Introducing scientists to primary children: Does this always enhance children's science capital?

● Alison J. Trew ● Ruth Shallcross ● Kate Redhead

Abstract

The benefits to primary pupils of introducing scientists' work (historical and cutting-edge) in the curriculum are considered from a science capital and social justice perspective. Two resources developed by the Primary Science Teaching Trust (PSTT), *Engineering Our World* and *I bet you didn't know…*, which both support teachers introducing scientists and their work to primary children, are discussed and evaluated with regard to enhancing children's science capital. These resources, used with appropriate consideration, could be an early step towards addressing the inequalities that currently exist in those who participate in science post-16 and those who do not.

Introduction

The effort to broaden students' aspirations, particularly in relation to Science, Technology, Engineering and Maths (STEM), needs to begin at primary school. The current focus of most activities and interventions at secondary school is likely to be too little, too late (Kings College London, ASPIRES, 2013).

Recognising the contributions of scientists and inventors is woven into most UK curricula and inviting STEM Ambassadors or science visitors into school is a staple of what is considered to be excellent science provision in primary schools. However, it is vital that consideration is given to not just the *why* of engaging with scientists and their work, but also *who* is engaged with and the nature of that engagement. When considering the motivations for engagement with scientists and their work, there are myriad reasons presented: providing a real-life context for science, building the STEM workforce of the future, helping children to understand the scientific process, linking to and enriching the taught curriculum, developing pupils' science capital, fostering a scientifically literate population, social justice, representation, fuelling inspiration and aspiration and, most recently, the implications of COVID-19. There are, of course, many additional reasons.

The whys or motivations for engaging with scientists should inform decisions around with whom to engage. For example, is the primary concern to expose pupils to science content, or to work to change and challenge the structures and practices within the classroom and education that create and maintain inequalities?

When looking through a science capital *lens* and focusing in on social justice, it can be observed that science content-rich teaching and learning can be excellent for developing scientific knowledge and understanding, but not necessarily for fostering equity and pupil engagement. Before engaging with scientists and their work, teachers, teacher trainers, STEM education organisers and curriculum resource developers need to establish clarity regarding the purpose of engaging with scientists and their work. What is the anticipated outcome? What is the actual outcome? Why should the children be invested in the content and experience?

Broadening perceptions of where STEM subjects could lead in the future, and who works (or worked) in STEM, are essential considerations to a science capital approach, as well as critiquing historic dynamics. Inviting scientists into the education setting or profiling their work could help to build science capital in pupils or help young people to see science as being for them.

When engaging with science capital, it is essential to sharpen the focus on the field. Within society, everyone exists in power relations. The field sets the rules of the game. It is the space of positions and position taking. In education, there are different levels of field: the education system, the world of science, the school, the science classroom.

A number of interventions in science focus on trying to change the young person. Yet, it is really the field that determines whether the individual can thrive. How are science educators levelling the playing field, or adopting a social justice model of taking down the fence or barriers to participation in science?

How does the choice of scientist affect the field? Inviting in a visitor who is not representative of the demographic of pupils to run a one-off session that does not relate to the curriculum is very unlikely to develop pupils' science capital. In addition, it is vital to question professional legacy. For example, in the age of the climate crisis, is it appropriate to focus on those working in the fossil fuel industry in the primary classroom? There is implied legitimisation of their work by virtue of invitation without critique.

To begin adopting a social justice model, the following questions can be asked by science educators prior to engaging with scientists' and their work:

- To what extent does this visit support equitable and science capital outcomes?
- To what extent are societally dominant forms of representation being challenged or reproduced?
- How does the choice of scientist impact on the field in terms of the education system, the world of science, the school, the science classroom?
- Does the scientist represent a traditional notion of what 'counts' as science and who works in science?
- Are children being supported to recognise and challenge inequalities in science?
- Are children's identities being represented?
- Who is the individual, where do they come from and what message are they giving?
- What ethics do they represent? Are they contributing to global wellbeing or harm? For example, what is their track record with human rights, environmental impact, etc.?
- How will this enhance pupil learning in science? Is the approach embedded or one-off?
- Are they a role model for our children? If they are no longer alive, what is their legacy?

