

Developing Spatial reasoning with under-resourced pupils' pilot project report 2024

Abstract

Three Year 3 and 4 teachers each chose six under-resourced children for a small pilot project which aimed to improve the children's attitude and self-belief in maths and their attainment. Spatial reasoning was chosen as the mathematical content as research has identified that it can impact not just on geometric understanding but also on number.

The children engaged in a workshop using pattern blocks and then they co-led a workshop for their peers back in class. Our findings revealed that despite the brevity of the project five children were more actively engaged, achieving more within their daily maths lessons and that one child had already improved their attainment. All the children commented favourably about their involvement and wanted to repeat the experience.

Introduction

Young children's spatial rather than numerical abilities predict their overall mathematics achievement: the key skills are visualising what shapes will look like when they are combined or rotated (Young et al., 2018). Several studies have also shown that these abilities are not innate, but teaching young children spatial skills actually improves their maths, including their number understanding and general thinking skills.

Optimizing spatial performance may be an underutilized route to improving mathematics achievement. (Verdine et al, 2017: 93,102)

Article Dr Sue Gifford March 2020.

In early January 2024 three primary schools with high numbers of pupil premium children were invited to pilot a small project across the spring term, involving teachers and pupils in Y3/4.

Each teacher was asked to choose six focus children who were identified as coming from 'under-resourced' backgrounds.

It was hoped the children's involvement would have a positive impact on their learning behaviours, namely their attitudes and self-belief in mathematics.

In addition, giving the children an opportunity to engage in such a project might boost their status in their maths community/class and in turn have a positive impact on their attainment.

The pilot also provided a means of testing out a structure for a larger project should the impact be found to be positive.

Elements of the pilot project were based on a combination of some of the pedagogical strategies that have been trialled in previous projects with Devon schools: e.g., pre-teaching and assigning competence and involving intervention children teaching the rest of their class.

The project reflected the Jurassic Maths Hub 'Teaching for Mastery' 2021 statement:

*The intention of teaching for mastery is to give all pupils (including those with SEND) access to **equitable** classrooms; classrooms where pupils can all participate and be influential...,*

It was also influenced by reading Lee Elliot Major's Practical Guide for teachers 'Equity in Education' (2023) and the need to do something different for under-resourced children to 'level the playing field of learning'.

Poor motivation of low-attaining students is a logical response to repeated failure in the classroom. Teachers should instead focus on getting them to succeed in class; their motivation and confidence would then be likely to improve (Coe et al, 2014). p. 28

Spatial reasoning was chosen as the mathematical focus as research has identified it can impact not just on geometric understanding but also on number:

"Our findings show that spatial play specifically is related to children's spatial reasoning skills," says psychological scientist and lead researcher Jamie Jirout of Rhodes College. "This is important because providing children with access to spatial play experiences could be a very easy way to boost spatial development, especially for children who typically have lower performance, such as girls and children from lower-income households. Playing With Puzzles and Blocks Could Build Children's Spatial Skills January 28, 2015

To give the children an opportunity to engage in spatial play it was decided that the project would involve the children in practical tasks using sets of pattern blocks.

Project structure

The three schools were Heathcoats, Two Moors and The Castle, all in Tiverton, Devon. A teacher from each of the schools and their respective six children came together for one afternoon's workshop at The Castle Primary School.

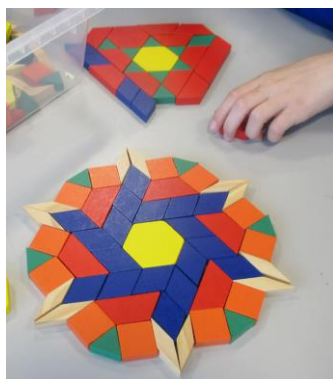
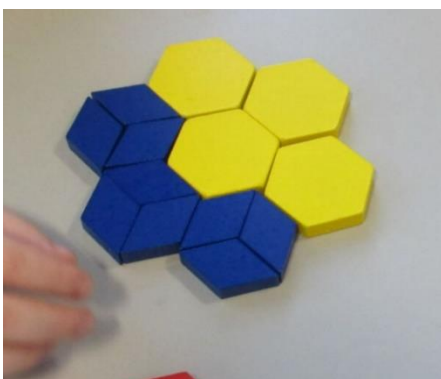
Prior to the workshop the teachers had been asked to inform the children's parents that their child had been especially chosen in the hope that this might raise the children's status.

