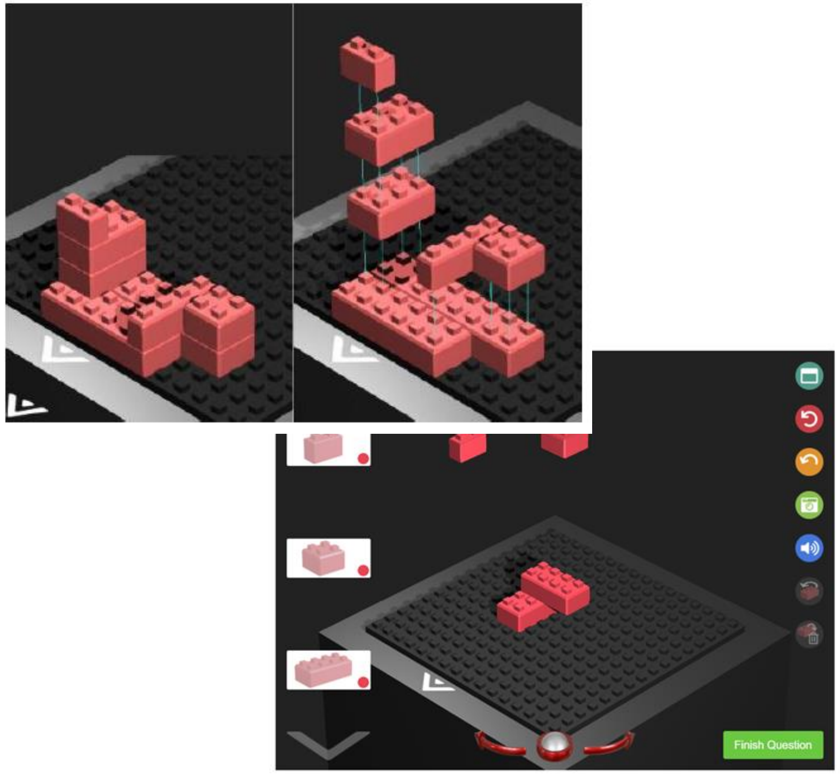
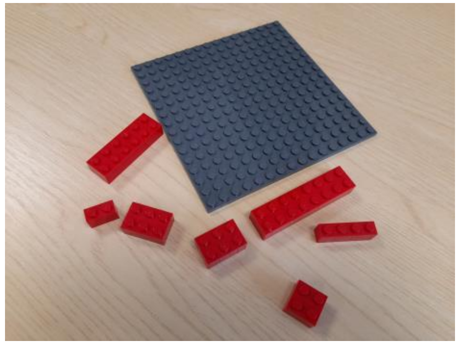
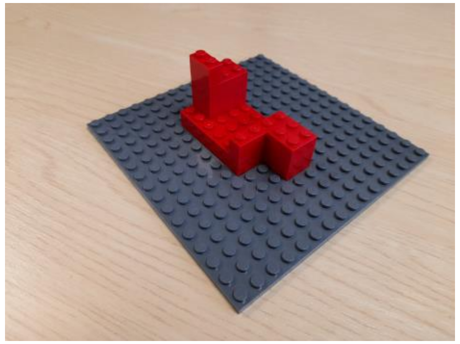
Phase 1: Associations

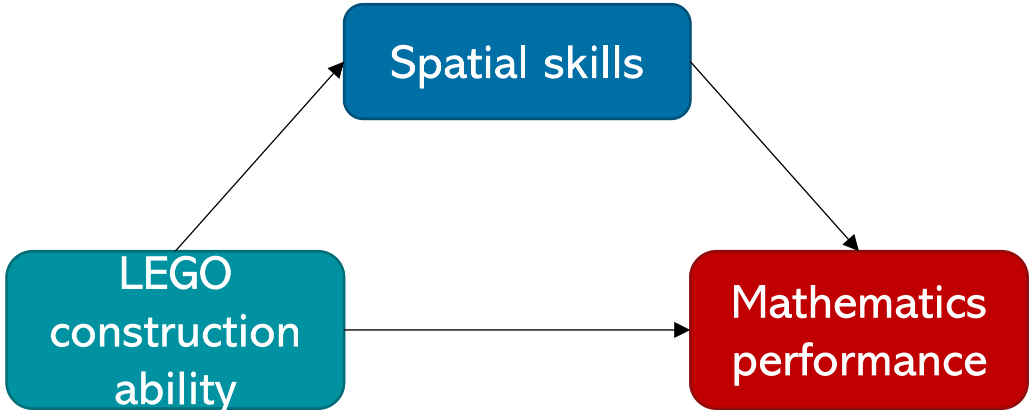
To what extent do spatial abilities explain the relationship between LEGO construction and mathematics performance in 7- to 9-year-olds?



Block Construction
Skills
For Mathematics
BLOCS







e.farran@surrey.ac.uk

Spatial abilities and mathematics: BLOCs

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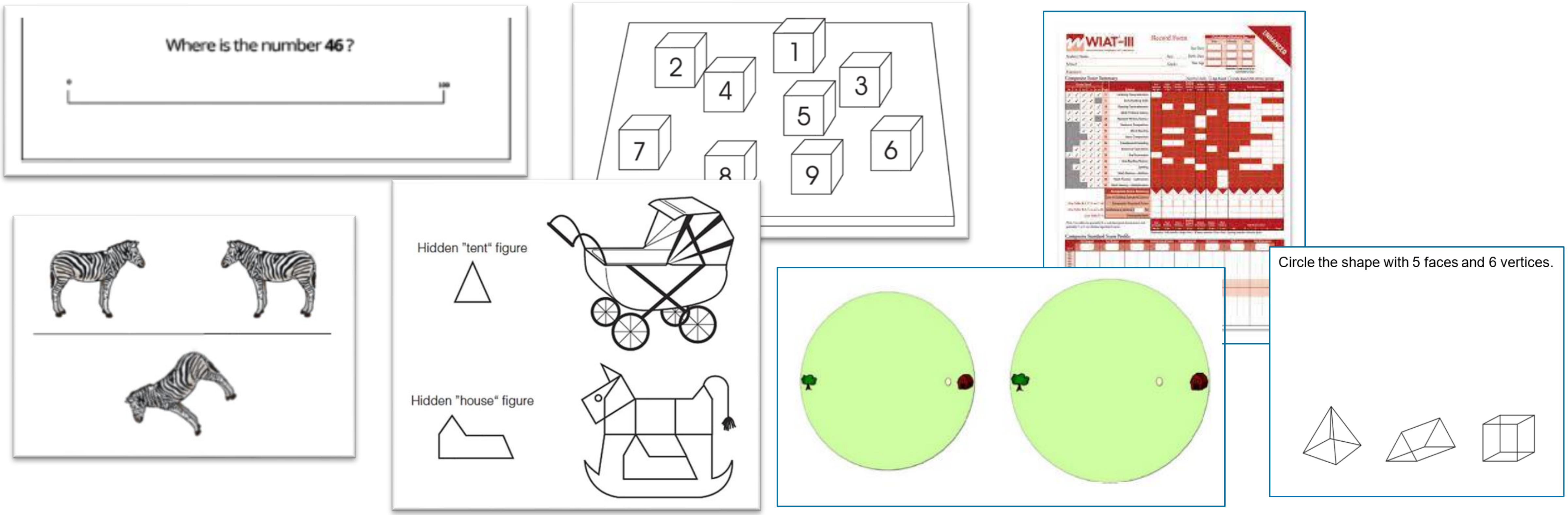

- Strong and consistent relationship between Lego construction ability and maths competence (numeracy, geometry and mathematics problem solving).
- Mediated by disembedding, spatial-numerical representation, mental rotation, visuo-spatial working memory

e.farran@surrey.ac.uk

BLOCs Intervention

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McDougal, Silverstein, Jerrom, Gilligan-Lee, Gilmore & Farran (2023b). https://doi.org/10.1111/desc.13432

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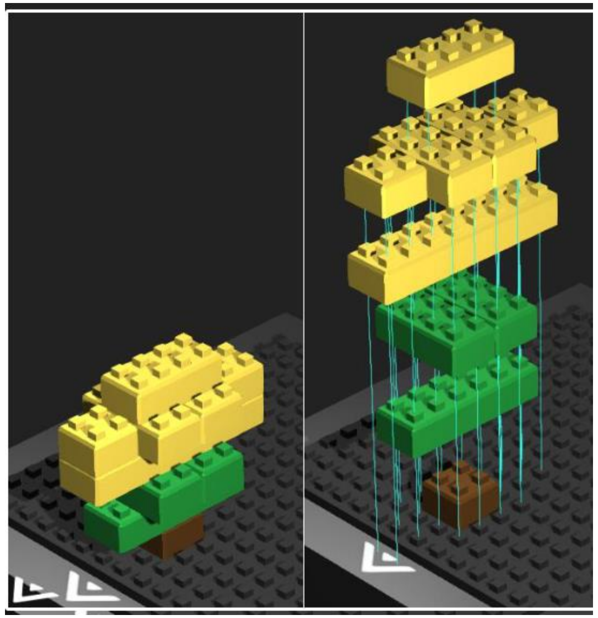
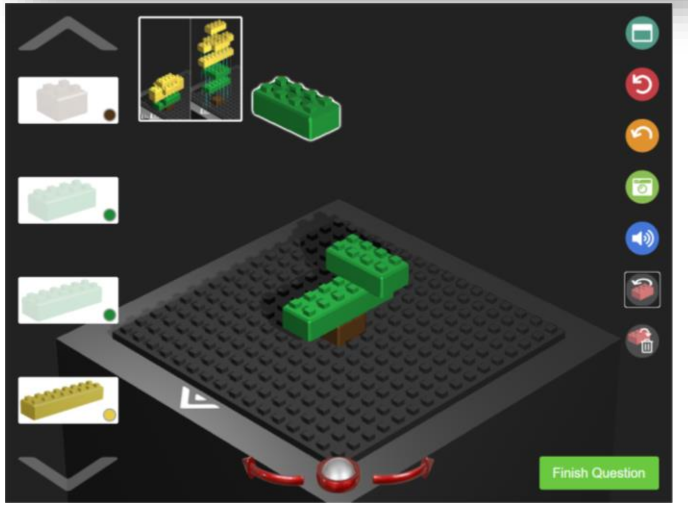
Phase 2: Intervention

1. Does physical and digital Lego training positively impact spatial and mathematical skills?
2. Do physical and digital Lego training have different effects on the spatial and mathematical skills measured?