In a science education community, a co-ordinated approach to changing science education, not just the pupils, is required. There is already awareness of existing inequalities in science education and careers, and the impact that time away from school has on learning loss. Research from the University of Central Lancashire shows that the current COVID-19 situation is set to lead to a magnification of these issues.

Families described as science 'haves' (or those with high science capital) have been able to supplement the science provision being set for home learning with sophisticated extra-curricular activities and technology. Meanwhile, it has been suggested that the families described as 'have-nots', or those with low science capital, may lack the confidence and resources to support any science activity at all (Canovan & Fallon, 2020).

What we are seeing is a widening of the gap. At a time when the COVID-19 crisis has put science at the forefront of news reporting and debate, it has also highlighted the need to fine-tune provision to address the widening gap in order to create greater equity in education.

This includes the why, who and how of engaging with scientists and their work.

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What resources are available to primary teachers wanting to develop children's science capital?

The Primary Science Teaching Trust (PSTT) recently published two new free resources on its website that support teachers to introduce scientists and their work to primary children:

Engineering our World (https://pstt.org.uk/resources/curriculum-materials/childrens-university-stem-clubs) and

I bet you didn't know… (https://pstt.org.uk/resources/curriculum-materials/cutting-edge-science-primary-schools). We asked teachers and children who have used these resources about the impact on their learning and their attitudes towards science and scientists. Due to the recent school closures, this feedback is anecdotal, and has been collected through informal conversations and short questionnaires.

Using real scientists to encourage ownership of a club resource – the PSTT 'Engineering our World' resource

The PSTT's *Engineering our World* resource was initially designed as a standalone resource for a science club. The intention was to create a resource that was easy for those new to science leadership to pick up to explore some practical activities with children that are linked to the work of 'traditional' scientists, engineers and artists. In choosing the famous people for the resource, a mix of gender was established: four females and four males. The recommended approach for use in a club follows a simple framework. Fact sheets (Figure 1A) for each famous person, which focus on the main achievements of the person, could be used within the club and/or as a take-home sheet. Included are some prompts for further learning, which could be used by the teacher or at home as a follow-up. Challenge sheets (Figure 1B on page 28) describe an activity that is linked to what the person was famous for, and explain the science behind their work.