To make the children from the different schools feel more at ease, they first ate their packed lunches as a group in the classroom where the workshop would take place.

The session was led by an adviser from the Devon Maths Team whilst a second adviser and the teachers observed the children's responses.

Initially the children were given a short time to play with and explore what shapes and patterns they could create and then share what they noticed, using what they knew including any related shape vocabulary.

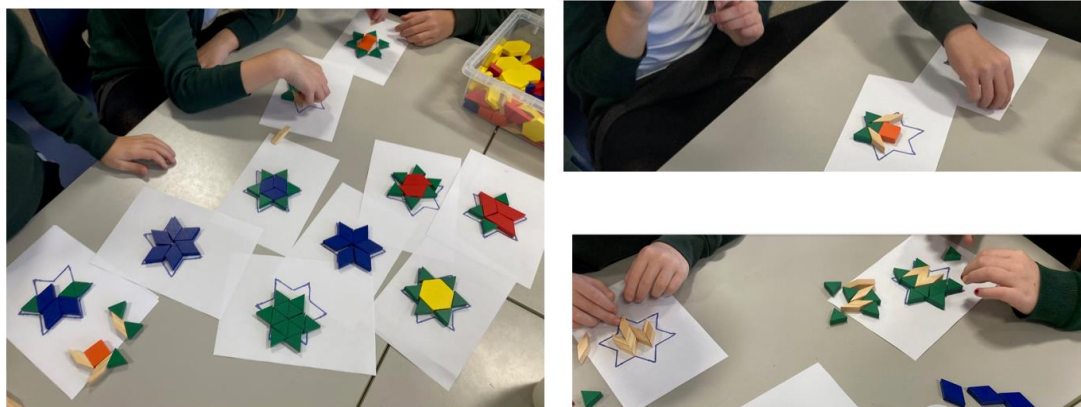
The children worked in their school groups within trios based on their teacher's knowledge of them to facilitate interaction.



Following feedback from the children's observations they were then set several challenges. An example of these challenges was to create a star, using templates which were given to each trio.

Key questions and prompts included:

- What shapes can you imagine inside of this shape?
- Use your pattern blocks to make this shape without any gaps.
- Now use your blocks to make it a different way.



The children were then given a choice of questions to explore:

- Can you make the star with only one colour? Which colours?
- What's the most /fewest number of pieces you can use to make the star?
- How many different ways can you make the star with two coloured shapes? 3 or 4 or 5 colours?
- Can you make a star with one line of symmetry? 2? 3? 4? etc?
- What other questions could you explore?

The teachers noted how engaged and focused the children were, they were 'in the flow'. They also noticed that the children showed resilience and perseverance, trying different approaches, and exploring without becoming anxious or losing interest.

It also gave the teachers an opportunity to assess the children's geometric skills.

Such activities are invaluable for many reasons:

Just as understanding and working with numbers involves developing sophisticated ways of joining and separating them, understanding, and working with space involves developing ways of composing and decomposing shapes. Seeing what shapes can be made from component parts, like pattern blocks, or what shapes are hidden inside others requires a visual fluency that can only be developed with time. Some students come to school having spent endless hours building with blocks or doing jigsaw puzzles, developing this visual fluency with each piece rotated, tested, and placed. Other students may have far less experience developing spatial reasoning, so we must create repeated and regular opportunities for students to work with and solve problems that involve space. Spatial reasoning, the larger nest that composing and decomposing shapes sits inside, is linked to patterning, algebraic reasoning, and mathematical thinking of all kinds.