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Block Construction Skills For Mathematics

BLOCS

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- Piloted with children and teachers
- Participants: N= 206, 7 to 9 years
- Intervention delivered by school staff: lunchtime club.
- Staff support: training, manual, weekly visit from a researcher.
- Story theme/ week (scientists, pirates, explorers, aliens, superheroes, spies).

Time 1: Spatial and Mathematics Task Battery (similar to Phase 1 study)

↓

Physical Lego | Digital Lego | Active Control Training

12 x 30 minutes, 2 per week

↓

Time 1: Spatial and Mathematics Task Battery (similar to Phase 1 study)

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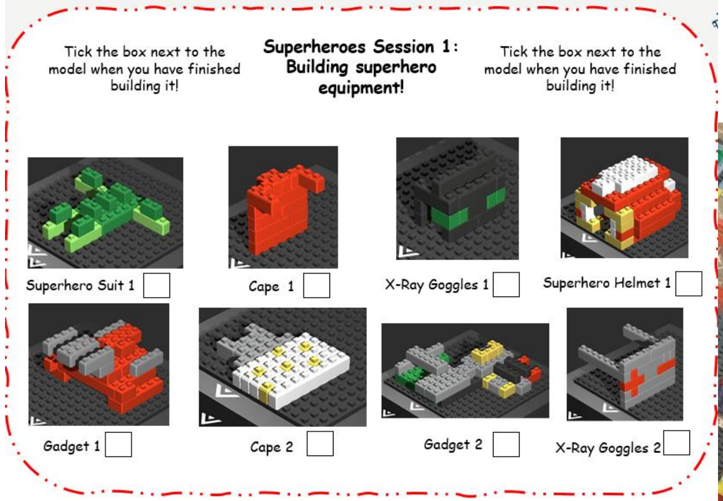
Block Construction Skills For Mathematics

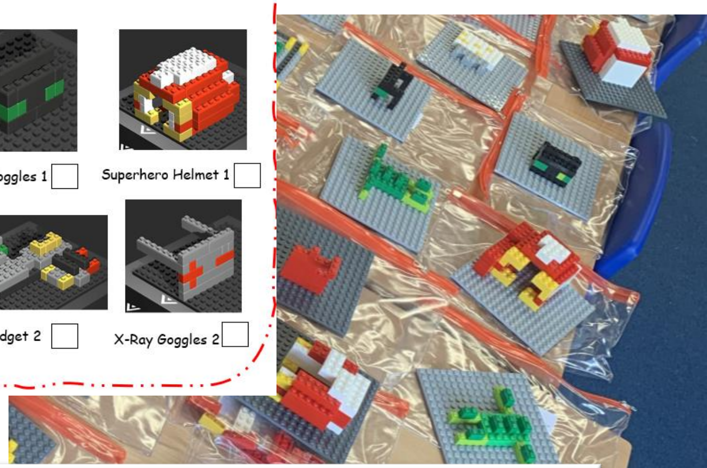
BLOCS

Lego intervention (physical)

» Children watch 2 min video and are given a booklet of 8 models to build (pictorial instructions) and 8 wallets of brick sets. Children work individually.

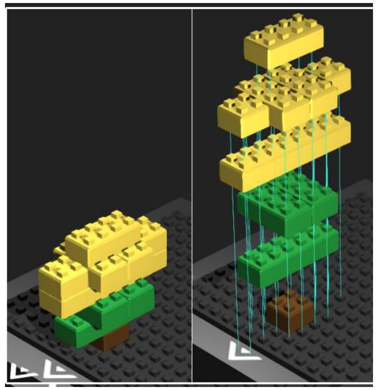
» For each model, the booklet displays the finished model and an exploded diagram of the model, and a tick box page for children to tick as they complete models.





Lego intervention (digital)

» As above, but pre-session on how to use the digital game and models are built digitally

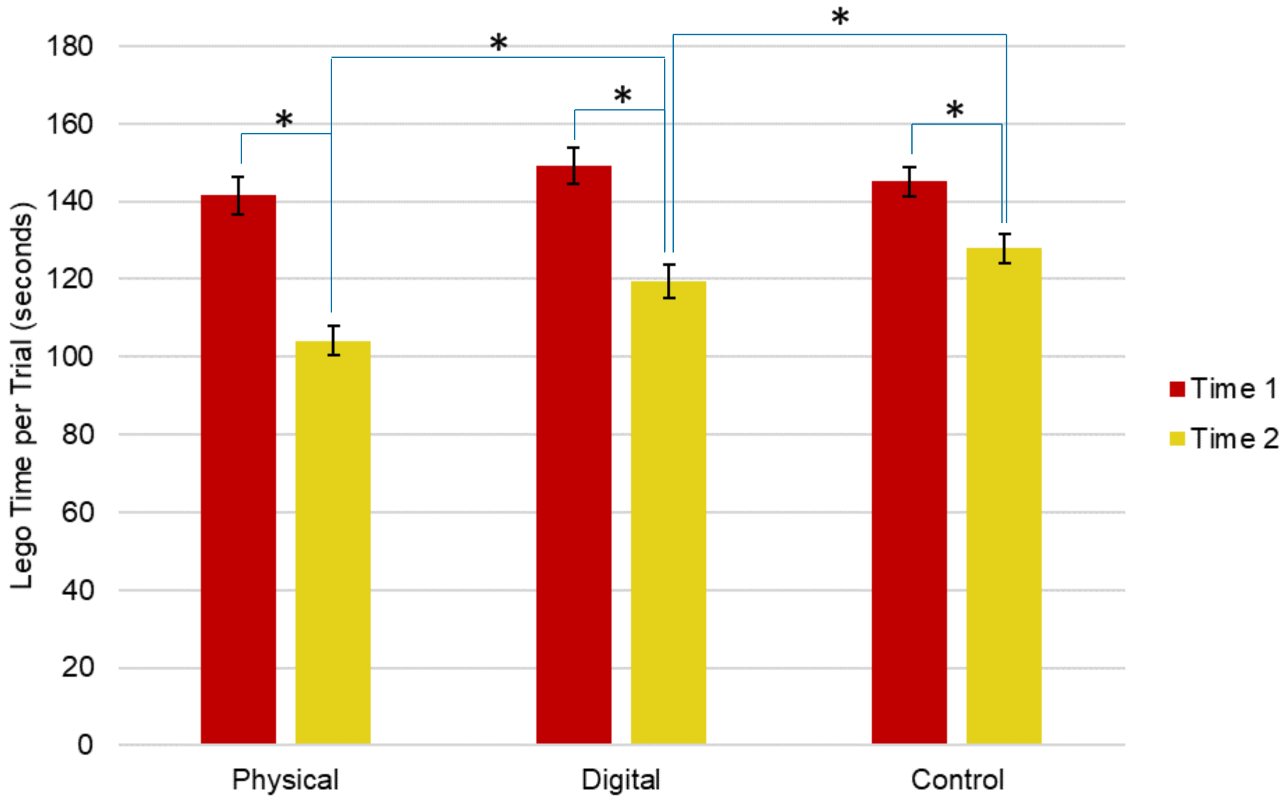


Active control

» Two craft activities per session

e.farran@surrey.ac.uk

Near transfer: Lego construction



Accuracy
No difference between groups:
$F(2, 179) = .69, p = .501$
Improvement in all three groups

RT

Performance significantly differed between training groups:

$F(2, 178) = 12.66, p < .001$

Physical > Control

Digital > Control

Physical > Digital

Improvement in all three groups

e.farran@surrey.ac.uk

Medium transfer: Spatial measures

Visuo-spatial working memory: **No difference** between groups: F (2, 185) = .61, p = .55
No within-group differences

Spatial scaling: **No difference** between groups: F (2, 189) = .15, p = .86
No within-group differences

Number line estimation: **No difference** between groups: F (2, 190) = .61, p = .55
No within-group differences

