Can a science storybook enhance children's science vocabulary and understanding?

● Jules Pottle ● Tina Whittaker ● Sinead Carroll Knight
● Jo Guillon ● Chris Wemyss

Abstract

Our experience in the classroom and in previous projects led us to consider whether a specially created picture book could stimulate discussion and learning about a topic such as gravity. Children's use of vocabulary was considered in Year 3 (age 7-8) classes in three schools in Stoke-on-Trent in England. A comparison was made between use of a factsheet and a storybook as a teaching stimulus.
The study found that children who had discussed the storybook rather than the factsheet used scientific vocabulary accurately and meaningfully more often in their explanations.

Keywords: Picture books, gravity, vocabulary, story

Introduction: The power of stories

From our experiences as teachers and trainers, we have found that stories are very engaging. We tell stories in assembly and two hundred children fall silent, eyes fixed on the storyteller. Two hundred faces react as the bird dies or the treasure is found. In training sessions full of teachers, who are constantly multi-tasking, the diaries are closed, their phones tucked away, and their bodies relax when told a story. There are important cognitive consequences of using the story format. Psychologists have referred to stories as 'psychologically privileged', meaning that our minds treat stories differently from other types of material (Willingham, 2011). People can find the story format engaging, easy to understand and easy to remember.

Bower (1978) says that our minds pay attention to stories in a different way from information presented in the absence of an emotional narrative. The emotional connection is what makes stories different from non-narrative texts. He says that we are hard-wired to engage with stories and our minds give psychological privilege to information presented in this form. Stories help us to empathise with others. Empathy with others is essential when maintaining one's place in a social group. Therefore, listening to stories, engaging with and empathising with others, may have been subject to natural selection. People who engage with stories remain in the social group, which is safer than living alone, so Bower suggests that it may be a trait that is positively selected in the evolutionary process.

Our journey into writing science picture books began when we were teaching the topic of evolution. Evolution is a complex theory that is often distilled into an overly simplistic definition: animals adapt to a changed environment, e.g. the brown bears that went north in search of food 'became' polar bears. Children whom one of the authors encountered believed that this meant that the brown bears stopped at the edge of the snow, aged and their fur went white (as human hair does) and that this white hair 'stuck' for all future generations. When children do not have all the facts, they tend to fill in the gaps with their own ideas, which are often incomplete ideas (preconceptions) or more fully developed incorrect ideas (misconceptions). We wanted to bring these preconceptions (and misconceptions) to light in the classroom and use stories to provoke discussion.

Teaching approaches that focus on purposeful 'dialogic' classroom interactions (Alexander, 2005)

highlight the need for open discussion, for teachers to be prepared to allow children to question evidence. Mercer *et al* (2004), for example, have shown that teaching interventions designed to promote 'exploratory' talk can enhance children's thinking, reasoning and understanding in science. A move towards more dialogic practice can be facilitated by the use of activities that enable groups of children to engage in discussion autonomously without constant intervention (Simon & Maloney, 2007).

Jules Pottle reflects on previous development of stories for science

In 2018, Rufus Cooper (R. Thomas) and I began toying with the idea of writing a picture book that demonstrated natural selection. We aimed to write a science-based book with sufficient ambiguity to promote dialogic talk in the classroom, where children could work through their ideas and also allow the teacher to hear their changing ideas as they reconsidered what others had said. I had previously found that the more ambiguous the evidence, the better the conversation, as they would all fix on different bits of evidence and argue it out from there: in this way, explicitly discussing their ideas including any misconceptions, leading towards the development of more scientific conceptions.
We trialled a prototype in schools to see if we had hit the mark in terms of the level of ambiguity (enough to create discussion, but not too much to cause confusion), the level of vocabulary and the emotional hooks in the story. Where it was too open, we added pages of extra pictures to clarify the story, together with teacher notes on possible pre/misconceptions. This led us to the creation of *The Molliebird* (Pottle & Thomas, 2018).

When trialling this text, we considered: Can the children *learn* a concept by reading and discussing a story? This informal research was challenging to analyse, as the children's answers were so varied. The teachers' answers were much clearer, however, with teachers reporting that the children talked more and were more engaged in the lesson than in other science lessons.