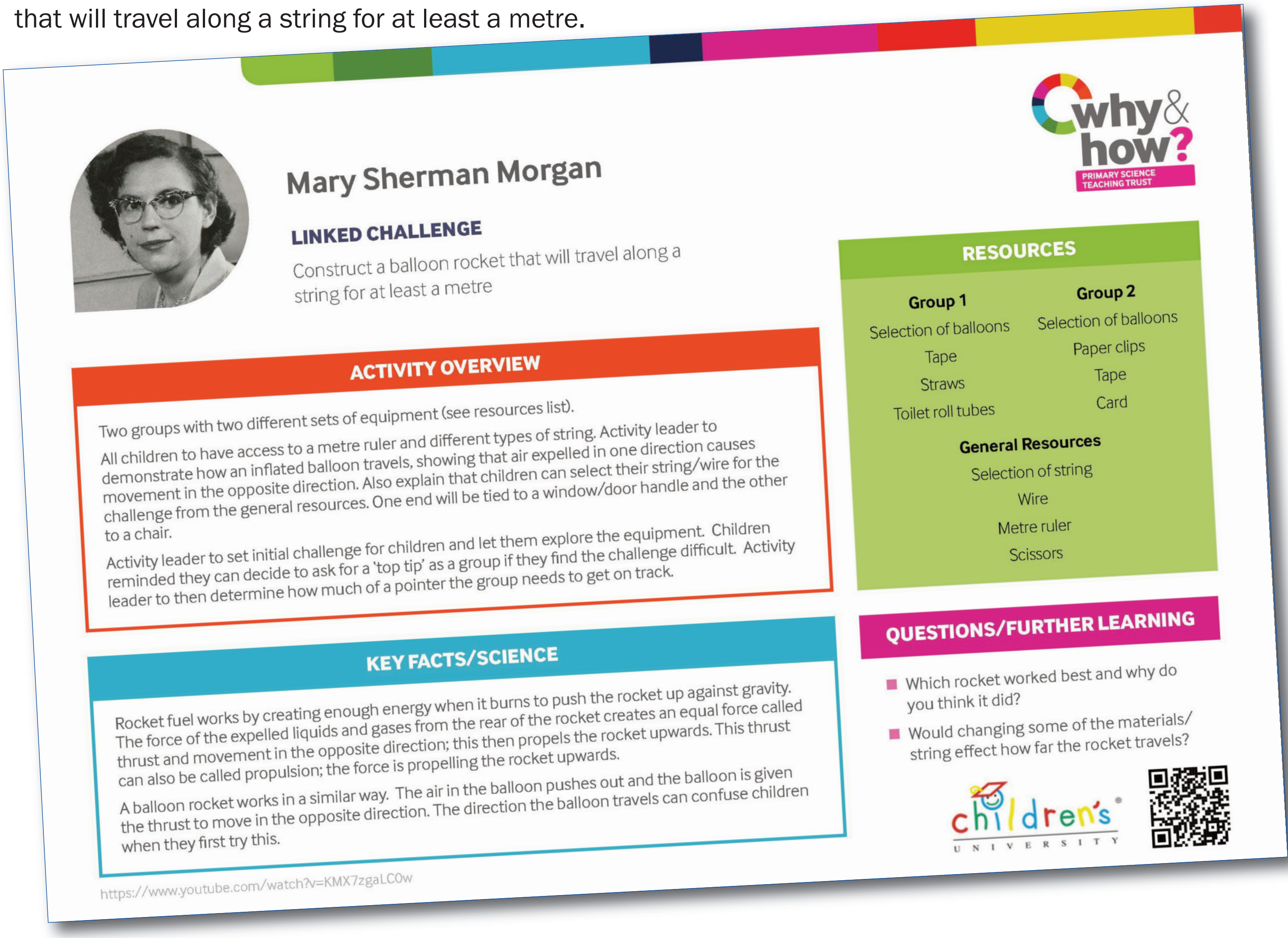
Figure 1A. Fact sheet describing the achievements of Mary Sherman Morgan, a rocket-fuel scientist who invented the liquid fuel, Hydyne.

Early feedback from schools that used the *Engineering our World* resources within a science club suggests that children are applying their learning about famous scientists' work to new situations. For example, children who had used the challenge sheets linked to Gustave Eiffel, the structural engineer who designed the Eiffel Tower, commented:

'I know the leaning tower of Pisa is falling and does not stand up straight. This might be because the base needs to be stronger.'
'We learnt how to secure our towers properly by making a strong base.'

During the COVID-19 lockdown and school closures, it has not been possible to gather data

Figure 1B. Challenge sheet linked to Mary's work: to construct a balloon rocket that will travel along a string for at least a metre.



why& how? PRIMARY SCIENCE TEACHING TRUST

Mary Sherman Morgan

LINKED CHALLENGE

Construct a balloon rocket that will travel along a string for at least a metre

ACTIVITY OVERVIEW

Two groups with two different sets of equipment (see resources list).

All children to have access to a metre ruler and different types of string. Activity leader to demonstrate how an inflated balloon travels, showing that air expelled in one direction causes movement in the opposite direction. Also explain that children can select their string/wire for the challenge from the general resources. One end will be tied to a window/door handle and the other to a chair.

Activity leader to set initial challenge for children and let them explore the equipment. Children reminded they can decide to ask for a 'top tip' as a group if they find the challenge difficult. Activity leader to then determine how much of a pointer the group needs to get on track.