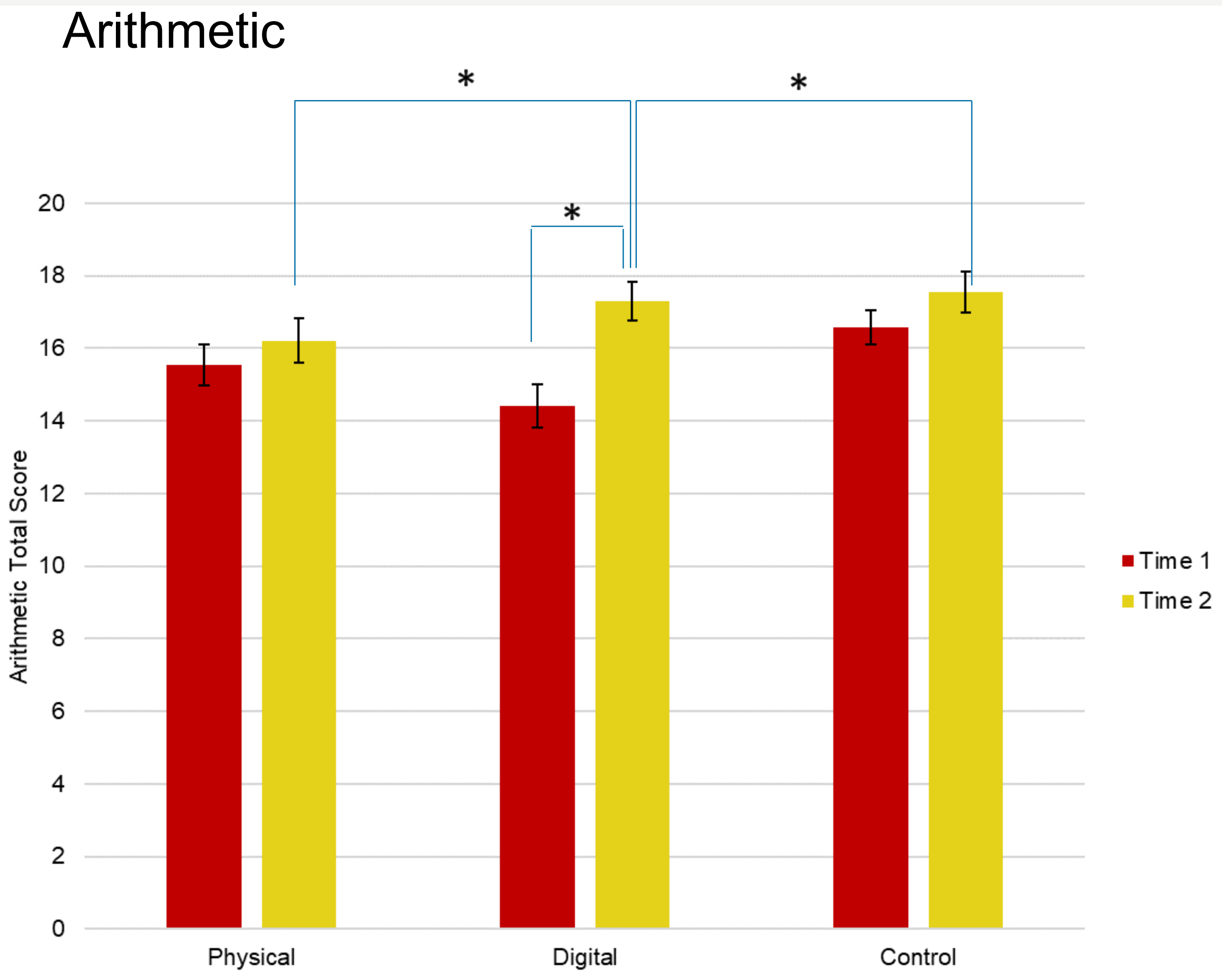
Mental rotation: **No difference** between groups: F (2, 179) = .87, p = .42
Improvement in mental rotation scores for digital group only

Disembedding: **No difference** between groups: F(2, 189) = 2.37, p = .096

Improvement in all three groups

e.farran@surrey.ac.uk

Far transfer: Mathematics measures



Arithmetic

Performance significantly differed between training groups:

$F(2, 172) = 8.15, p < .001, \eta_p^2 = .087$

Digital > Physical

Digital > Control

Improvement in digital group

Geometry

No difference between groups:

$F\ (2, 185) = .45, p = .64$

Overall mathematics

No difference between groups:

$F(2, 177) = .04, p = .958$

e.farran@surrey.ac.uk

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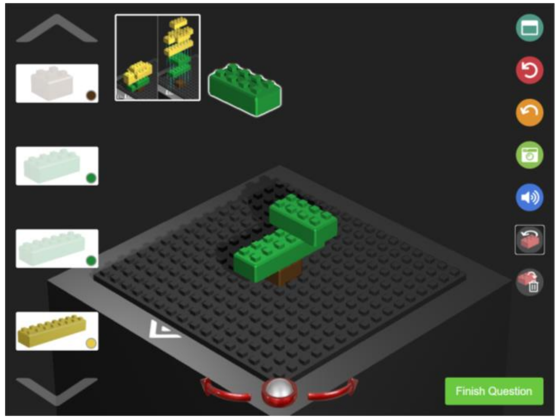
McDougal, Silverstein, Jerrom, Gilligan-Lee, Gilmore & Farran (2023b). https://doi.org/10.1111/desc.13432

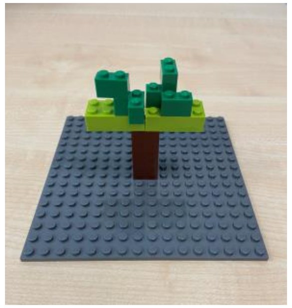
» Associations existed (replication of McDougal et al., 2023).

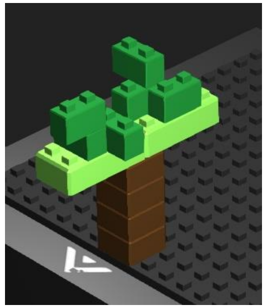
» Lego construction training: Evidence for near transfer (Lego construction ability) and far transfer (arithmetic)



» Far transfer for digital Lego only:

- Digital training supports general reasoning development (children formed and held mental representations)
- Do children rely more on the numerical properties of digital bricks (counting and multiplying pips) when digital, but use size estimation for physical bricks?





e.farran@surrey.ac.uk

Feedback from BLOCs teachers

“I think they really enjoyed having the theme to each week. I think that made it a bit more exciting.”

“They love structure … They love how they know exactly what to do”

“[it was challenging] being just me and not having somebody maybe like kind of rounding them up.”

“I think that's hard then when you do it in their break times. It's kind of like a double-edged sword of, it's fun, but they want that kind of ‘this is my time to do what I want’.”

“They just love Lego”, “I think that's the part they all like about Lego, making, doing the designs”

“And [the researcher] was in every so often, so I could still have that communication and chat with her or be like, ‘oh we need more of this’ … it just felt like it was definitely more, I don’t know what the word is, but like a joint thing, rather than just being left on our own to run it and then handing it all over at the end.”

“they were like, ‘can I go?’ And it was like, well, I can't actually force you to be here”

“Knowing who it was, it wasn't really the type of thing that I thought he would be kind of interested in”

e.farran@surrey.ac.uk

Conclusions: Why were training effects limited?

» Isolated training, rather than embedded training (Hawes et al., 2023).

» Programme deliberately designed to not explicitly reference spatial or mathematical constructs.

- Implicit training of mechanisms
- Children did not receive explicit spatial instruction, e.g., teacher prompts: “try turning the brick in your head”.
- Teachers had limited understanding of the evidence base for the training: negative impact on motivation and engagement to deliver BLOCs?

» Lunchtime club to reduce burden on school curricula: high attrition rate

(self-selected sample who already engage in Lego).

» Control intervention has spatial elements

e.farran@surrey.ac.uk

SPACE (SPAtial Cognition to Enhance mathematical learning)

feasibility trial funded by the Education Endowment Foundation

Farran, Gilligan-Lee, Mareschal, Zivkovik, Bartusevica, Bell, Jay, Gilmore (2025). *Mind, Brain and Education*

SPACE
SPATIAL COGNITION TO ENHANCE MATHEMATICAL LEARNING

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Key areas maintained

- Use of teacher feedback and piloting during development phase
- Use of a weekly story theme
- 6-week length (12 session dosage)
- Feasibility and monitoring checks
  - session timings, engagement, classroom space, delivery at group level, session registers, model tick boxes
- Positive relationship with the school and teachers – weekly check-ins
- Consistent structure (but remain flexible to real-world challenges)
  - Comprehensive intervention manual and teacher scripts and class videos

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e.farran@surrey.ac.uk

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SPACE
SPATIAL COGNITION TO ENHANCE MATHEMATICAL LEARNING

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Key areas of change

- » Extended Professional Development (PD) for teachers (importance of teacher awareness, agency and confidence).
- » Explicit rather than implicit focus on spatial strategies via prompt cards and PD.
- » Increased diversity in the sample.
- » Embedding the programme within the maths lesson, with explicit links to maths as part of PD.
- » Reduce Lego volume (for scale-up)
- » Funder requests
  - Teacher-led whole-class assessment development
  - Age 6 to 7 years

University of Surrey · Education Endowment Foundation · Centre for Evidence and Implementation · Learnus (Understanding Learning) · Birkbeck University of London · Loughborough University · UCD Dublin

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Does Lego training positively impact spatial and mathematical skills?