Our next project was with teachers in Stoke (through Science Across the City), working with Year 2 (age 6-7) classes on classification. We wrote a story called *Jasper the Spider* (Pottle & Thomas, 2019) and, in partnership with the teachers, devised some techniques to gather data on the following questions: Do children learn and retain information presented in a fictional story as well as information presented as a factsheet? These included a 'before and after' quiz, with questions that showed their understanding of the differences between spiders and insects. It also included some forest school/art activities, where the children constructed and described their own models of spiders and insects. We found that, generally, the learning appeared to be similar – both groups learned that spiders were not insects (Pottle, 2021). Teachers also reported that the children using the book were much more engaged with the topic: they talked about spiders in the classroom spontaneously, they brought in research that they had done at home (on which spiders eat their own mates), and they used the vocabulary learned from the book, correctly and with purpose, to talk about insects and spiders encountered in the rest of the topic and beyond.

We found with *The Molliebird* and *Jasper the Spider* that these stories stimulated engagement and discussion (see Box 1). For this next study, our research question was designed to consider any improvement in vocabulary more closely:

Do children accurately use scientific vocabulary more after reading a science picture book or after reading a fact file on the same topic? (NB: In both cases, the teacher read the text out loud).

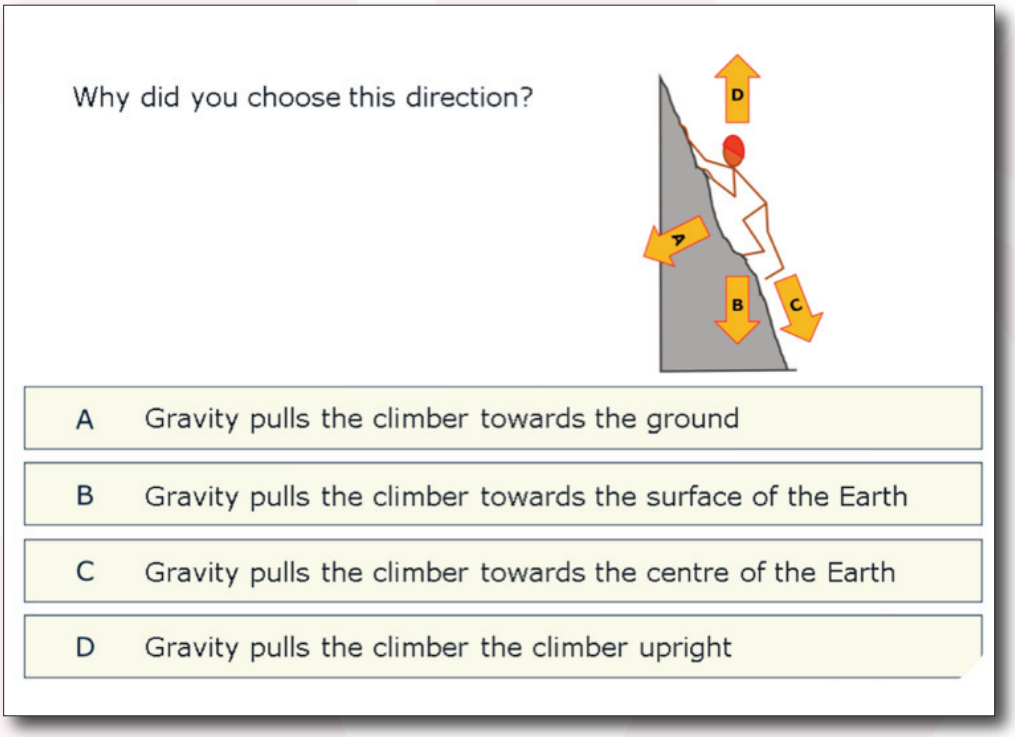
In order to answer this question, we created a new science picture book on the topic of gravity.

Why did we write a book on gravity?

In 2021, the data available to secondary schools at transition were limited due to the COVID-19 pandemic pause on reportable Key Stage 2 (KS2, ages 7-11) attainment data. As an interim solution across all primary schools in Stoke-on-Trent, every Year 6 (age 10-11) child completed diagnostic assessments for English, mathematics and science. The pupil question data were analysed centrally within the local authority, to inform secondary schools of curriculum gaps for their upcoming Year 7 (ages 11-12).