KEY FACTS/SCIENCE

Rocket fuel works by creating enough energy when it burns to push the rocket up against gravity. The force of the expelled liquids and gases from the rear of the rocket creates an equal force called thrust and movement in the opposite direction; this then propels the rocket upwards. This thrust can also be called propulsion; the force is propelling the rocket upwards.

A balloon rocket works in a similar way. The air in the balloon pushes out and the balloon is given the thrust to move in the opposite direction. The direction the balloon travels can confuse children when they first try this.

https://www.youtube.com/watch?v=KMX7zgaLCOw

RESOURCES

Group 1: Selection of balloons, Tape, Straws, Toilet roll tubes

Group 2: Selection of balloons, Paper clips, Tape, Card

General Resources: Selection of string, Wire, Metre ruler, Scissors

QUESTIONS/FURTHER LEARNING

- Which rocket worked best and why do you think it did?
- Would changing some of the materials/ string effect how far the rocket travels?

children's UNIVERSITY

Figure 2. Pupil voice data from 12 children at the English Martyrs' Primary School, which used *Engineering our World resources* to run a STEM club.

	Pupils who attended a STEM club	Pupils who did not attend a STEM club
Percentage of children who discuss science at home	86%	55%
Percentage of children who aspire to go on to further education	86%	82%
Percentage of children who would ike to study science or engineering in further education	57%	50%

from a large number of schools or children to explore the impact of the *Engineering our World* STEM clubs. However, feedback from one school where pupil voice was used to ask children, some who attended the STEM club and some who did not, whether they talked about science at home and about their aspirations for further education, is encouraging (Figure 2 on page 28).

Several schools reflected on what worked well with the resource in their setting, and built upon the framework. In one school, the Rube Goldberg activity was used with Year 6 (age 11) science ambassadors who then visited other year groups to share the challenge. Children constructed their own cause and effect contraptions from junk materials and shared them with the whole school during a science fair. This led to an inter-school science fair within the school's Trust. Other science leaders have used the approach to support teachers working with key workers' children and as a home learning activity for parents during the COVID-19 lockdown. The whole school (all groups of key workers' children) took part in the Leonardo da Vinci flying machine-linked challenge: *Which hoop glider travels furthest?* Children investigated the effect of different variables: length of straw, width of paper, diameter of hoop (Figure 3).

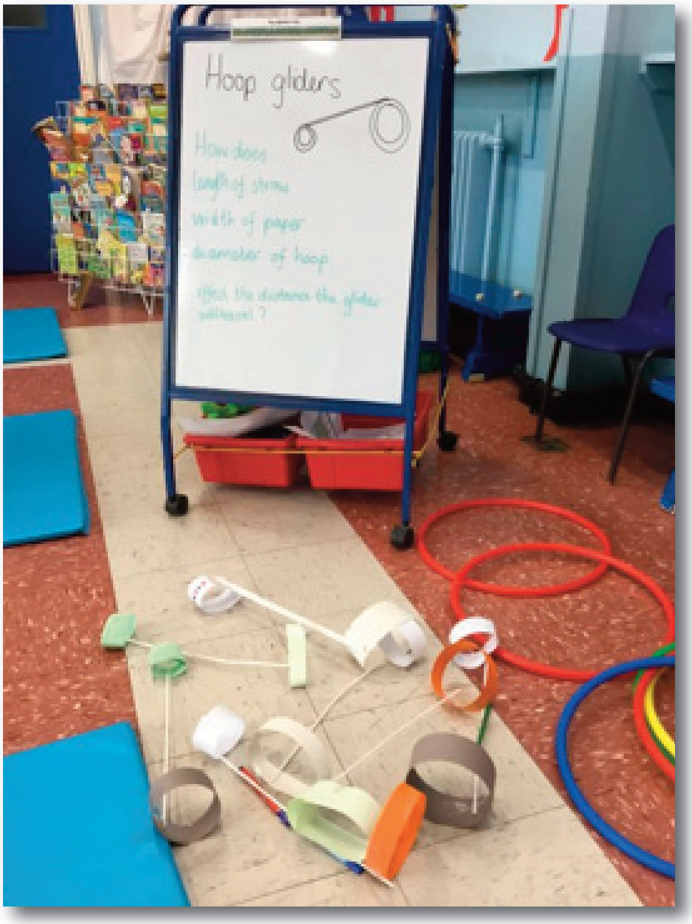


Figure 3. Hoop gliders created by children investigating the effect of different variables on the distance that the glider will travel.