- Participants: N=409 SPACE; N=104 Business-As-Usual control. 6 to 7 years.
- 6-week (12 sessions) whole-class Lego training, delivered by the classroom teacher during maths time.
- Teacher support:
  - Half-day professional development (PD) (importance of teacher awareness, agency and confidence).
  - SPACE Resources
  - Weekly check-ins with researcher

e.farran@surrey.ac.uk

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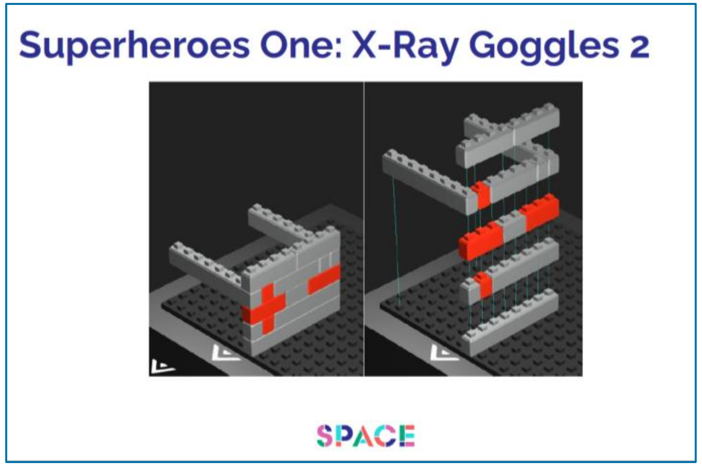
Does Lego training positively impact spatial and mathematical skills?

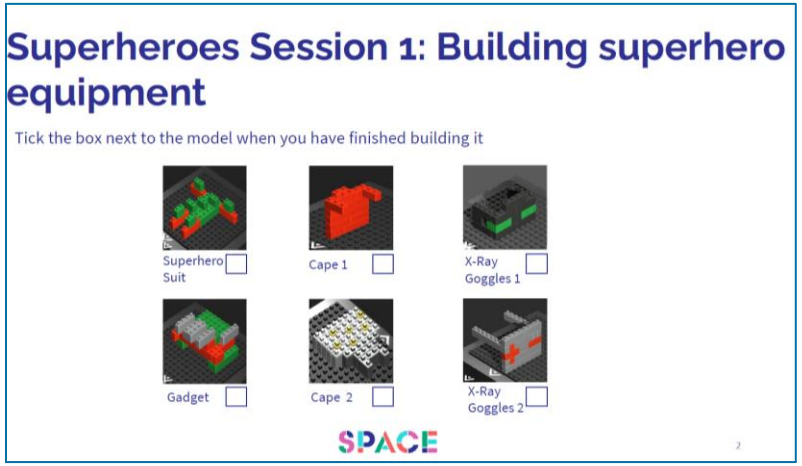
SPACE sessions

» 6 models to build (pictorial instructions) per session. Children work individually.

» For each model, the booklet displays the finished model and an exploded diagram of the model, and a tick box page for children to tick as they complete models.

» Teachers prompt spatial strategy use and spatial language.

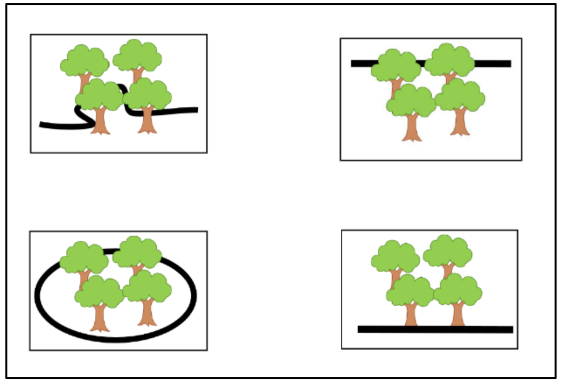




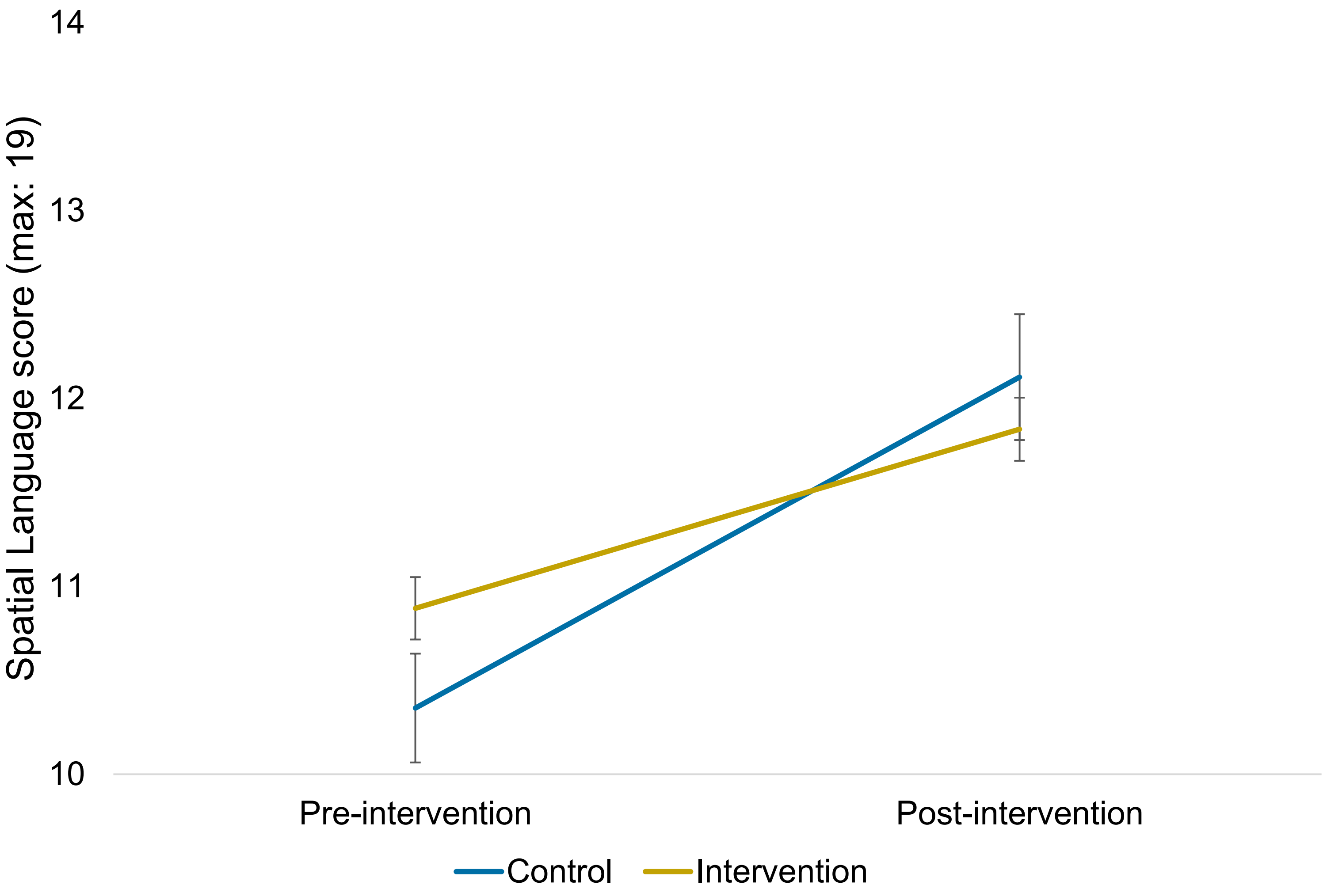
e.farran@surrey.ac.uk

SPACE findings: spatial language

- Spatial language did not change as a result of SPACE training (*p*>.05).