Furthermore, having question data from over 3000 children from 70 schools enabled an understanding of themes that were causing the greatest challenge in primary science (Price, 2021). The diagnostic assessment was built from BEST questions (see BEST weblink below) that were relevant to the KS2 Teacher Assessment Framework (STA, 2018). More children gave incorrect responses to the question about gravity than to any other, with only 32% of respondents stating that gravity pulls the climber towards the centre of the Earth (Figure 1). Most children recognised a link between gravity and the Earth, but there was confusion about the ground. 32% selected 'Gravity pulls a climber to the ground', and 28% selected 'towards the surface'. Primary teachers in the city reflected upon the findings and pondered whether their teaching approaches were resulting in simple vocabulary recall rather than development of conceptual understanding. This resulted in a desire to find a new strategy that would be more supportive of children's learning in the future.

Figure 1. Diagnostic question for gravity from BEST.

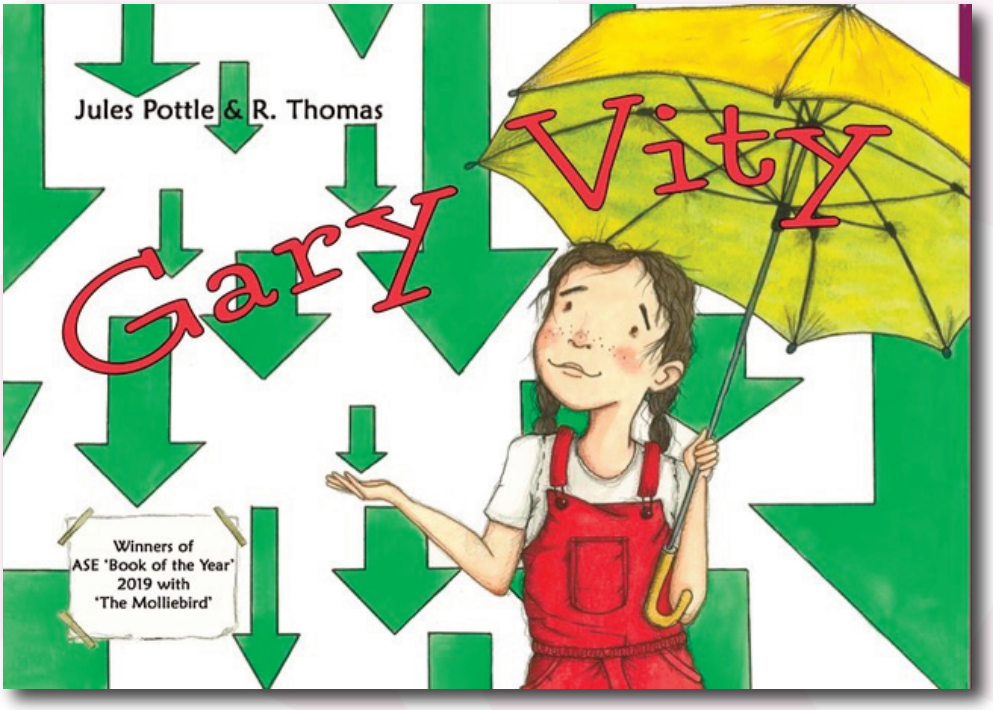


Professional learning model

Having recognised a city-wide issue regarding the understanding of gravity, a practitioner research forum was set up. Jules Pottle was invited to lead on the development of the new resource in response to the identified learning gap, and teachers reviewed, tweaked and trialled the resource as it emerged from concept to final publication reality. This peer joint-practice model for professional learning is sustained, collaborative across schools and enables authentic enquiry, with evidence of impact on pupil outcomes at the heart of the professional dialogue (DfE, 2016; Earley & Porritt, 2010). Engagement in this CPD approach was reported by those involved to have a lasting effect beyond the publication of the book, with other teaching approaches now more likely to be justified and evaluated rather than selected simply for novelty.

Method

The Year 3 classes from three schools from across the city took part in this research project. We were interested to see if class discussions and vocabulary use differed depending on the stimulus resource used for teaching. The stimulus resource was either a factsheet or a story, the latter being a trial PowerPoint version of the new story of the character 'Gary Vity', which was read to the children.