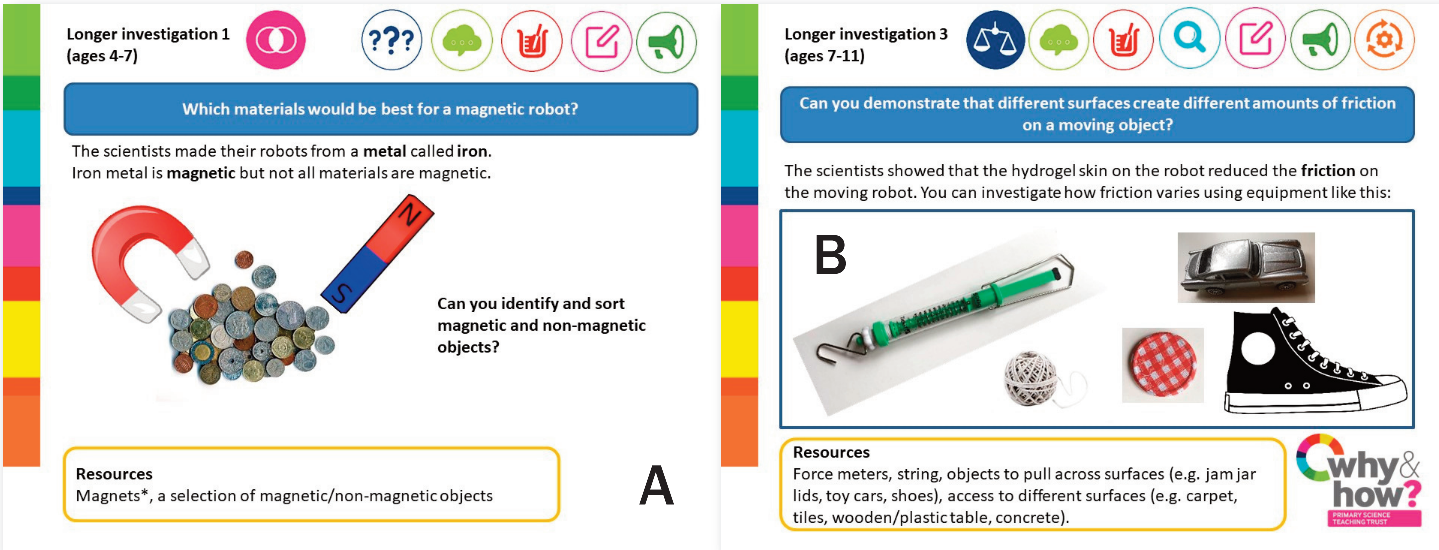
Some teachers and children have used the framework of the club resources to investigate the work of scientists chosen by themselves. An example that worked well with children is Tim Peake (a British astronaut who visited the International Space Station in 2015), with linked challenges to create and investigate stomp rockets.

Disseminating cutting-edge science research to primary children to stimulate learning – the PSTT *I bet you didn't know…* resource

Primary school children and their teachers are rarely considered in any dissemination strategy by research scientists and it is difficult for primary teachers to access cutting-edge research. Teachers could (and many do) read science articles in the news, but this limits what is available. Cutting-edge science research can be read on social media and on the Internet, but these are not always reliable sources of information. Even if teachers were able to track down papers in peer-reviewed journals (many are now open-access), teachers may not have the time, expertise or confidence to link the science reported to an investigation or discussion at a primary school level.