The road goes *through* the trees



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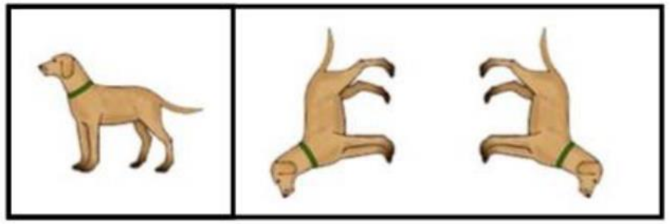
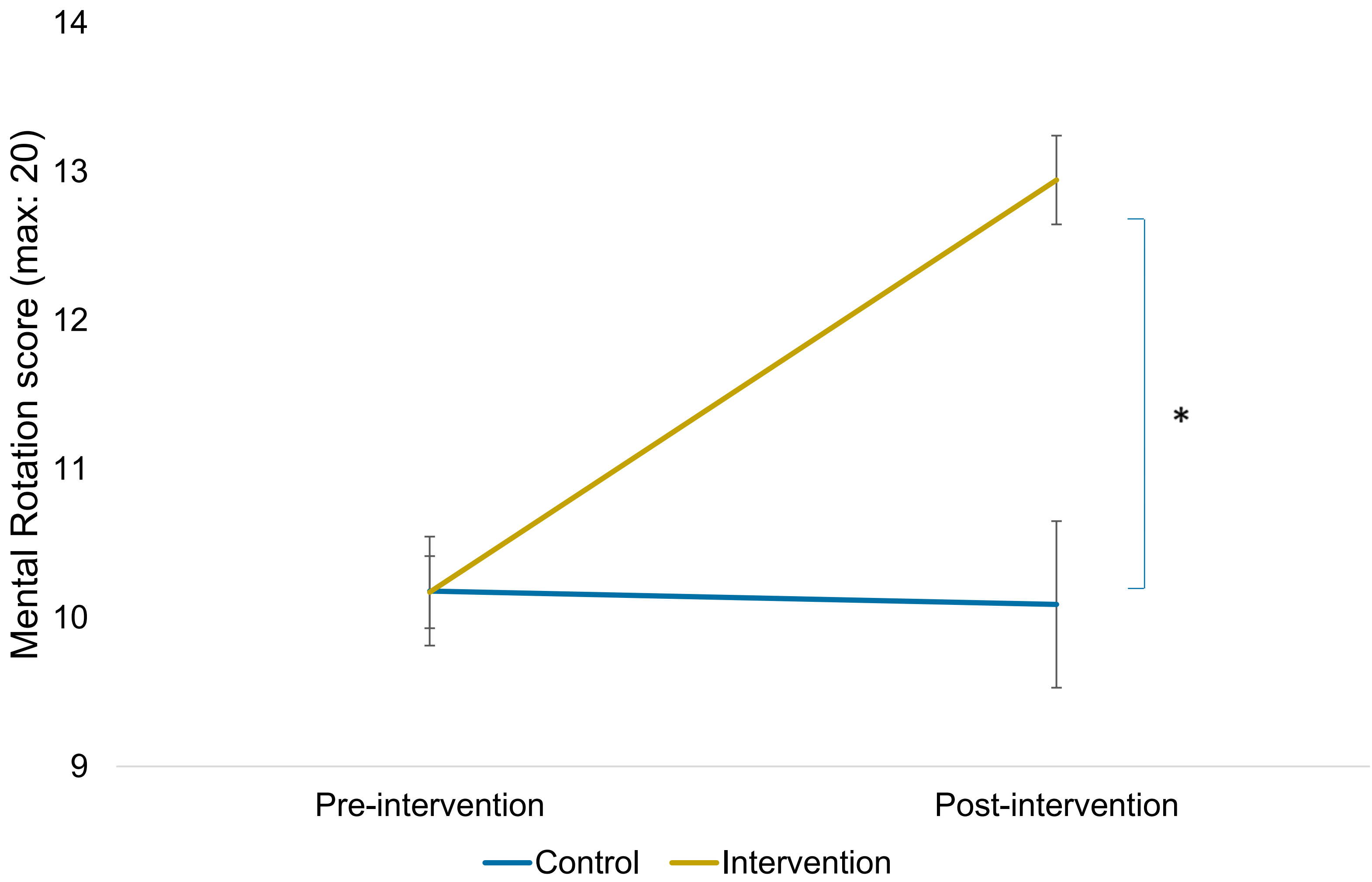
SPACE findings: spatial ability (mental rotation)

- Significant improvement in mental rotation as a result of SPACE training: *p*<.001





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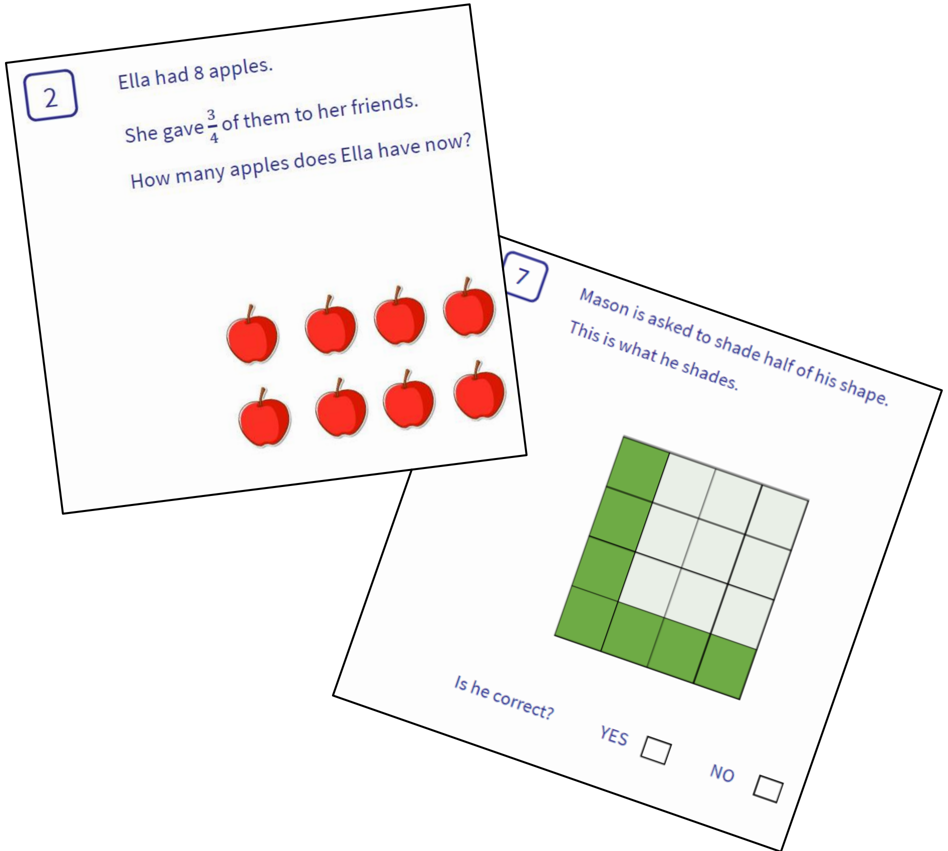
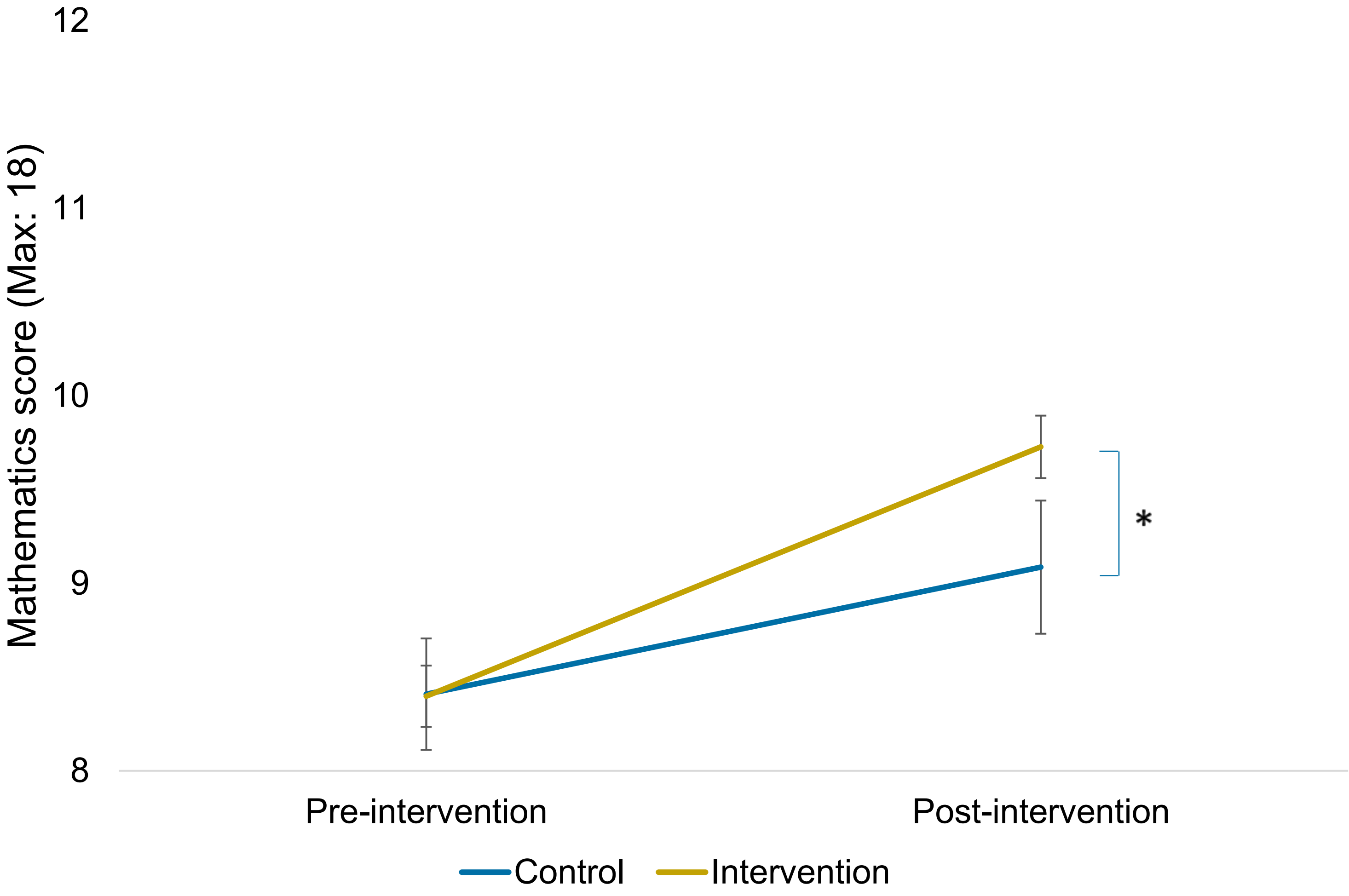
SPACE findings: Mathematics

- Significant improvement in mathematics as a result of SPACE training: p=.039





e.farran@surrey.ac.uk

SPACE findings: Inclusion

» Increased resilience and perseverance

» Inclusion:

