The BLOCS study in more detail

Our research aimed to better understand the role of children's mathematics and spatial reasoning skills when they play with block construction toys such as LEGO®.

Background information about children's maths and spatial skills

Spatial reasoning involves perceiving the location and properties of objects and the distances between them. We use spatial reasoning skills to visualise and manipulate the objects that are around us during day-to-day tasks, from packing a bag to navigating a busy supermarket. Spatial reasoning skills are important for children's development because children need to reason spatially in many aspects of their lives. Examples include comparing shapes, learning about anatomy in a science lesson, gesturing and exploring with other children in the playground, knowing whether they will fit in a hiding place, and map-reading.

Maths skills are important for children's development. We use maths skills in daily life, for example, using money and getting to an appointment on time, and many career paths require strong maths abilities.

Research has shown that children's spatial reasoning skills are strongly related to their maths skills. This means that children who are better at spatial reasoning tend to be better at maths. This is because maths draws heavily on spatial skills. The ability to visualise and manipulate objects in space helps children to solve geometry problems. In addition, spatial reasoning is important for children's numeracy skills, such as understanding how symbols are arranged in equations, solving missing-number equations by mentally rearranging the locations of the numbers, and solving addition problems by imagining two sets of dots coming together.

Mental rotation

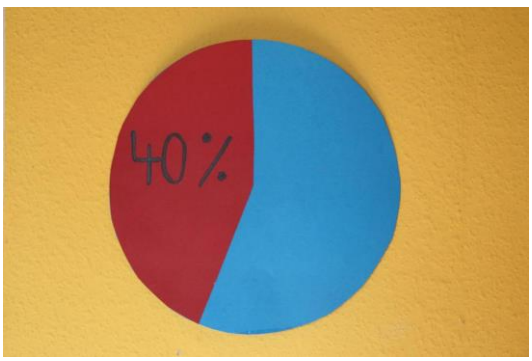
$7 + \_ = 15$

becomes...

$15 - 7 = \_$

The role of spatial and maths skills in block construction

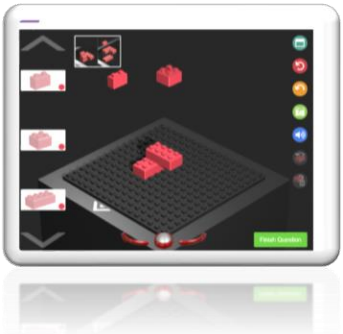
Studies have shown that children's block construction skills and maths skills are related, meaning that children who are more skilled with toys such as Lego tend to be better at maths activities. However, until our study it was unclear why these skills are related. Children's spatial skills might explain this. In this research we aimed to investigate which spatial skills explain the link between children's maths and Lego construction abilities.



The role of digital technology in maths and spatial skills

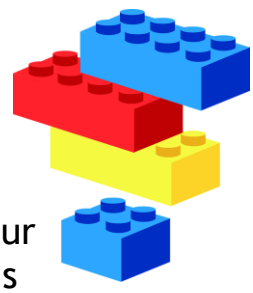
Some popular video games like Minecraft and Lego Worlds involve block construction activities and so, like Lego, these games might be relevant for children's maths and spatial skills.

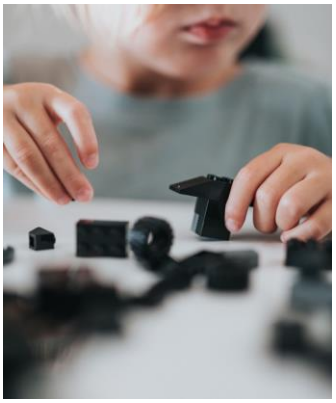
We created a digital Lego construction task so we could investigate whether digital block construction skills link to maths skills, and if so, whether spatial skills explain this link.



Why was it important to do this research?