Fellows of the PSTT's Primary Science Teacher College, who have backgrounds in science

Figure 4. Slides from the *Teacher Guide* for article *What small magnetic robots can do*.
A: A sorting investigation for younger children. B: An investigation of friction for older children.



research and experience of teaching in primary classrooms, are using their expertise to gather recent research papers (published within the last two years in peer-reviewed journals) and to write articles that explain cutting-edge science research in language that primary children can understand. Each Fellow has associate status at the University of Bristol and can access the *Web of Science* to source possible papers. Fellows meet periodically to review articles, to ensure clarity of the research and to identify appropriate connections to the primary science curriculum.

I bet you didn't know... articles explain what scientists have done, what they have discovered, and suggest questions for children and teachers to consider in the classroom (Trew *et al,* 2019). Accompanying *Teacher Guides* (which can be used as classroom presentations) indicate links to relevant science topics and describe in more detail investigations and activities that children can do to mirror the research (Trew *et al,* 2020). For some papers it is not possible to mirror the research methodology, but the area of research is interesting to children because they can see the impact of the science on real life.

For example, *I bet you didn't know... What small magnetic robots can do*, explains how scientists have created sub-millimetre soft magnetic robots that can travel through small vessels inside the body (Trew, 2020).

There is a range of investigations that children can carry out: younger children can investigate which materials would be best for a magnetic robot (identifying, grouping and classifying), whilst older children can investigate which magnetic materials can survive best in a wet environment or design a simple investigation to show that different surfaces create different amounts of friction on a moving object (comparative/fair testing) (Figure 4).

Feedback from children who have read the articles with their teachers and carried out some of the linked investigations indicates that primary children engage positively with cutting-edge research and that their attitudes towards science research process and scientists is enriched (Figure 5 on page 31).

Figure 5. Feedback from children aged 9 and 10.

Comments from primary children engaging with *I bet you didn't know*... articles.

'If children know more about what scientists do, more could aim to grow up to be a scientist.'

'It helped me think like a scientist as it gave me ideas to base my own ideas on.'

'I got better at using the science vocabulary that real scientists would use.'

'Now I've read this, I think I know how to read science so I might read about science in a magazine.'

Discussion

The *Engineering our World* resource has worked well in its context with five schools in the West Midlands, engaging children in asking questions about real scientists and supporting science leaders in having whole school impact.

Evaluation of the impact on children who have used *Engineering our World* resources has been limited by the recent school closures. Early data showed that more children who have attended a STEM club talk about science at home compared with children who have not (see Figure 2). Similarly, more children who attended a STEM club hope to go on to further education and to study STEM subjects. Maybe the STEM club has raised children's confidence and aspirations, but equally one could argue that the children who attended the club were probably encouraged to do so by their families who are already interested in science (in other words, these children and their families may already have higher levels of science capital than the children who chose not to attend).

Whilst *Engineering our World* provides a strong standalone club and (most recently) home-schooling resource, its real potential lies in its ability to provide a structure for finding out about scientists or engineers in the world, which ideally will prompt children to carry out their own investigations. This has most impact when the people chosen are from the local area, known by the children, and have similar backgrounds and ethnicity to the children. These scientists may initially be prompted by the teacher/parent/carer, but children can also be drivers here, taking more ownership of their learning, following their individual curiosity, and consequently fostering stronger connections with science and scientists. We suggest that both teachers and children could take ownership of their science club by brainstorming different scientists who they could investigate in club sessions, or at home, or during a science week. Used thus, the *Engineering our World* resource could allow science subject leaders to support teachers in exploring new methods to engage children in learning about science, and to modify existing pedagogy to suit the learning of their children. By placing children at the heart of the learning process and finding scientists with whom children can identify, teachers could engage children who may otherwise not have seen science as 'for them'.

