

Professor Emily Farran - Written Evidence (NUM0041)

Prof. Emily Farran

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Emily Farran (University of Surrey; Centre for Educational Neuroscience, University of London) directs the leading [UK spatial cognition lab](#). She has led numerous studies to demonstrate the importance of spatial reasoning for numeracy and written [policy briefings](#) on this topic.

The value of spatial reasoning for numeracy for life

[Spatial reasoning](#) refers to the ability to understand the spatial properties of objects such as their size and location, and to visualise objects and problems in the mind. Spatial reasoning underpins problem solving and critical thinking, fosters resilience and perseverance and is an essential skill for numeracy proficiency. There is a robust body of research which demonstrates that spatial training is effective in improving spatial thinking and numeracy attainment ([Farran et al., 2025](#); [Gilligan-Lee et al., 2023](#); meta-analysis: [Hawes et al., 2022](#)).

Spatial reasoning offers opportunity to close gaps. Teaching children to think spatially can enrich educational provision with experiences that lay the true foundation for school readiness and lifelong learning for ALL.

Questions

Attitudes to numeracy

1. How does the commonly experienced mindset - a level of acceptance, across the UK, but particularly among girls and women, of being "unable to do maths" - impact attaining the necessary numeracy skills?

2. What needs and can be done to change this mindset, and how might this be implemented?

In contrast to the sometimes dull image of numeracy, spatial activities are enjoyable; engagement scores for our spatial activities and training

demonstrate that children love learning spatially. Paradoxically, opportunity to develop spatial abilities in schools is limited. Our recent research has shown that not only does spatial training improve children's numeracy and mathematics performance, but children find it highly engaging and motivating, leading to improved attitudes to maths ([Farran et al., 2025](#); [Gilligan-Lee et al., 2023](#); [McDougal et al., 2023](#)). Furthermore, spatial training helps children to build resilience and perseverance ([Farran et al., 2025](#); [Gifford et al., 2024](#)). A focus on spatial abilities in schools could contribute to a change in the "unable to do maths" mindset; without it we risk further dampening children's motivation to learn.

Numeracy skills

5. How is numeracy likely to change in the future, in particular as a result of technological developments such as AI? How can the curriculum, teaching and maintenance of numeracy skills through life keep pace?

Spatial abilities in childhood predict adult expertise in Science, Technology, Engineering and Mathematics (STEM) ([Wai et al., 2009](#)). In the context of the STEM skills shortage (>£1.5bn annual UK losses; [IET, 2021](#)), this is becoming increasingly important due to the current employment revolution. Data use and data science, much of which is underpinned by spatial reasoning, is increasing across careers ([Royal Society, 2023](#)). This includes careers in AI and technology innovation, [which rely strongly on spatial problem solving skills](#). Numeracy for life entails aligning education with the needs of a future-ready workforce, ensuring that the next generation meet the heightened demands for critical thinking, problem solving and data use.

Teaching children to think and work spatially:

- » Is an evidence-based, inclusive route to achieving this goal.
- » Addresses the Curriculum and Assessment Review recommendations to provide opportunities for problem solving.
- » Does not require additional resources or time. It can be easily embedded into existing maths lesson content (see our [Bee Spatial](#) collaboration with White Rose Education for a current example).

7. Given the importance of the 0-5 years in a child's development and future trajectory, what role might the family environment, parental influence, early years providers and pre-school activities play in the foundation of numeracy skills and confidence? What is the role for government, if any, in supporting the development of numeracy skills in the early years pre-school?

Early education has to-date not been prioritized within early years services, and should be, not least because early education can close opportunity and attainment gaps. The first 0 to 5 years represent a critical window in brain development, where early experiences shape lifelong learning trajectories. [Spatial reasoning](#) is a promising avenue for improved quality of early education and children's outcomes in spatial reasoning. Spatial reasoning underpins problem solving and critical thinking ([Gilligan-Lee et al., 2023](#)), fosters resilience and perseverance ([Hall et al., 2025](#); [Farran et al., 2025](#)) and could close attainment gaps ([Gifford et al., 2024](#); also see response to Q9). Children's spatial reasoning from as young as two years old, is associated with later competence in number and mathematics. That is, children with stronger spatial reasoning skills are better at numeracy mathematics (e.g., [McDougal et al., 2023](#)). Furthermore, spatial training fosters inclusivity and improves attitudes to number and mathematics ([Gifford et al., 2024](#)). Paradoxically, opportunity to develop spatial abilities is limited in early years provision, and the early years workforce do not yet receive professional development on spatial reasoning ([Bates et al., 2023](#)). Including spatial activities and spatialised curricula would move children towards the government's target of 75% of children completing Reception year performing at the expected level across the Early Years Foundation Stage early learning goals by 2028.

The [Spatial Reasoning Toolkit](#)

To support wider adoption of spatial learning in education, we have developed a [Spatial Reasoning Toolkit](#) (SRT; Gifford et al., 2022). The SRT was designed to assist practitioners working with children from birth to seven years. Informed by international research evidence, the SRT offers practical support focused on enhancing young children's spatial abilities. Resources available in the SRT include a research summary, a trajectory of spatial reasoning development, posters, videos, key rings and children's book lists.