- *"some children otherwise identified as having lower abilities found that they could quickly grasp the concept"*
- *"children with English as an Additional Language (EAL) enjoyed the visual instructions and revealed an aptitude that they had not previously been able to express."*

  (independent evaluation report)

Breaking down barriers to opportunity

» Could spatial training be used to close attainment gaps? Children from "left behind groups" show more benefit from spatial training and a spatialised curriculum than their peers (Bower et al., 2020b; 2021; Schmitt et al., 2018).

e.farran@surrey.ac.uk

SPACE conclusions

SPACE
SPATIAL COGNITION TO ENHANCE MATHEMATICAL LEARNING

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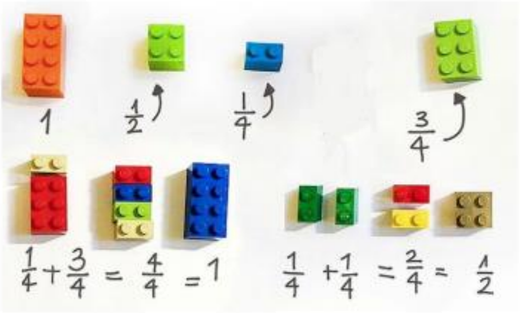
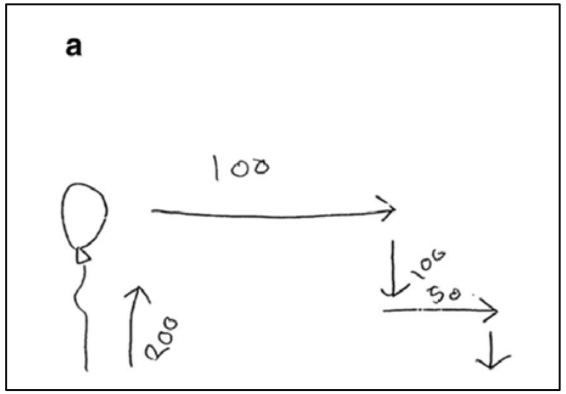
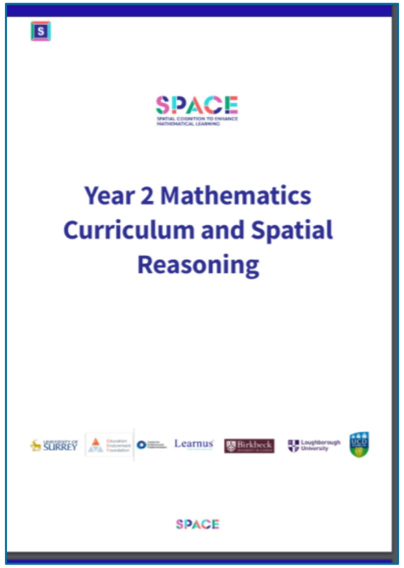
- Classroom opportunities to engage in spatial reasoning are an effective activity for mathematics improvement.
- Spatialising the mathematics curriculum by emphasising thinking and working spatially has broad benefits for mathematics, including geometry, measures, number, algebra and statistics.
- Professional development, guidance and resources are needed to support a spatialised mathematics curriculum (Bates et al., 2022; Gripton et al., 2025).







e.farran@surrey.ac.uk

Development of the Spatial Reasoning toolkit

- Supported by ESRC Impact Accelerator Account at the University of Surrey, and the Centre for Educational Neuroscience.
- Based on a growing body of research into the importance of spatial reasoning for mathematics
- Birth to 7 years
- Shaped by practitioner input via an online questionnaire and series of focus groups (birth to 4 and 4-7).









Practitioner's Perspectives

Bates, Williams, Gilligan-Lee, Gripton, Lancaster, Williams, Borthwick, Gifford, Farran (2023)

https://doi.org/10.31234/osf.io/m8nfv

Kathryn Bates

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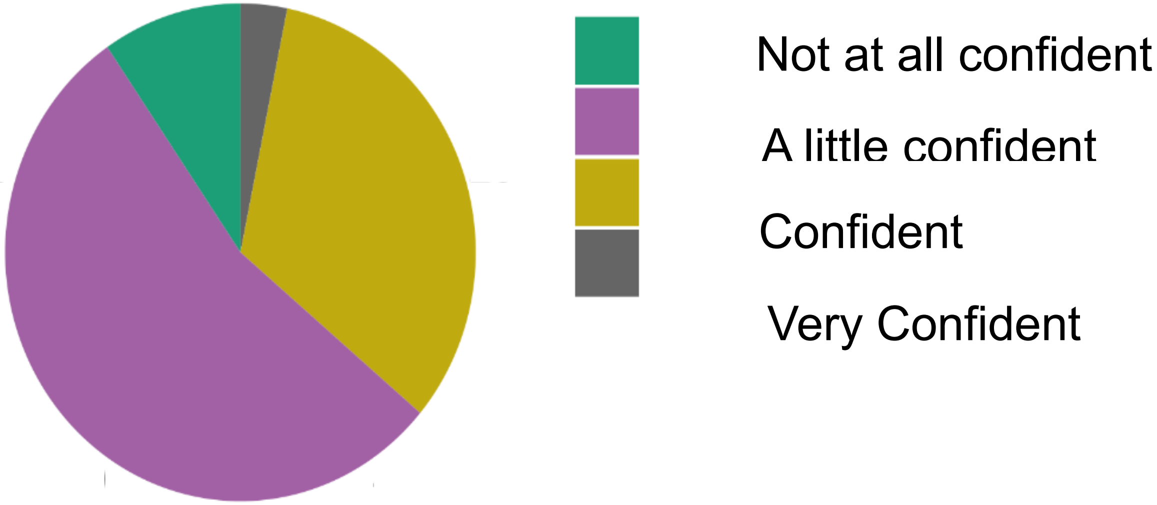
» If you were asked to explain what spatial reasoning is to someone else, how confident would you be in your definition?



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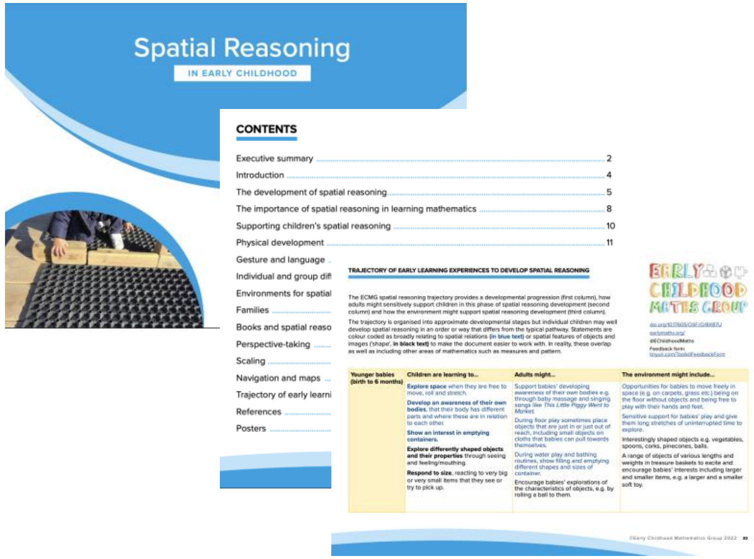
The Spatial Reasoning Toolkit (SRT)

www.earlymaths.org/spatial-reasoning

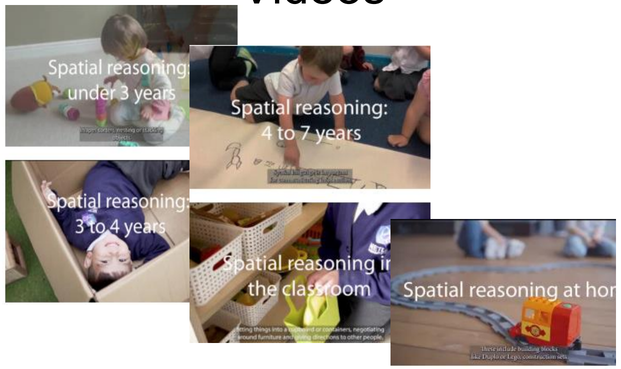
Research Summary and Development Trajectory



(Gifford et al., 2022)

Posters

Videos



Book Ideas

Keyrings

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EARLY CHILDHOOD MATHS GROUP

Spatial Reasoning Toolkit guidance document, keyrings, and posters - hard copies now available to pre-order

Pre-Order Now

Hard copies sold in partnership with

100 YEARS 1923 - 2023

Early Education

The British Association for Early Childhood Education

The trajectory for spatial reasoning development

Spatial relations

Spatial objects and images

7 approximate age bands:

- Younger babies
- Older babies
- Toddlers
- 2 year olds
- 3 year olds
- 4&5 year olds
- 6&7 year olds