The impact on young learners and their teachers engaging with learning about active scientists and their current research has been demonstrated (Galindo *et al*, 2006; Griffin *et al*, 2007). The PSTT's *I bet you didn't know*... articles and teacher guides provide access to cutting-edge science research for teachers and young children, with links to the primary science curriculum topics. When the children's investigations mirror the scientists' research, the children see themselves as scientists because they can copy or reproduce an aspect of real research. This fosters a 'can-do' attitude and engages children who may otherwise not have seen themselves in this role. Even if science is not their future career, using *I bet you didn't know...* resources could increase many dimensions of a child's science capital: a better understanding of the nature of science enquiry (improved scientific literacy); seeing the relevance of science in everyday life; and more likely to read science content elsewhere (Godec *et al,* 2017).

Whilst there are other ways to introduce scientists and their work to primary children, through visits to museums and science discovery centres, or arranging visiting scientists in the classroom using the STEM Ambassador scheme (https://www.stem.org.uk/stem-ambassadors), in the current socially distancing situation in which we find ourselves, this may not be possible for the foreseeable future. Both PSTT resources discussed in this paper offer a safe and cost-free opportunity to increase children's experiences and knowledge of real scientists and their work, either in a school or home-learning situation.

Conclusions

To support equitable and science capital outcomes, our choices of scientists to introduce to primary children must be fine-tuned. Teachers must think about who they are bringing into the classroom (in person or via resources): in particular, whether the scientist chosen reflects the identities of the children, whether the planned session promotes or reinforces stereotypes, and the broader ethics that the scientists' work represents.

Whether teachers are looking at a scientist's work or inviting a scientist into their school, it is useful to ask a series of questions (as described in the introduction). The choices that teachers make could appear to condone the scientists' work and sometimes this might need to be challenged. For example, does the scientists' work contribute to global wellbeing or harm? What is the human rights legacy and the environmental impact of the work?

Group-based engineering challenges and classroom practical enquiries can develop an understanding of how scientists carry out their work and that science is carried out by a diverse range of people. The two PSTT resources described here could be a step in the right direction for addressing the inequalities that currently exist between those who participate in science post-16 and those who do not (Smith & Gorad, 2011).

References

Canovan, C. & Fallon, N. (2020) *Widening the divide: the impact of school closures on primary science learning.* Available from: https://osf.io/preprints/socarxiv/98rd5/ Accessed 31.07.20

Galindo, A.A.G., Sanmarti, N. & Pujol, R.M. (2006) 'Explaining events in the environment to primary school students', *Journal of Biological Education,* (40), 149–154

Godec, S., King, H. & Archer, L. (2017) *The science capital Teaching Approach: engaging students with science, promoting social justice*. London: University College London

Griffin A., Harrison, T.G. & Shallcross, D.E. (2007) 'Primary circuses of experiments', *Science in School,* (7), 28–32

Kings College London, ASPIRES (2013) *Young people's science and career aspirations, age 10-14.* Available from: https://www.kcl.ac.uk/ecs/research/aspires/aspires-final-report-december-2013.pdf Accessed 31.07.20

Smith, E. & Gorad, S. (2011) 'Is there a shortage of scientists? A re-analysis of supply for the UK', *British Journal of Educational Studies,* **59,** (2), 159–177

Trew, A.J. (2020) 'What small robots can do', *Why & How Newsletter,* (9), 26–27. Also available from: https://pstt.org.uk/download_file/3727/649 Accessed 31.07.20

Trew A.J., Bird, L., Early, C., Ellis, R., Harrison, T.G., Nash, J., Pemberton, K., Tyler, P. & Shallcross, D.E. (2019) 'Cutting edge science research and its impact on primary school children's scientific enquiry', *Journal of Emergent Science,* (17), 40–44

Trew, A.J., Nash, J., Early, C., Ellis, R., Pemberton, K., Tyler, P. & Shallcross, D.E. (2020) 'Cutting-edge science in primary school: support for classroom practitioners and the development of teacher guides', *Primary Science Special Issue: PSEC Conference 2019,* (1590), 8–11

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