To compare responses to the two teaching methods, two comparative groups were set up in each of the Year 3 classes. We selected a cross-section of the class to include boys and girls and all abilities with respect to science. Both groups were taught about gravity, but used either a factsheet or the story of Gary Vity. A cross-section of children were selected by the class teacher to create groups with mixed prior attainment (low attainment, middle attainment and higher attainment). The research project was discussed with the children and parents, to ensure informed consent. Data were stored securely on the school system and anonymised before sharing beyond the school.

The children were filmed before and after learning about gravity using the book or the factsheet. Both groups were asked to explain gravity through two different scenarios:

- *Can you explain scientifically what will happen when a pencil is dropped on the floor?*
- *Can you explain scientifically what will happen when a toy car goes down a ramp?*

The class teacher watched the video recordings back and analysed vocabulary use by counting the frequency of accurately-used specific scientific vocabulary.

Results

After the group discussions, the following vocabulary use was tallied from the video recordings: *gravity, push/pull, pull to centre of Earth, speed/power, straight down* and *force.* A tally (x) was recorded for each time that a word was used by each child (xx = twice) in the group table (e.g. Figures 2 and 3). (HA = high attainment in science, MA = Middle attainment in science, LA = Low attainment in science.) We only counted words that the children used. We did not pre-select the vocabulary.

Figure 2. Vocabulary use in factsheet group.

Information sheet group

Child											
	Gravity correctly	Gravity incorrectly	Push and pull correctly	Push and pull incorrectly	Pull down to centre of earth correctly	Pull down to centre of earth incorrectly	Speed and Power used correctly	Speed and Power used incorrectly	Straight Down correctly	Straight Down Incorrectly (side to side)	Force correctly
HA Boy	xx		Xxx		X Plummeted down	X			xx		xxx
HA Girl	xx		xxx		x						
MA Boy	xxx		x		x				xx		x
MA Girl	xxxx								x		x
MA Boy	xxx		xx				xx		xx		
MA Girl	xxx						x		xx		x
LA Boy	xxx		x		xxx			x			x
LA Girl	xxx		xx								x

Figure 3. Vocabulary use in story group.

Story Group/PPT

Child											
	Gravity correctly	Gravity incorrectly	Push and pull correctly	Push and pull incorrectly	Pull down to centre of earth correctly	Pull down to centre of earth incorrectly	Speed and Power used correctly	Speed and Power used incorrectly	Straight Down correctly	Straight Down Incorrectly (side to side)	Force correctly
HA Boy	Xxxx invisible		xxx		Xx core		xxx		xxx		xxx
HA Girl	Xxxx Invisible force		xxx		Xxx Middle of earth		Xxx Aerodynamics xx		xxx		xx
MA Boy	x xx		x						x		
MA Girl	xxxx		x						x		
MA Boy	xxx		x								x
MA Girl	xxx		xx		xx		xx		xxx		xx
LA Boy	xx	xx	x	xx					xxx	x	xx
LA Girl		x	x	xx							

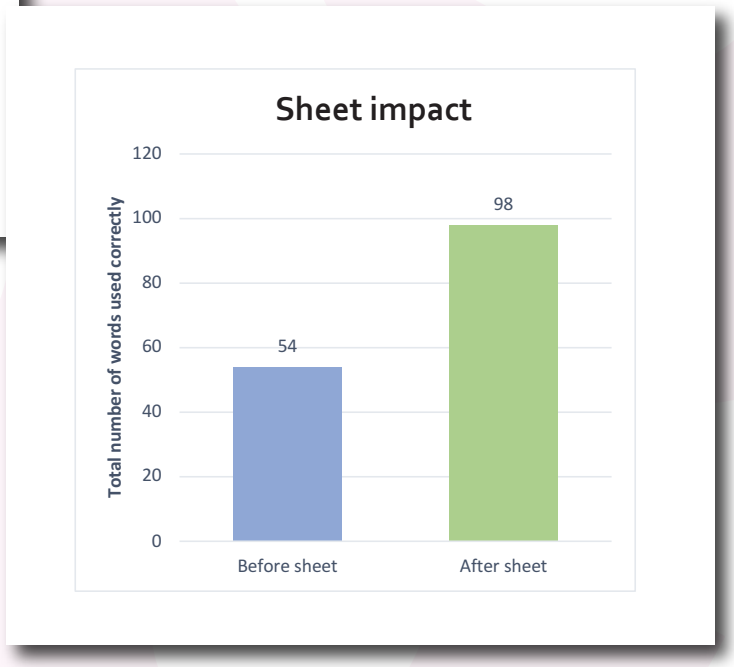
Figure 3 contd.. Vocabulary use in story group.