Multiplicity Lab 2020

At the end of the maths session the children were then informed they would be given the responsibility of sharing their experiences back in class and be the 'peer experts' where they would lead and support a geometric task with either pairs, small groups, or their whole class.

They were also given the task of producing a PowerPoint to showcase their work that would be published on their schools and the Devon County Council website.

It was hoped by giving children such a responsibility they would feel more powerful and engaged.

As Jean Gross quoted in an interview in 2023:

*We need to do is give children real responsibility, and a chance to make a difference...
If children feel powerful, they are much more likely to engage with school and with their teachers.*

How school has to change for disadvantaged pupils to thrive Interview 26th April 2023

After the workshop the teachers and advisers met online to collaboratively plan how and when each group of six children would work as 'peer experts' in their own schools. The teachers decided on different approaches depending on their own school context and focus children.

One teacher decided to work with their focus group prior to them leading a session to ensure they all felt comfortable and prepared. He also wondered if the children might like to take on specific roles (speaker, scribe, resource organiser...) so that they could play to their strengths. As he had a Y4/5 class he planned for the group to first deliver the learning to their own Y4 peers before the Y5 children.

Another teacher described how two days after the project, the children did a 'mini lesson' with the rest of their class having been given time to plan it first.

The project children worked in pairs (one boy and one girl). Initially they were given time to consider what the first activity they could introduce/teach to the class could be and then shared their ideas. They decided on teaching the class the shape names for the pattern blocks, getting them to find similarities and differences between them and then allow them free time to play and explore.

The teacher remarked how the focus children went home and told their parents that they were going to be teaching the class and how the parents spoke to her the following morning about their child being excited about this.

As well as the focus children leading a session, the third teacher described how she used a shape 'warm-up' with the whole class, in which they had to identify quadrilaterals, including a rhombus which the project group had met in the workshop.

I deliberately included a rhombus which children from the project knew the name of and no one else did. It was like our little secret.

This was an example of assigning competence to them to raise their status.

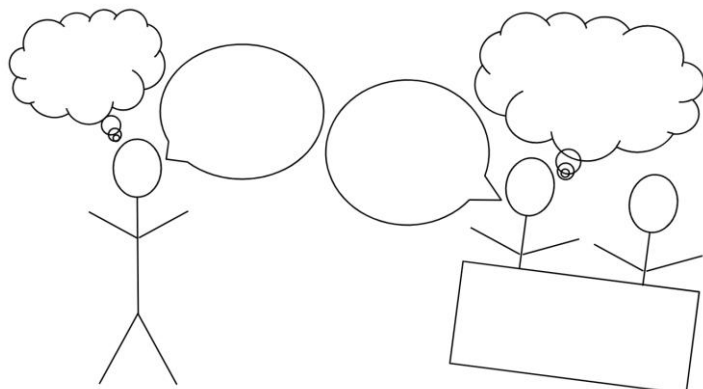
Data collection

It was agreed that some qualitative and quantitative data would be collected to support understanding of impact and contribute to findings. To anonymise the data each child was given an individual number from 1-18.

Teachers completed a pen portrait on their focus children describing their reasons for choosing each child and added their reflections at the end of the project.

Children completed pupil view templates and short questionnaires which they then repeated at the end of the project:

Before and after pupil view template



Child writes what they think the teacher is thinking and saying and what they are thinking and saying in a maths lesson.

Before and after project pupil questionnaire

Date:	Pupil number:
Question	Response
When you are about to have a maths lesson, which of these do you feel?	   Why?
How do you feel when you are asked to share your maths with other children?	   Why?

Child circles and gives reason for:

When you are about to have a maths lesson which of these do you feel?

How do you feel when you are asked to share your maths with other children?

Focus children selection

The teachers had various reasons for selecting their focus children. Many of the under-resourced children were working below ARE or under-performing, lacked confidence and self-esteem, struggled to work independently and/or had difficult home lives.