3 year olds	Children are learning to...	Adults might...	The environment might include...
	and common shape names (e.g. *circle*, *triangle*). **Partition and combine shapes** to make new shapes with 2D and 3D shapes (e.g. cutting 'square' sandwiches into different shapes, putting blocks together to make a 'floor'). **Create arches and enclosures** when building, using trial and improvement to select blocks.	Encourage children to select blocks for specific purposes when building, e.g. "*What will we use for the elephants trunk?*" Offer an appropriate or inappropriate shape for what you think the child's purpose might be (to investigate their thinking). Value children's constructions (e.g. helping to display them or taking photos of them) and talk about how the shapes have combined to make new shapes. 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?*".	Lightboxes for silhouette play. Books and props for traditional tales involving ordering and size, e.g. *The Three Billy Goats Gruff, Goldilocks* and *The Enormous Turnip*. 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	**Children are learning to...**	**Adults might...**	**The environment might include...**
	Understand relative position, such as *between, in front of, behind, before* and *after* (where the position is in relation to other things, e.g. *in front* of the house or *behind* the wall). **Follow and give directions**, e.g. *forwards, backwards, sideways*, and *left* and *right* turns when accompanied by gestures.	In everyday play and routines, encourage children to describe position and give directions, e.g. in small world play, when following pathways or creating obstacle courses. Play 'barrier games' where you give instructions to a partner to 'make it the same', with an identical set of objects. Begin without a barrier (copying) then introduce one when they become proficient.	Controllable and programmable toys, with simple routes and obstacles to negotiate. Small mirrors for exploring reflection. Provide toys, pictures and pen/paper for experimentation. Toys or packaging to create marble runs, predicting the path of the marble/ball and solving problems in the marble run design.

e.farran@surrey.ac.uk

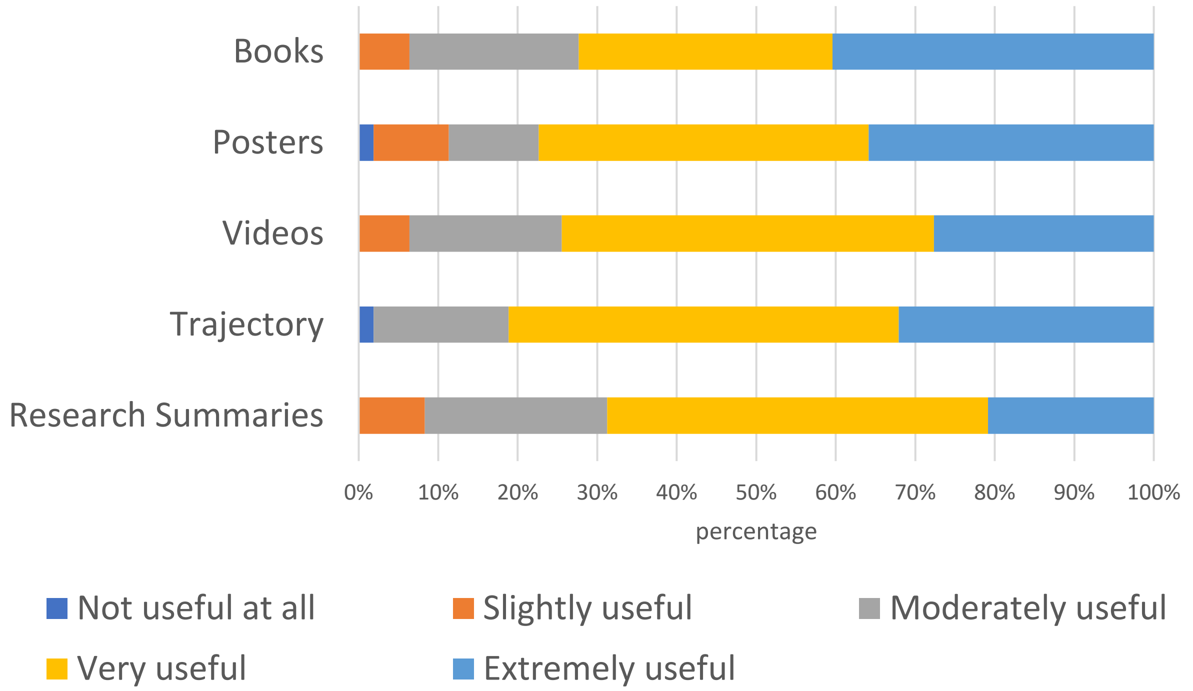
Use and Impact of the Spatial Reasoning Toolkit

Farran et al. (2024)

» On average, participants found the SRT to be ‘very useful’ on a scale of 1 (not at all useful) to 5 (extremely useful)

» The Trajectory was rated the most useful resource

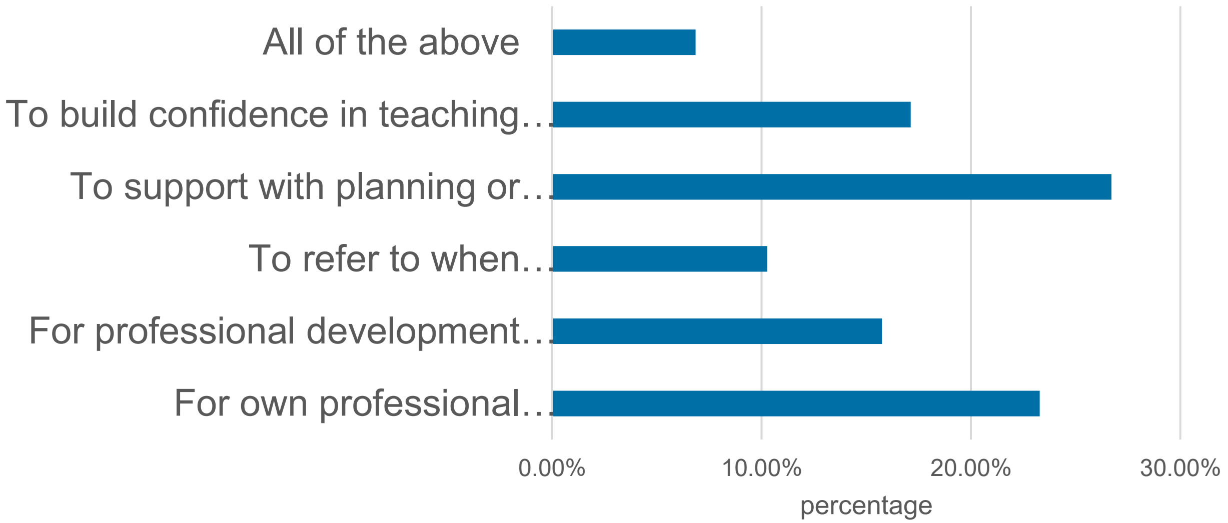
Practitioner Rating of the Usefulness of Spatial Reasoning Toolkit components



» Main use of SRT “To support planning or making choices about provision”

» Practitioners who had not used the toolkit reported ‘lack of time’ as a barrier to use.

How Do you Use the Spatial Reasoning Toolkit in Your Practice?



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Use and Impact of the Spatial Reasoning Toolkit

- The Toolkit has been adopted for inclusion in the early years and primary teacher training pathways by Teach First, a teacher-training organisation focused on providing excellent teachers in disadvantaged areas.
- The National Centre for Excellence in the Teaching of Mathematics (NCETM), has included the Toolkit in the spatial reasoning training pathway for primary school teachers in England across 40 regionally based maths hubs, to date 1690 practitioners have received the training.
- The Toolkit was used as a training tool for practitioners in the SPACE research project
- Royal Society primary and early years expert panel perspective: spatial reasoning
- “Bright beginnings” curriculum

Use of the Spatial Reasoning Toolkit in Action

Ideas for using the Spatial Reasoning Toolkit

Spatial Week in Year Two.

Practitioners in a large urban primary school used the Spatial Reasoning Toolkit to design a focus week on spatial reasoning for Year Two pupils. Spatial Week ran in the Summer Term. Spatial reasoning activities were incorporated into many parts of the school day across different subjects.

The days started with spatial language games such as 'Teacher Says' asking the children to draw shapes in certain orientations and in relation to other shapes. In P.E., children created obstacle courses and completed them being supported with spatial language. In geography, children navigated the school grounds to locate items and drew maps. In maths, nets were used to discuss 3D shape properties.

During reading, books relating to shapes, space and measures were used to support children's understanding of spatial reasoning concepts. In choosing time, jigsaw puzzles allowed pupils to practice their visuo-spatial skills such as mental rotation. All the activities were engaging and fun and provided a contrast to desk-based learning. The result from just one week of focused spatial reasoning training was a significant improvement in children's spatial language skills. An added benefit was the social development opportunity provided by these team-based, predominantly child-led activities. Practitioners have now incorporated many of these ideas into their curriculum planning for Year Two.

Spatial reasoning integrated into the curriculum.

In a small, coastal primary school the Spatial Reasoning Toolkit facilitated a strategic decision to embed spatial reasoning objectives into the Key Stage One maths curriculum. Staff took time to explore the content in the research summaries and learning trajectory to understand what spatial reasoning encompassed. The videos were used for staff training and prompted discussions about how to introduce spatial reasoning into lessons. The posters were used on classroom walls to provide spatial reasoning ideas and language prompts to support practitioners in teaching moments. Similarly, in Early Years, spatial reasoning objectives were extended in the medium-term maths planning. Continuous provision now incorporates elements of spatial reasoning to support the relevant development steps.

In Reception, books, such as Rosie's Walk, have been used as a base for teaching a range of spatial skills across a whole week. Topics such as perspective taking have allowed children to consider objects and places from different viewpoints and develop their prepositional language skills. As a result of this work, practitioners have an increased understanding and awareness of the importance of spatial reasoning and how teacher-led and continuous provision environments can support it. One of the biggest impacts for children has been an increased comprehension of spatial language and their ability to use it in the appropriate context.