MA girl talked extensively about the steep slope making the car go faster. The force at the top will make it go slower and as it gets to the bottom of the slope it goes faster. It stops at the carpet because of gravity. It is mixed speed.

HA had a similar discussion but used the word 'gravity' in context more frequently. HA girl also talked about aerodynamics and could explain it. ("A shape of an object that can affect how something goes through the air - wind too")

When comparing the impact of the non-fiction sheet versus the story, the results show that the story had a greater impact on the vocabulary that the children were using. This can be seen in the greater number of Xs in Figure 3 than in Figure 2. The pupils who had read the story showed improvements in the correct use of scientific vocabulary linked to gravity. While the children who read the factsheet did make improvements, these were not as large as in those who had read the Gary Vity story. Those who read the story used 109 correct words, compared to 44 words for those who read the factsheet (Figure 4).

Figure 4. Bar charts to compare vocabulary use in the factsheet and story groups.

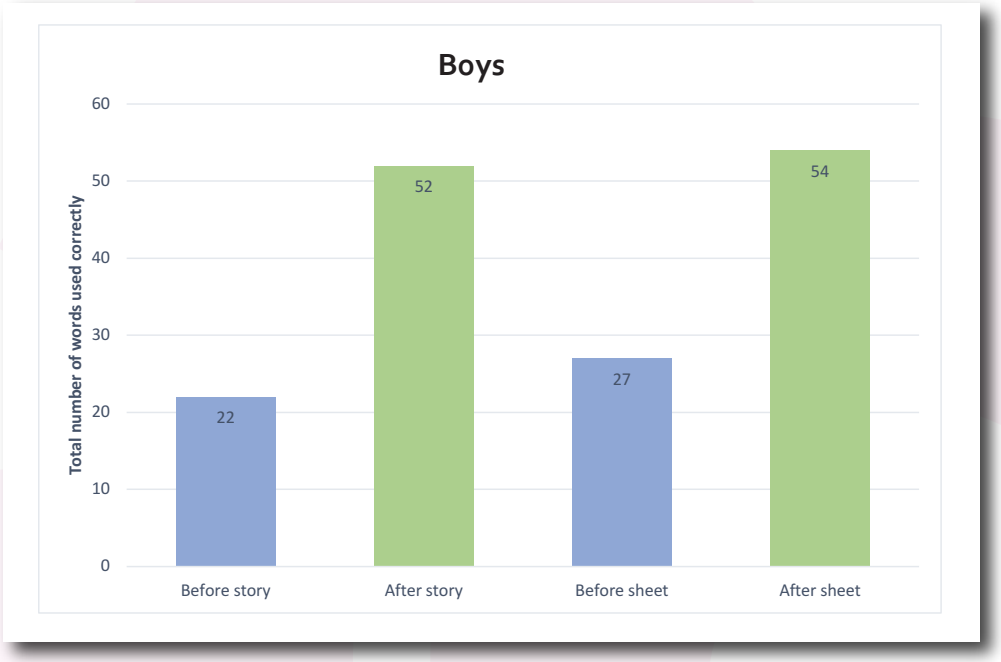


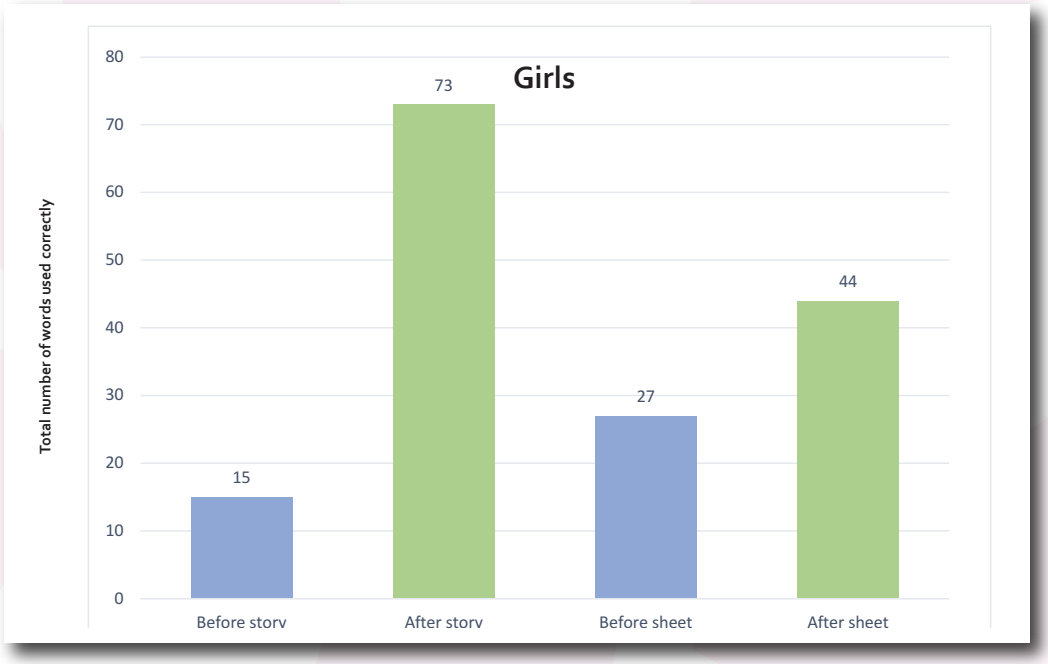
Gender comparison

The results show an interesting comparison between the effects of the story versus the factsheet between boys and girls. Whilst boys have shown a good amount of improvement using both the story and the non-fiction sheet, the girls' data reveal something interesting: girls who read the story made a greater improvement in the use of their scientific vocabulary compared to the girls who read the factsheet text (Figure 5).

This led us to wonder if this significant finding was due to Gary Vity having a female main character, or whether the fictional story appealed more to girls.

Figure 5. Bar charts to compare vocabulary use for girls and boys in the story group.