For example:

Y4 Child 1

*PP She is currently (WTS) across core subjects. She is very quiet in maths lessons and will retreat into herself when asked questions and become anxious rabbit in headlights
I hope this will be an opportunity for her to be the one imparting her knowledge to others.*

Y4 Child 5

PP, at risk of not meeting ARE and he is very quiet in class with a tendency to rely on others. When questioned he struggles to articulate his thinking and explain his method. I wonder how he will respond to a more abstract, hands-on approach.

Y3 C11

*Single parent family, only boy with lots of girl siblings
Very quiet in class and reluctant to answer questions.*

Y3 Child 16

Difficult home life and little support.

Happy to sit in lessons and let others to do the talking.

Lacks confidence and doesn't like to be asked a question.

At the end of the project one of the advisers then visited each school to gather the class teachers' reflections and to repeat the pupil view template and pupil questionnaire with the children.

Findings:

The teachers reflected that all the children enjoyed participating in the workshop and being 'peer experts' back in their own schools.

He did enjoy teaching his peers and has spoken to me about the activities since.

She was confident to take a lead and was excited about presenting and teaching others.

Liked standing at the front and telling peers what to do.

Enjoyed teaching his peers and telling them about their trip to The Castle.

The children also commented about their enjoyment and included this on their PowerPoint.

We got to let them have fun and also to think of how to support them.

Nice to be experts and be able to tell them what to ~~do~~do.'

It is something that we would like to do again maybe with our class or other classes.

Teachers heard from parents about the impact of the project on their child.

His parents also informed me that he was excited.

...had gone home and told his mum about it who said he had been excited.

Teachers noticed a change in some of their focus children's behaviour in maths lessons following the project:

...started showing more pride in maths lessons, presentation and amount of work completed has improved greatly.

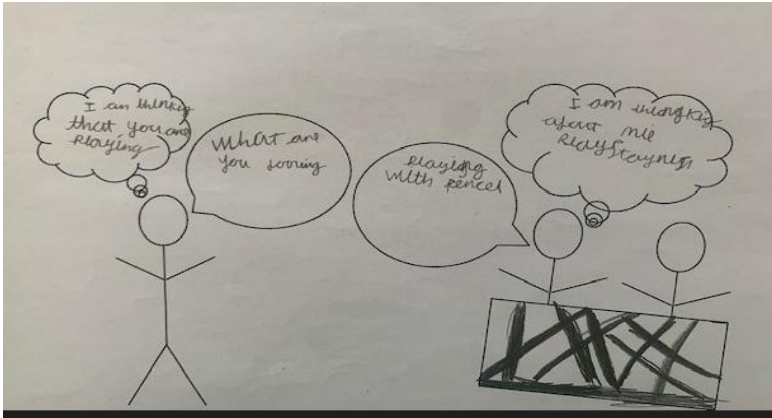
...has moved to working independently rather than in a guided group.

...has begun to work more independently.

A teacher feedback that one child's attainment had already improved.

Her maths has improved both in terms of assessment and in class. Further evidence was obtained by directing comparing children's pre- and post-pupil view templates and questionnaires. **(See appendices for other examples)**

Child 8

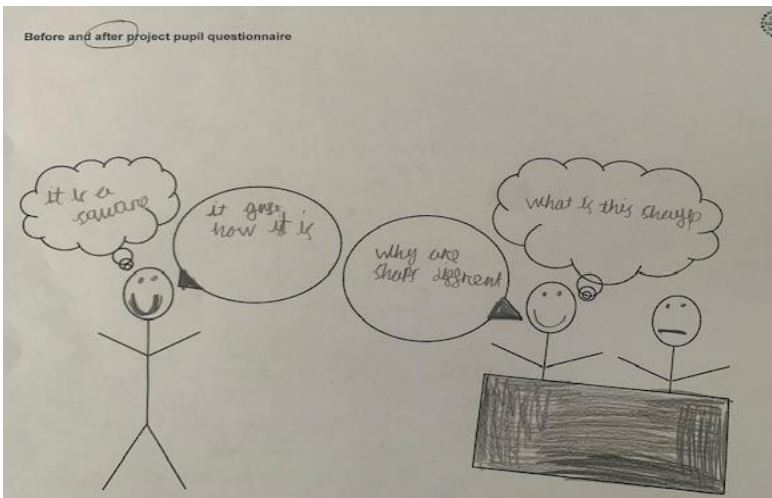


Before

T- I am thinking you are playing.