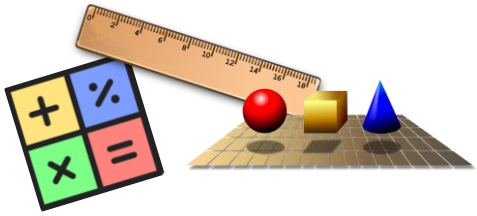
Our findings have educational implications. Research shows that children's spatial skills can be improved with training. Spatial training programmes often lead to improvements in maths skills too, because of the link between children's spatial reasoning and their maths skills. If Lego construction taps into the same spatial skills as in maths, then construction toys such as Lego could be used in spatial training programmes aimed at improving children's spatial and maths skills. Our research will also tell us whether this training is best targeted at Lego or digital block construction activities.

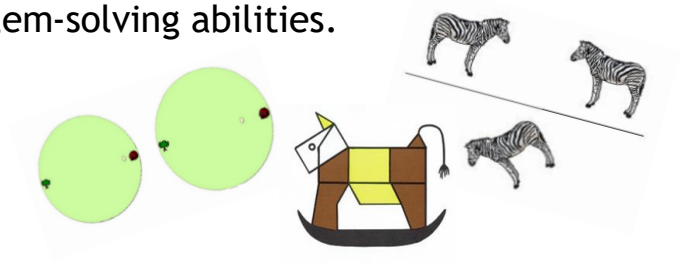




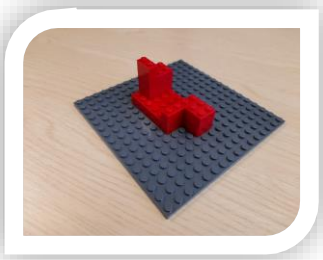
How we carried out the study

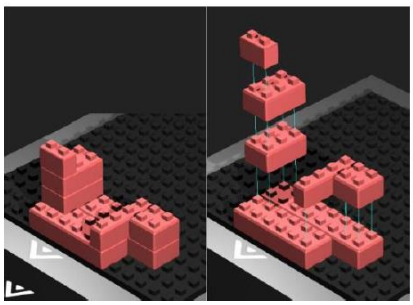
Children completed tasks that assessed their spatial skills, maths performance, and Lego construction ability. We assessed spatial skills that are known to be important for maths and Lego building, such as mental rotation, disembedding and scaling. For maths, we assessed numeracy, geometry, and mathematical problem-solving abilities.

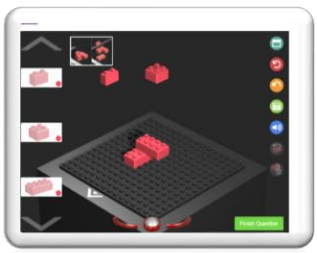




To assess Lego and digital block construction skills, we asked children to follow instructional diagrams to build a series of models as accurately as they could. Some children were given sets of Lego bricks to build the models while others completed this task on the digital game. All children attempted the same set of models.

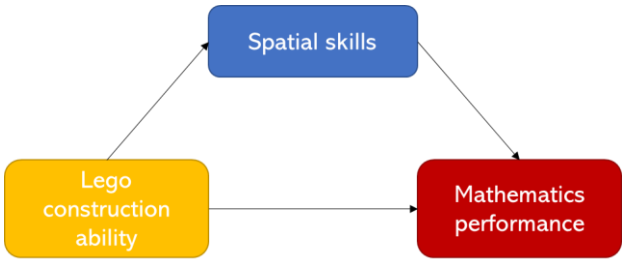






Our findings

Excitingly, we found that children's spatial skills explained a substantial part of the relation between their block construction skills and maths skills. This was the case for both types of Lego, digital and physical.