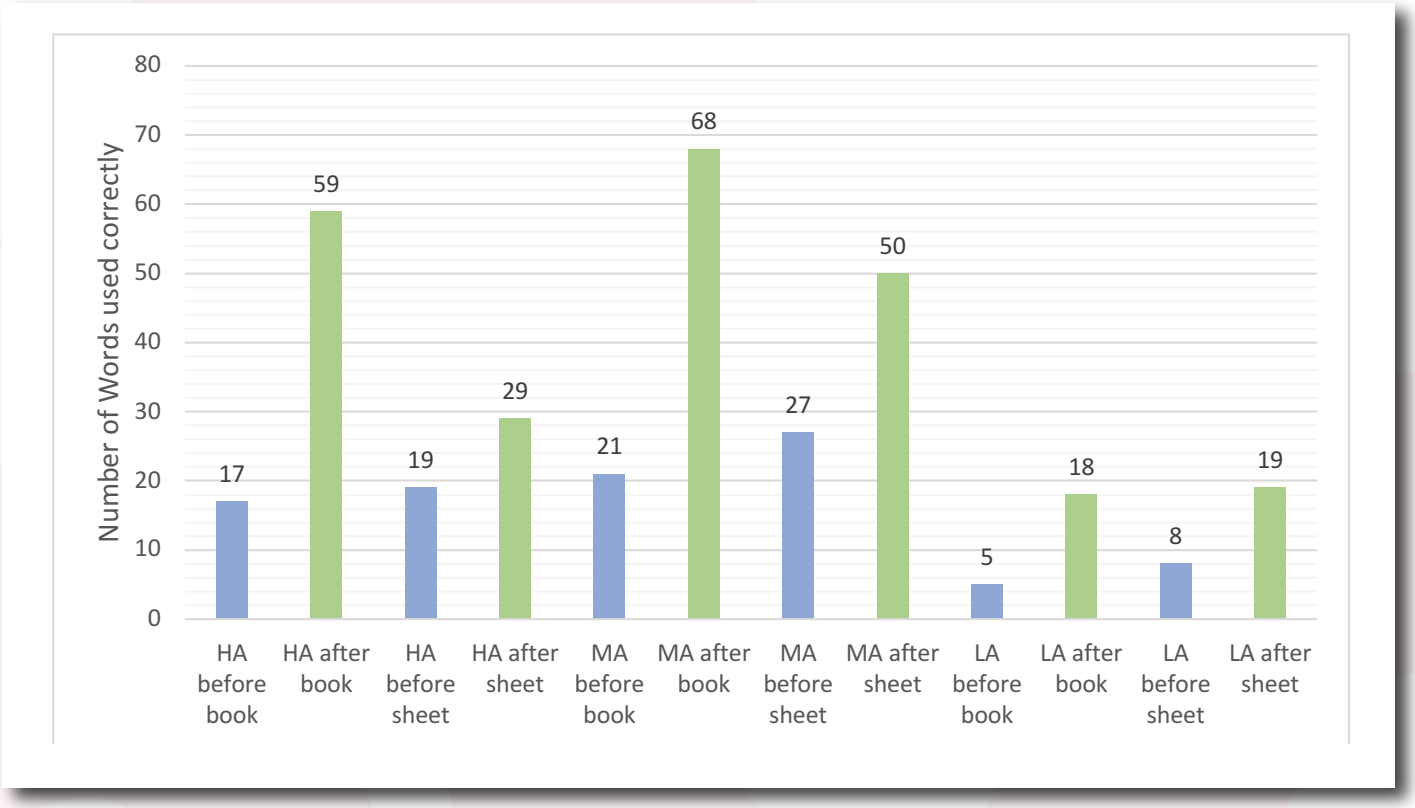




Prior attainment comparison

We also broke down the data to see whether prior attainment had an effect on the data. In the high and middle attaining groups, there was a clear improvement when reading the story: the group with higher prior attainment used the correct vocabulary 30 more times, whilst for those with middle prior attainment, vocabulary was used 18 more times than when reading the factsheet.

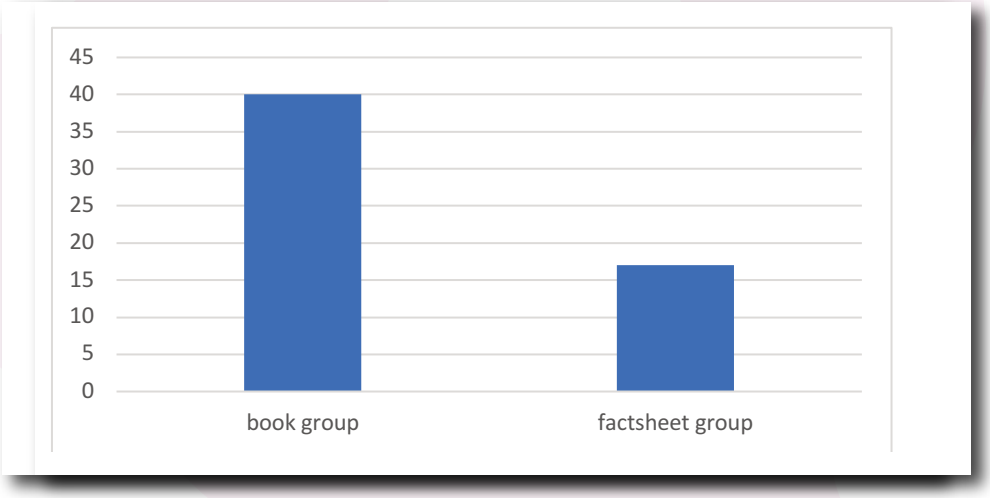
Figure 6. Graph to compare vocabulary use for high, middle and lower prior attainers in the story group.



Spontaneous mentions of gravity in the classroom

After the first session, where one group read the story and one group used the factsheet, both the teachers and teaching assistants in the classroom logged when gravity was discussed, spontaneously, by the children in the classroom (i.e not introduced by the teacher). This was mostly outside of science lesson time. The data were collected on a tally chart and, where possible, quotes were also noted down. From the average of the three schools, the book appeared to have had a stronger impact on the children compared to the factsheets.

Figure 7. Number of spontaneous mentions of gravity in later class time.



On average, the book was mentioned 14 times, compared to 4 times by the factsheet group. These mentions were not purely about the book, but referencing gravity correctly in everyday scenarios and lessons outside of science. References to gravity were varied and often playful: a pencil fell on the floor and a child said, 'Gravity!' and, when a pencil pot was knocked over, a child joked that it was 'Gary Vity up to no good!'.