'What are you doing?'

C-Playing with pencil 'I am thinking about my PlayStation.'

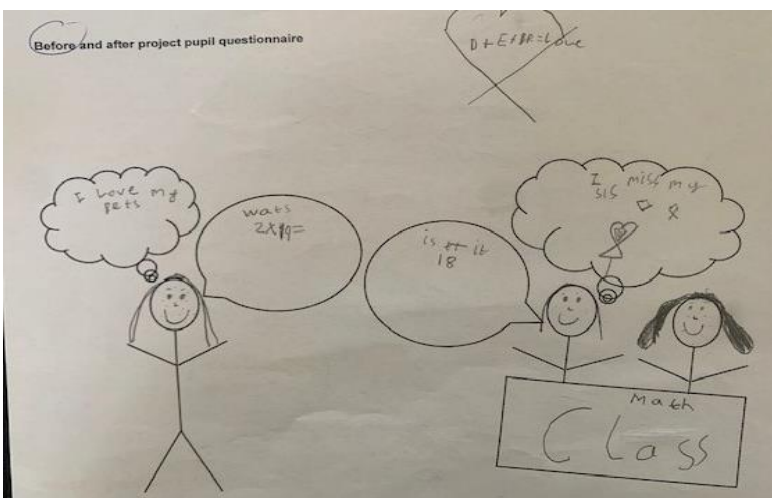


After

T- It is a square. 'It's just how it is'.

C- What is this shape? 'Why are shapes different?'

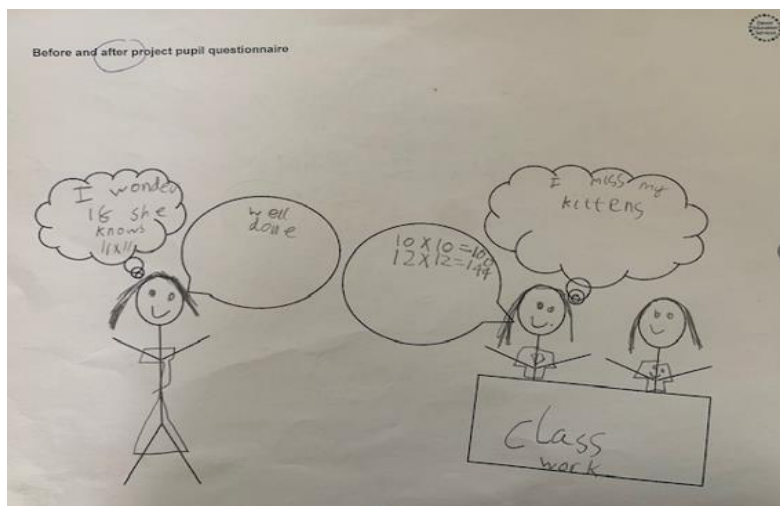
Child 17



Before

T- I love my pets. 'What's 2 x 9?'

C -I miss my sister. 'Is it 18?'



After

T- I wonder if she knows 11x 11? 'Well done.'

C- I miss my kittens. "10 x10 = 100, 12 x 12 = 144'

Pupil questionnaires:

Child 7

Before and after project pupil questionnaire

Date:	Pupil number: 7
Question	Response
When you are about to have a maths lesson, which of these do you feel?	Why? <i>Writing numbers is easy and helps me learn</i>
How do you feel when you are asked to share your maths with other children?	Why? <i>Because I am nervous and worried</i>

Before

Happy – *writing numbers is easy and helps me learn.*

Sad- *because I get nervous and worried.*

Before and after project pupil questionnaire

Date:	Pupil number: 7
Question	Response
When you are about to have a maths lesson, which of these do you feel?	Why? <i>I love maths</i>
How do you feel when you are asked to share your maths with other children?	Why? <i>I am excited</i>

After

Happy for both- *I love maths and am excited.*

Child 10

Before and after project pupil questionnaire

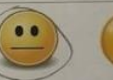
Date:	Pupil number: 10
Question	Response
When you are about to have a maths lesson, which of these do you feel?	   Why? because you get a little intelligence
How do you feel when you are asked to share your maths with other children?	   Why? because im a bit shy

Before

Frown- because you get a little bit of intelligence.