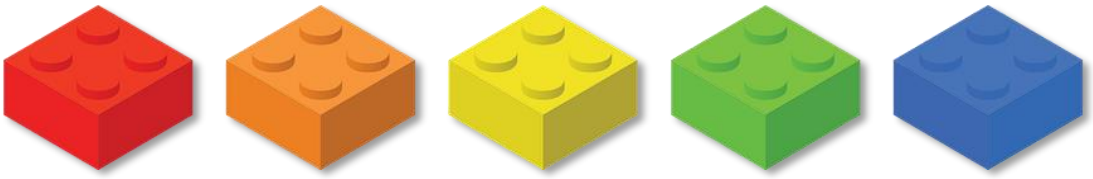
What does this finding mean?

Our findings show that children's block construction skills are important for their maths performance, and spatial skills make an important contribution to this relationship. This is because block construction and maths tasks both draw on similar spatial skills. For example, holding spatial information in memory, mentally rotating objects, estimating the length of objects, and identifying shapes embedded within complex patterns.

To find out more about the spatial skills we measured and how they might have helped children with the maths and Lego tasks, please see the Appendix: spatial skills explained, on page 9.

What are we doing with our research findings?

Using our findings, we have designed a spatial training programme in which children recreate models from instructions, using either physical or digital Lego bricks. As spatial training programmes often lead to improvements in spatial *and* maths skills, we predict that our training programme will benefit mathematics competence in children.



Ideas for applying these findings at home or school

Structured Lego play

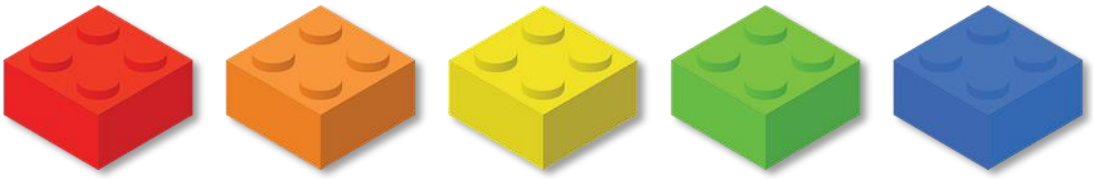
- Although children enjoy building Lego creations from their imagination, a way of engaging the spatial skills that are important for maths is to encourage children to build models by following instructions. Our research shows that when children recreate models by following instructions, they use a range of spatial skills which are important for maths development

    - If you already have access to Lego bricks, the Lego website has freely accessible instruction sets for building models that require common Lego pieces. Alternatively, you could create instruction sets for your own models using websites like Mecabricks. Other construction toys with instructions could be used, such as wooden blocks, K'Nex, Stickle Bricks, and Meccano, which might involve spatial reasoning

- Studies have shown that children's maths skills benefit when adults guide children towards a maths-relevant learning goal during play. Using Lego or other construction toys, adults could prompt children to use maths-relevant spatial skills, for example, 'why don't you imagine the pieces rotating in your mind before placing them?' (see the next page for more examples)

- Adults could also encourage children to create more spatially complex constructions, with prompts such as 'why don't you add a roof to the top of that building?', 'perhaps now you could build a bigger city?'

- Research finds that children's maths skills benefit when adults use spatial words during play. You could aim to use (and encourage children to use) words such as above, below, between, further, closer, left, right, in, overlapping, around. For example: 'place that brick on top of that red piece and next to the blue piece' (see the next page for more examples)



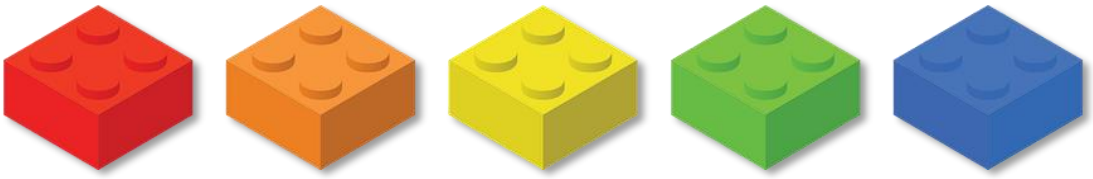
Ideas for applying these findings at home or school

Ways to engage maths-relevant spatial skills in Lego play

For these examples, please first read Appendix: spatial skills explained (page 9) for more detail about the spatial skills referenced here.