The story had a big impact on the children and they were talking about gravity long after the those from the factsheet group. Anecdotal evidence from the factsheet group included comments that the factsheets were 'dull compared to the book' and, when they had read the book, 'the factsheets were boring'. The factsheets themselves were colourful and informative, but children repeating the poem from the story and the characters' comments had a bigger impact. Forces are difficult concepts for children to understand, but the story helped the children to retain and show a deeper understanding of gravity.

Conclusion and further questions

Returning to our research question:
Do children accurately use scientific vocabulary more after reading a science picture book or after reading a fact file on the same topic?

From this limited study, we found the answer in this context to be:
Children used more scientific vocabulary after reading a science picture book and this was more pronounced in the girls' usage compared to the boys'.

This is, of course, a very small study. It would need to be repeated on a much larger scale, with careful consideration of allocation to groupings and reading materials, etc., to increase confidence in the results. However, from our experience, we have found that story raises engagement in the topic; it acts as an effective prompt to increase the amount of discussion and often provides the link that helps children to remember their learning years later. Stories can often be more easily remembered. Learning associated with that story may be easily recalled too. It is as if the story becomes a peg upon which to hang that learning within our memories.

This study also raises other interesting questions. Do girls engage with the book because the protagonist and the wise helper are both female, or is it simply the narrative form that engages girls more? If we made another book with the same story but a male protagonist and a male wise helper, would it still have a greater effect on girls? Furthermore, if we put a child of colour at the centre of a story, would it have a positive effect on children of the race portrayed in the book? Stories are certainly powerful tools in education and have a strong link to long-term memory. If we can place familiar figures in the centre of emotive stories that also engage us in the science, then we may have the perfect way to help children to see themselves in scientific careers at the same time as giving them the vocabulary that they need to talk about science more confidently.

References

Alexander, R. (2004) *Towards Dialogic Teaching: rethinking classroom talk.* Thirsk: Dialogos

Best Evidence Science Teaching (age 7-11): https://www.stem.org.uk/primary/resources/collections/science/best-evidence-science-teaching

Bower, G. H. (1978) 'Experiments on story comprehension and recall', *Discourse Processes*, **1,** (3), 211–231. DOI: 10.1080/01638537809544437

Department for Education (2016) *Standard for teachers' professional development.* https://www.gov.uk/government/publications/standard-for-teachers-professional-development

Earley, P. & Porritt, V. (2010) *Effective Practices in Continuing Professional Development*. London: Institute of Education, University of London

Mercer, N., Dawes, L., Wegerif, R. & Sams, C. (2004) 'Reasoning as a scientist: ways of helping children to use language to learn science', *British Educational Research Journal,* **30,** (3), 359–378

Price, B. (2021) 'Is our lost generation now the BEST generation?', *Connect,* (4), 18–21. https://www.scienceacrossthecity.co.uk/connect-issue-4/

Pottle, J. & Thomas, R. (2018) *The Molliebird: an evolution story.* Bristol: Primary Science Teaching Trust

Pottle, J. & Thomas, R. (2019) *Jasper the Spider.* Artful Fox Creatives. https://www.artfulfoxcreatives.com/book/6ztGogkXYLELa9xS8UNOld
Pottle, J. (2021) 'Jasper the Spider – The Stoke Science Picture Book Project', *Connect*, (4), 16–17. https://www.scienceacrossthecity.co.uk/connect-issue-4/
Simon, S. & Maloney, J. (2007) 'Activities for promoting small-group discussion and argumentation', *School Science Review,* **88,** (324), 49–57
Standards and Teaching Agency (STA) (2018) *Teacher assessment frameworks at the end of key stage 2.* https://www.gov.uk/government/publications/teacher-assessment-frameworks-at-the-end-of-key-stage-2
Willingham, D.T. (2011) *Ask the Cognitive Scientist.* https://kbsgk12project.kbs.msu.edu/wp-content/uploads/2011/02/Ask-the-Cognitive-Scientist.pdf

Jules Pottle, Primary Science Specialist Teacher, author (DK and Artful Fox Creatives) and Storytelling Schools Assistant Director.
E-mail: julespottle@gmail.com

Tina Whittaker, Science Across the City, Stoke-on-Trent.

Sinead Carroll Knight, Our Lady and St Benedict Catholic Academy, Stoke-on-Trent.

Jo Guillon, Packmoor Ormiston Academy, Stoke-on-Trent.

Chris Wemyss, Gladstone Primary Academy, Stoke-on-Trent.