Frown- because I'm a little bit shy.

Before and after project pupil questionnaire

Date:	Pupil number: 10
Question	Response
When you are about to have a maths lesson, which of these do you feel?	   Why? Because I like Maths a little bit
How do you feel when you are asked to share your maths with other children?	   Why? because I like sharing Maths with other people

After

Frown because I like maths a bit.

Happy because I like sharing maths with other people.

Discussion

The pattern blocks experience was new for all three schools. The workshop gave the focus children an opportunity to explore and become familiar with the blocks before the rest of the class and this gave them the confidence to take on the role of 'peer-experts'.

The focus on spatial reasoning rather than number and calculation also allowed the children to engage creatively in a way that was less likely to cause anxiety about being 'wrong'. (Several teacher comments reflected their focus children being anxious and reluctant to give an answer in maths lessons.)

The brevity of the project: one workshop and one experience teaching other children in their class meant we worried that there would be little impact on the focus children.

However, our findings revealed several children were more actively engaged and achieving more within their daily maths lessons and that one child's attainment had already improved. All the children also commented favourably about their involvement.

Additionally, the experience highlighted how engaging under-resourced children in a such a 'special maths' project can lead to increased parental interest and child- parent talk about maths.

We were glad that the teachers recognised the positive impact of the pattern block project but sadly teachers reported that they don't feel able to fit this type of geometric activity into their school's maths curriculum on a regular basis.

I wish there was more time for this sort of stuff. It is shame I would like there to be more play and exploring. At the end of the day, you need to cover the objectives.

As this mini- project has illustrated perhaps we should make more time for this area of the curriculum. The 'under-resourced' children evidently thought so.

It is something that we would like to do again maybe with our class or other classes.

References:

Association for Psychological Science January 28, 2015 in Cognitive Science-
<https://www.psypost.org/playing-puzzles-blocks-may-build-childrens-spatial-skills/>

Coe et al, (2014) What makes great teaching? London: The Sutton Trust

Elliot Major, L. & Briant E. (2023) Equity in Education- A practical guide for teachers

Gifford S. (2020) The Importance of Shape and Space in the Early Years <https://nrich.maths.org/14544>

Gross J. How school has to change for disadvantaged pupils to thrive -TES Interview 26th April 2023
<https://www.tes.com/magazine/teaching-learning/general/jean-gross-school-change-disadvantaged-pupils-thrive>

Gross J. (2021) Reaching the Unseen Children: Practical Strategies for Closing Stubborn Attainment Gaps in Disadvantaged Groups by Jean Gross (Early Intervention Foundation, UK)

Jurassic Hub (2022) Jurassic Maths Hub Teaching for Mastery Statement
<https://www.jurassicmaths.com/jurassic-maths-hub-teaching-for-mastery-statement/>

Munsen J. et al (2020) Multiplicity Lab - <https://multiplicitylab.northwestern.edu/big-ideas/#comp-decomp-shapes>

Verdine, B.N., Golinkoff, R. M., Hirsh-Pasek, K. & Newcombe, N. S. (2017) Links between Spatial and Mathematical Skills across the Preschool Years. Monographs of the Society for Research in Child Development, 82, no. 1 (March): 1-150. <http://onlinelibrary.wiley.com/doi/10.1111/mono.v82.1/issuetoc>.

Young, C.J., Levine, S.C. & Mix, K.S. (2018). The Connection Between Spatial and Mathematical Ability Across Development. Frontiers in Psychology, 04 June. <https://doi.org/10.3389/fpsyg.2018.00755>