Disembedding: Encourage children to think about the various ways in which Lego bricks combine to form new shapes. Children could look at a set of instructions to see different examples of Lego bricks combining to form whole shapes. This encourages children to understand proportions and how small parts make up wholes. This skill is useful for understanding maths concepts such fractions and percentages. During Lego play, use words such as: 'small, smaller, big, bigger, part, whole, half'

Visuospatial working memory: Encourage children to check their part-finished model against the instructions and to align their part-finished model with the instructions. This encourages the child to hold images of the complete model in mind while building, which engages their visuospatial working memory. This is a skill that is useful in maths activities. Use words during Lego play such as 'same, different views, corner, sides, opposite, across, around, turn, high, low'

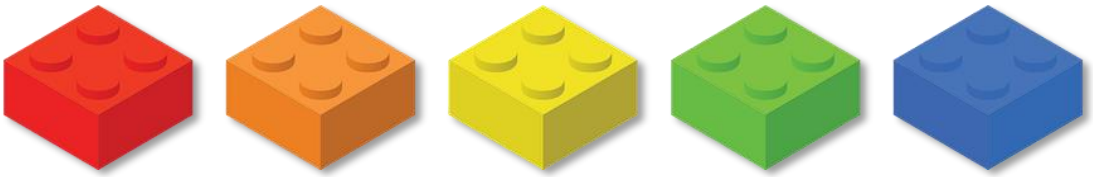


Ideas for applying these findings at home or school

Ways to engage maths-relevant spatial skills in Lego play

Mental rotation: When recreating models from instructions, talk to children about how they need to rotate bricks to fit them in the right place. Point out to the child that they could try turning the brick in their mind. This encourages visualisation, which is a useful skill for solving maths problems. This is also a good way to practise thinking about magnitudes (in this case, the degrees of rotation), which might be helpful for maths activities that involve comparing magnitudes (e.g., comparing sets of numbers). Example words to use during Lego play: 'turn, on, next to, fit, short side, long side'

Spatial Numerical Associations: Encourage children to compare the size, length, and width of different bricks, and to compare how different size bricks have different numbers of pips on them. Encourage children to attempt challenging models that consist of varying brick sizes, and to estimate the length of pieces that they need to use. Ask children what would happen to the model if they estimated incorrectly and used a brick that was too long or too short (e.g., a 2 x 4 brick when a 2 x 3 brick is needed)? This helps children to think about spatial proportions and the relationships between space and numbers – a skill underlying many maths activities



Appendix: Spatial Skills and Link to Maths Explained

Here you can find out more about how the spatial skills we assessed might have helped children complete the Lego construction tasks and maths tasks.

Disembedding

Disembedding is the ability to locate a shape that is embedded within a larger image or pattern of diverse shapes. This ability helps children to understand how small parts can make up a whole.

Disembedding might help children to identify a specific piece from an instructional Lego diagram and then locate it within a diverse stockpile of Lego bricks.

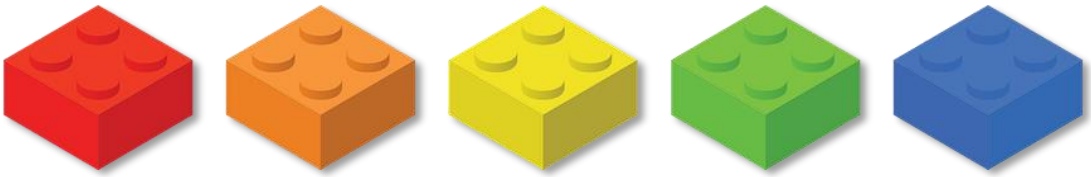
Disembedding skills might help children to solve place value column problems by identifying individual digits within big numbers. It is also helpful for understanding fractions.

