ISSUE 27 JANUARY 2020

CAMBRIDGE √Mathematics

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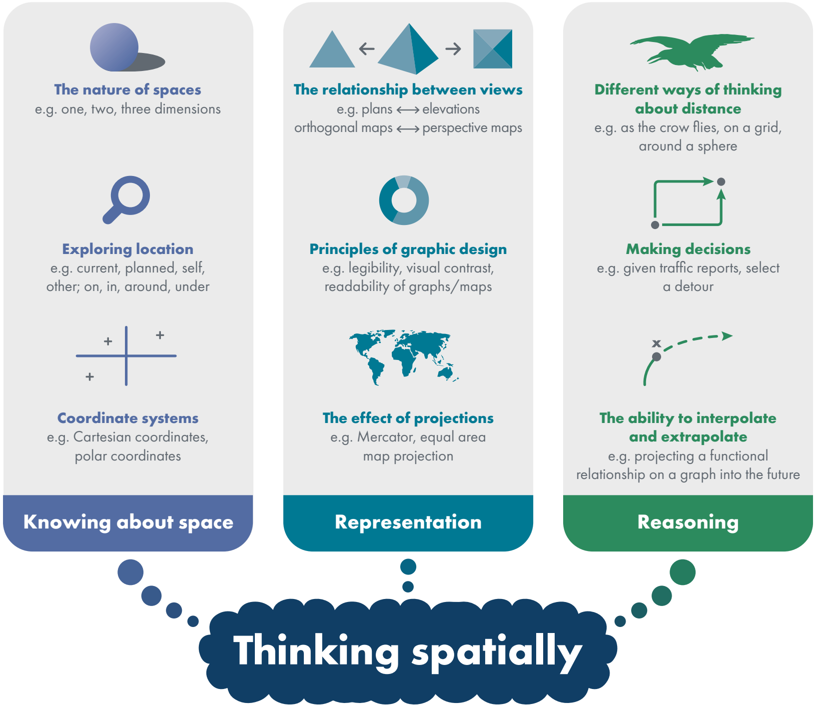
TALKING POINT:

WHAT DOES RESEARCH SUGGEST ABOUT EARLY DEVELOPMENT OF SPATIAL SKILLS?

IN SUMMARY

- Students who have good early spatial skills are more likely to have success across mathematics and other subjects; for example, such skills may be linked to the development of a mental number line
- Spatial skills are important for mathematical reasoning and useful when finding strategies for solving more complex mathematical problems
- Spatial skills may be two or three dimensional and viewer- or object-centred and students should have more early experience of using spatial skills in each of these aspects
- Sex differences in spatial abilities may be linked to quantity of play with spatial toys including home puzzle play; it may be particularly beneficial to improve spatial skills for girls and other underrepresented groups
- It is possible to improve spatial skills with training; providing students with spatial scaffolding when learning a new concept may enrich their understanding
- More research is needed on spatial skills in the early years and more professional development is needed to ensure primary and early years teachers are confident in teaching them



Adapted from "Learning to Think Spatially," National Research Council (2006)

1

The term "spatial skills", also known as spatial abilities, spatial reasoning and spatial thinking, refers to "forming and manipulating visual-spatial mental images" or the "ability to generate, retrieve and transform well-structured visual images."[2] They involve mentally manipulating both 2D and 3D shapes – and crucially, the ability to visualise the relationships between them.[3] There is extensive research suggesting a strong correlation between spatial skills and success in the many varied strands of mathematics, such as geometry, mental arithmetic, calculus, algebra, word problems and more advanced mathematics.[1,4] Evidence suggests that students can be held back in their mathematical progression due to lack of attention to spatial skills.[4] Spatial reasoning skills also overlap with, and could be necessary for, mathematical reasoning skills.[5] Children who have good spatial skills are more likely to succeed in STEM (science, technology, engineering and maths)[4] and these skills have also been linked to success in other subjects such as geography, physical education and the arts.[1] Promoting spatial skills in the early years may therefore have potential for creating long-term positive effects on mathematical performance.[6]

IMPLICATIONS: Students who have good early spatial skills are more likely to have success in mathematics (various strands) as well as other STEM and non-STEM subjects

Spatial skills may overlap with and be important for mathematical reasoning

> "There exists a distinct cognitive factor related to visual imagery/mental manipulation that could be called spatial ability"[1]
>
> **Mix & Cheng, 2012**

> "Spatial ability affects many fields and disciplines and is a predictor for success in many areas of life"
>
> **Mohler, 2008**

2

Spatial skills involve both two and three dimensions and have been classified in different ways, but one model suggests organising them as egocentric (viewer-centred) or allocentric (object-centred: see infographic). The concepts of reference points are important links to developing ideas about Cartesian co-ordinate systems, graphs, maps and transformations.[3,7] Nurturing a variety of spatial skills in the early years allows pupils to later apply spatial strategies (for instance diagram drawing or mental rotation) to complex mathematical problems; a good understanding of spatial skills is applicable not only to select areas of the mathematics curriculum, but to mathematical problem solving across content areas.[8]

IMPLICATIONS: Spatial skills may refer to two or three dimensional manipulation and may be centred on the viewer or an object; all are important

Students with good early spatial skills will be able to draw on them for more complex mathematical problem-solving strategies across content areas

3

Spatial skills are malleable and can be improved with training.[1,9] They have been linked to the development of a mental number line; improving students' spatial skills may therefore improve their arithmetic performance.[10,11] Research is mixed in terms of significant sex differences or patterns of variation linked to sex in spatial skills; the suggestion has been made that giving boys and girls equal time practising spatial skills (e.g. playing with blocks) eliminates any differences.[6,12] The quantity of home puzzle play of 2–4 year-olds has been linked to performance in spatial skill tasks; the teaching of puzzle play may be particularly valuable for girls,[13] as the connection between mathematical achievement and spatial skills may be stronger for girls.[6] It has been suggested that neglecting spatial skill development in girls (and other underrepresented groups) is a hindrance to their progress in maths and that they would benefit from additional support in acquiring spatial skills.[4] It may be particularly important to provide students with spatial scaffolding when they are learning a new mathematical concept: providing students with a repertoire of spatial tools, such as gesture, rich spatial language, diagrams and spatial analogies can facilitate their spatial thinking.[2] Not all studies agree that mental rotation training always improves other mathematical skills; more research is needed in this area, particularly in the early years.[1,5]

IMPLICATIONS: It is possible to improve spatial skills with training and they may be linked to the development of a mental number line

Spatial skills have been linked to the quantity of home puzzle play

Sex differences in spatial abilities may be linked to quantity of play with spatial toys; improving spatial skills for girls and other underrepresented groups may be particularly beneficial

Providing students with spatial scaffolding when learning a new concept may enrich their spatial thinking and help deepen their understanding

More research is needed on spatial skills, particularly in the early years

4

Spatial skills have been identified as a "major blind spot"[1] in the US curriculum and a "curiously unacknowledged and neglected area of the curriculum."[14] Research has identified that currently early years geometry typically focuses on naming and sorting (2D) shapes.[4,16] More focus and research on 3D shape, especially with younger children, is suggested.[4] In one study, early years teachers were able to work with 2D shapes with little difficulty, but struggled with 3D shapes, suggesting more training is needed in this area.[4]

IMPLICATIONS: Students should have more early experience of spatial skills, including experiences of 3D as well as 2D shapes

More training is needed to ensure primary and early years teachers are confident in teaching spatial skills

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