The SRT is freely available and designed to be immediately usable in early education settings, including nurseries, childminding contexts, and

Reception classes. It is currently being used internationally by researchers in the Netherlands and in Brazil. In England, the SRT has been adopted for inclusion in the early years and primary teacher training pathways by Teach First. The Government's National Centre for Excellence in the Teaching of Mathematics (NCETM) has included the SRT in the Pattern, Shape, Space and Measures early years training pathway (for reception practitioners) and the Spatial Reasoning training primary pathway. The Government's Early Years Practitioner Development Programme (EYPDP) (which has trained 10,000 practitioners of 2- to 4-year-olds) have listed the SRT as wider reading on their 'space' module.

SRT Policy Brief (Feb 2024):

<https://www.surrey.ac.uk/sites/default/files/2024-02/spatial-reasoning-policy-briefing.pdf>

Numeracy education

8. How effective is the maths education system, both in terms of curriculum and teaching, in providing students with numeracy skills? What are the key barriers to gaining a strong foundation in numeracy at school?

Despite the above evidence, spatial reasoning currently has little emphasis in mathematics curricula or teaching. This is the case for KS1 through to KS4. Teaching children to think and learn spatially will improve numerical and mathematical understanding, attitudes and attainment, for life.

Recommendations

1. The mathematics curriculum should include more explicit reference to spatial reasoning, with associated assessment. All mathematics domains should be "spatialised". A spatialised mathematics curriculum should focus on the importance of: visualisation for problem solving (i.e., using a mental blackboard); spatial representation of numbers, data and relationships (drawing, maps, diagrams and graphs); and the use of spatial language and gesture. Examples of how to spatialise the curriculum:
 - a. With colleagues we provide examples of how practitioners can apply spatial reasoning in the classroom here: https://www.surrey.ac.uk/sites/default/files/2023-12/spatial-reasoning-for-teachers_0.pdf)
 - b. As part of our EEF funded "SPACE" intervention, we provided resources on how to spatialise the Year 2 mathematics curriculum across all domains of mathematics: <https://www.surrey.ac.uk/spatial-cognition-enhance->

[mathematical-learning-space/space-programme-resources](#) and <https://www.surrey.ac.uk/sites/default/files/2024-06/spatialising-maths-curriculum.pdf>

- c. With the Early Childhood Maths Group, we have developed a learning trajectory with activities for children from birth to seven years (see: <https://earlymaths.org/spatial-reasoning-toolkit/>) and, with the Royal Society, for children aged 7 to 11: <https://royalsociety.org/news-resources/projects/mathematics-education/mathematics-curriculum/>.
 - d. With Dr Sue Gifford and Dr Alison Borthwick, we produced the "ACME Primary and early years expert panel perspective: Spatial reasoning": <https://royalsociety.org/-/media/policy/topics/education-skills/maths/perspective-spatial-reasoning.pdf>
2. Spatial reasoning supports mathematical problem solving. Ensure that statutory assessments do not prioritise rote retrieval and processes to the exclusion of spatial reasoning problem solving approaches.
 3. A change to curriculum can only be effective if it is supported with corresponding professional development. We found that the majority of practitioners are not confident in their definition of spatial reasoning ([Bates et al., 2023](#); [Farran et al., 2024](#)) and have had little professional development in this area ([Gripton et al., 2024](#)). Aligned with the curriculum, practitioners need access to professional development on the importance of spatial reasoning. Relatedly, guidance and resources from official sources are needed to support spatialised pedagogy. Professional Development and guidance will provide practitioners with agency to be confident in teaching children to think and work spatially. Include the importance of spatial reasoning in the Early Career Framework.

9. How can disparities in maths and numeracy levels across gender, ethnicity, socio-economic background and geographic location be addressed? Is there any evidence of disparities in numeracy skills attainment between different types of schools?

The limited opportunities to develop spatial abilities at school risks missing opportunities to address diversity, including children from disadvantaged backgrounds and children with SEND. These are the two most 'left behind' groups ([Metcalf & Davison, 2025](#)) and would benefit the most from high-quality education which includes opportunity to develop spatial abilities. In fact, relative to peers, children from disadvantaged backgrounds have lower spatial skills ([Verdine et al.,](#)

2014), lower spatial language ([Bower et al., 2020](#)), reduced access to spatial toys ([Levine et al., 2012](#)) and are at risk of experiencing lower quality parent-child interaction during spatial play ([Jirout & Newcombe, 2015](#)). Given that spatial interventions with children report larger gains in numerical and mathematics competence for children from disadvantaged backgrounds compared to their peers ([Bower et al., 2020; 2021; Schmitt et al., 2018](#)), opportunities to develop spatial abilities could contribute to ameliorating the opportunity and attainment gaps that are evident as early as the early years.

In our Spatial Cognition to Enhance Mathematical Learning ([SPACE](#)) programme, independent evaluators highlighted that spatial training helps children to build resilience and perseverance and that “some children otherwise identified as having lower abilities found that they could quickly grasp the concept—which teaching staff attributed to them being more comfortable with visual instructions. ... Similarly... teachers reported that 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.”.

To view the report:

<https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/space-2022-23-pilot>

For all other outputs: <https://www.surrey.ac.uk/spatial-cognition-enhance-mathematical-learning-space/research-outputs>

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