Visuospatial Working Memory

Visuospatial working memory (VSWM) is the ability to hold visual and spatial information in mind while solving problems.

Children engage their VSWM when holding the components of a Lego model's instructions in mind whilst building.

VSWM is used to hold numerical information in mind while solving a problem.



Spatial Skills and Link to Maths Explained

Mental Rotation

Mental rotation is the ability to use your mind's eye to rotate a shape or object.

In order to match the placement of a brick with the instructional diagram, children must first mentally rotate the brick before placing it.

Mental visualisation and manipulation of information is frequently used to solve maths problems, particularly in geometry.

Spatial Numerical Associations

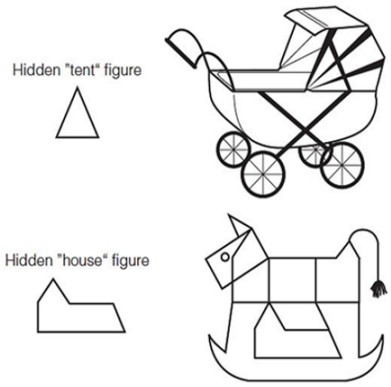
Spatial numerical association relies on spatial representation of numbers, and is the ability to estimate where a number should be placed along a physical or mental number line.

Children might use this skill to estimate the length of bricks and distance between bricks.

Being able to spatially represent number helps many mathematical activities, such as making judgements about size or proportions, or when estimating lengths.

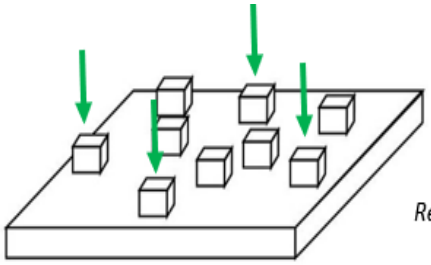
Spatial Skills and Link to Maths Explained

Disembedding



Which number is in the tens place?

536,342



Visuospatial Working Memory

Remember the sequence and repeat it back!

Mental Rotation

Mental rotation

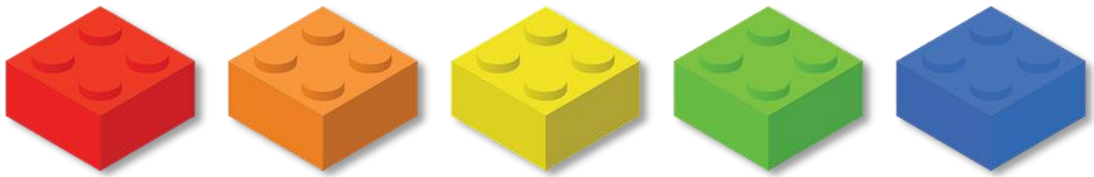
$7 + \_ = 15$

becomes...

$15 - 7 = \_$

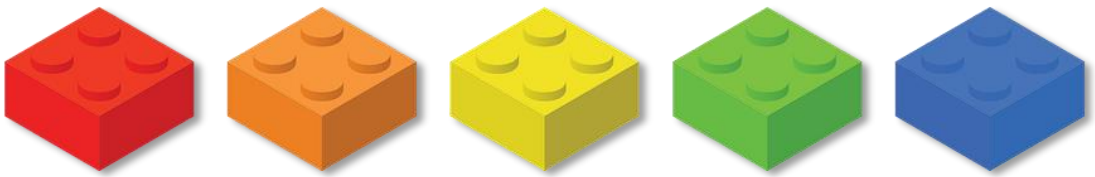
Where is the number 36?

Spatial Numerical Associations



Thank you for reading about our research.

A special thank you to the children who participated in this study, to their parents who signed them up, and to schools for accommodating us.



Block Construction Skills For Mathematics

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