SCAN ME

Scan the QR code to visit the Spatial Reasoning Toolkit

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Trajectory for spatial reasoning development (7 to 11 years) and spatial reasoning progression

THE ROYAL SOCIETY

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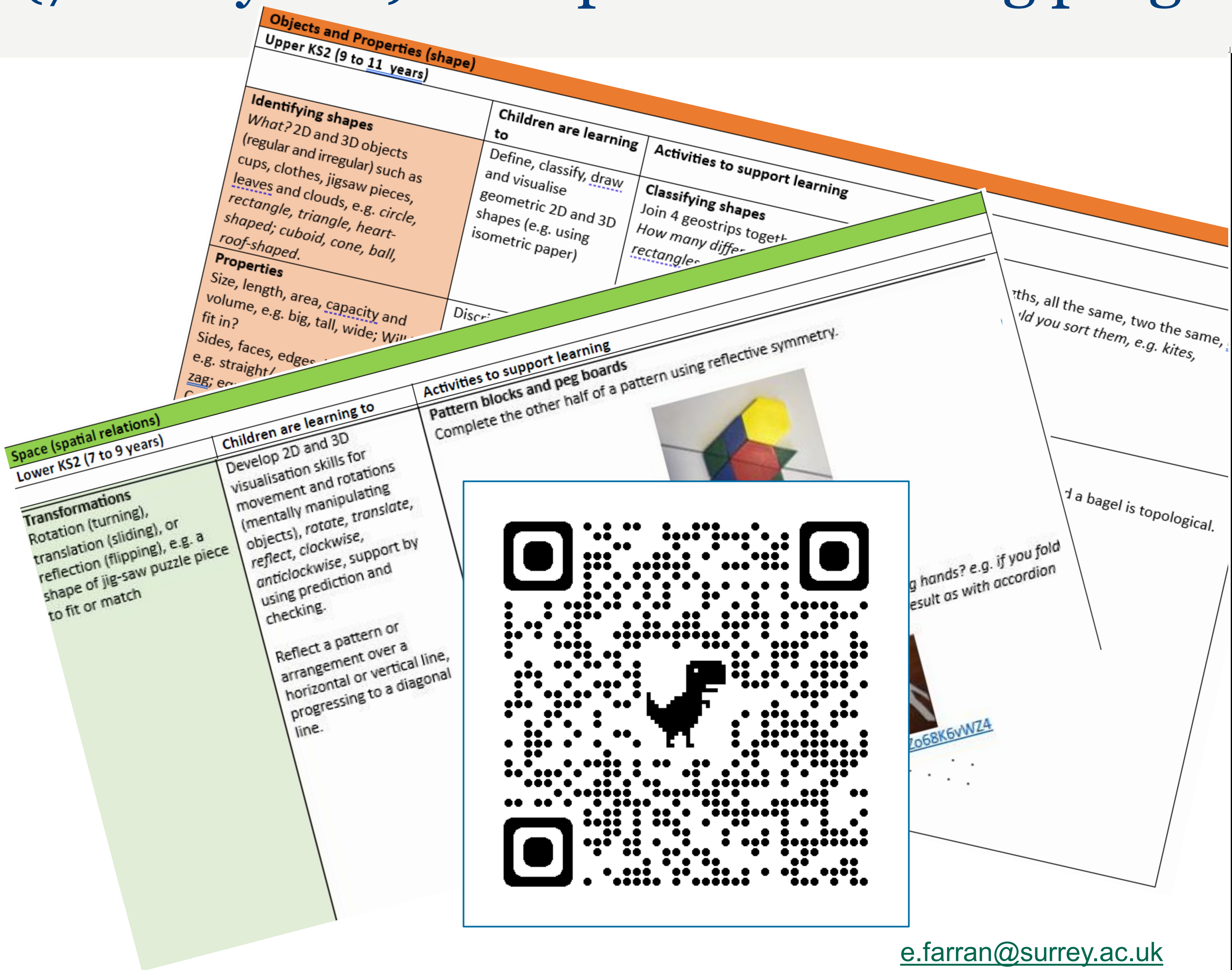

TOPIC Reference no.	Early	Middle	Later
GEOMETRY: SPACE – learners should have opportunities to:			
Position 6, 11, 28	Respond to and use language of position, *in, on, under, up, down, next to, between, in front of, behind, opposite, overlapping*, including terms relative to the viewer, and supported by gestures.	Continue to use the language of position, *horizontal, vertical*, and supported by gestures. Identify relative positions on a line and 2D positions within an area, using terms such as *middle, midpoint, nearer, edge*, and simple coordinates.	Extend the language of position, *parallel, incline, decline, perpendicular, orientation*, and supported by gestures. Identify and reason about position in 2D and 3D contexts, using more precise coordinates on maps, and in four quadrants.
Direction 1, 11, 16	Follow and give directions, *up, down, left, right, straight on, through, around.* Make whole, half and quarter turns.	Continue to use the language of direction using appropriate language, *left, right, diagonal.* Describe direction from the origin, e.g., left 3 and up five. Identify turns that are more or less than 90 degrees e.g. using Logo turtle.	Extend the language of direction, *north, south, east, west.* Give and follow more complex sequences of directions, using greater accuracy to describe turns e.g. using ICT to sequence instructions, to create shapes and patterns
Dimensions (measuring space) 1, 2, 18	Use distance to identify the location of objects. Compare and predict length/distance, volume/capacity, e.g., place and describe relative distances, *nearer to.* Begin to use proportional language, *halfway, middle.*	Estimate distance between places in large-scale space. Use representations to place things at approximately correct relative distances. Continue to use the language of dimension.	Use more precise units, including decimals. Understanding 2D representations of large-scale space, including heights and slopes: e.g., interpreting map contours
Transformations	Use movement and rotation, *sliding, flipping, turning.* Develop simple 2D visualisation skills (mentally manipulating objects), e.g.	Develop 2D and 3D visualisation skills for movement and rotations (mentally manipulating objects), *rotate, translate*	Predict the result of transformations, e.g., how more complex shapes (2D and 3D) will appear when rotated, the result of cutting

e.farran@surrey.ac.uk

Take home message: spatial skills are important

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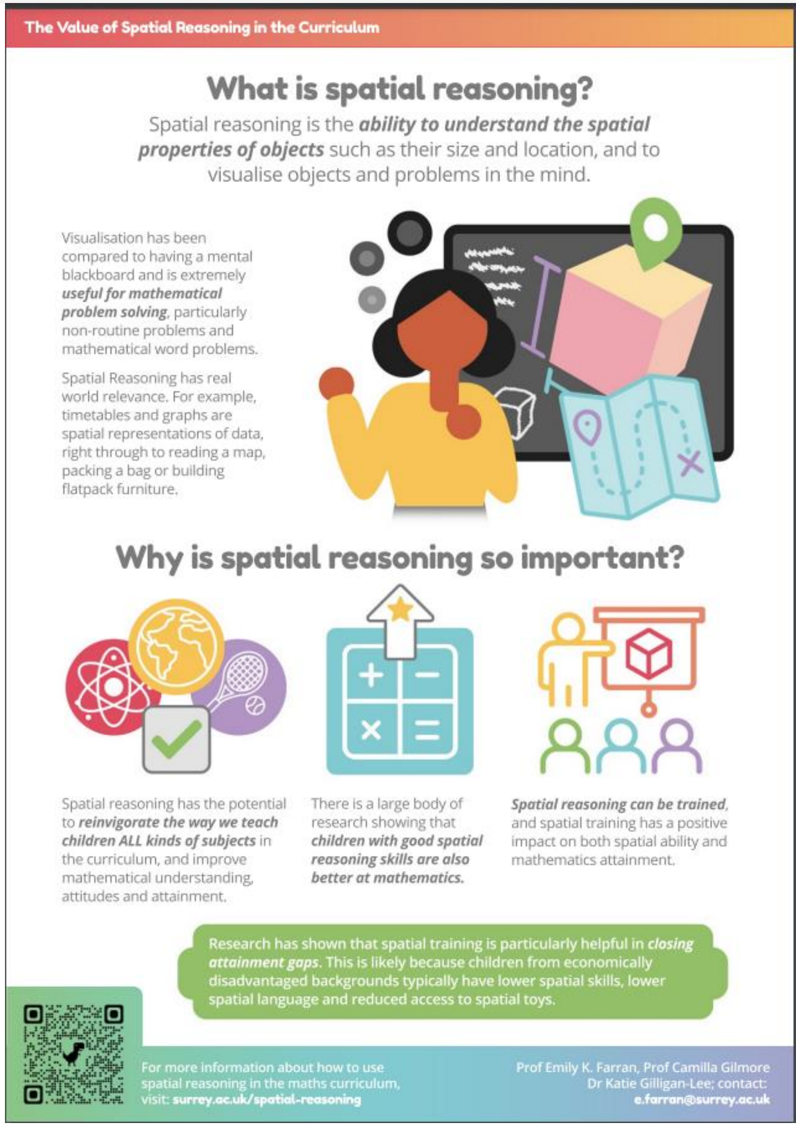
We need to equip the next generation to meet the heightened demands for critical thinking, problem solving and data use brought about by technological and AI-enabled change.

Teaching children to think and work spatially:

» Is an evidence-based, inclusive route to achieving this goal.

» Does not require additional activities - existing content can be spatialised.

e.farran@surrey.ac.uk



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e.farran@surrey.ac.uk

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