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The Association for Science Education
Promoting Excellence in Science Teaching and Learning

why & how?
PRIMARY SCIENCE TEACHING TRUST

Contents

Issue 21 June 2021

Contributions

Research Guidance

Practitioner Perspective

Original Research

Regulars

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Editorial

- **Sarah Earle**

The *Journal of Emergent Science* (JES) is designed to bridge the gap between research and practice. In this Editorial, I would like to consider ways to make this a 'two-way street'.

Traditionally, research has been the remit of academics, looking at practice from outside but, more recently, the lines between the researcher and the researched have blurred. Collaborative and practitioner-led research have risen in prominence, with the aim of bringing research closer to practice, removing the void between research outcomes and practitioner application. Of course, as with any approach to research, there are advantages and disadvantages. Moving closer to practice may help recommendations to become more practical and take account of the complications of the environment, but may also mean that data are inextricably linked to a particular context and key insights may be lost in the everyday busyness of a classroom or early years setting. Nevertheless, practitioner involvement in research arguably raises the authenticity and applicability of findings, supporting research and theory to do 'real work' in real contexts (Cobb *et al*, 2003). In addition, inclusion in research can support both teacher agency and teachers as agents of change (Priestley *et al*, 2015).

This issue aims to support the involvement of non-academics in research in three ways:

❒ Providing support for Action Research (AR) in the form of an extended ***Research guidance*** article from an expert in the field, **Deb McGregor**. Deb explores the definition of AR, scaffolding questions to help with the set-up of an AR project, together with detailed consideration of data collection during the cyclical process.

❒ Creation of a new ***Practitioner perspective*** article category for *JES*, with the first two articles in this section within this issue. Firstly, **Kate Sutton** researched how to support careers education by trialling activities with her class. Secondly, **Helen Spring** puts forward a case for outdoor learning by exploring research around its benefits.

❒ An invitation to apply to join the *JES* Editorial Board – do get in touch if you would like to review future articles for the biannual editions of *JES*. With some board members retiring, there are spaces for both practitioners and academics.

I am also pleased to introduce three new ***Original research*** articles. Firstly, **Diana Varaden, Heather King, Elizabeth Rushton and Benjamin Barratt** present an innovative citizen science study, whereby the scientists worked with the children to monitor air pollution with data-collecting backpacks, whilst also considering the effect on children's and teachers' ideas about air pollution as a result of being involved in the project. Secondly, **Polly Bell** explores the nature of creativity in arts and science as part of her PhD with Deb McGregor. She draws on questionnaire data from over one hundred teachers, to consider ways to promote creativity both across subject disciplines and within science. Finally, **Cherry Canovan and Naomi Fallon** consider the ongoing impact of school closures due to the COVID-19 global pandemic. They surveyed parents and teachers in the UK to compare perceptions of science provision between the first closures from March 2020 and the more recent closures from January 2021.

Whether you identify as an academic researcher, a practitioner researcher, or a mix of both, I encourage you to utilise the articles in this issue to reflect on your practice, and to consider how you could continue the conversation through writing your own article. The deadline for the next issue is the end of October 2021. Prospective authors are encouraged to make contact if they would like to discuss submissions for this or future issues. Authors working in or with practitioners in the Early Years would be particularly welcome. For further details about contributing to *JES*, please see the details on page 55.

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Action Research: Applying the principles to frame a professional development project

Deb McGregor

There are many approaches to educational research that can support professional development for teachers. Currently, there is much discussion about 'evidence-informed practice', 'close-to-practice research', 'teacher enquiry' and 'practitioner research'. Action Research (AR) is a particular approach that could be included within each of these types of activity. It may feel that the practice of teaching itself, of energetically collecting, scrutinising and analysing evidence from pupils might be deemed AR. This is, however, a somewhat limited view of AR. It usually involves generating an intervention or novel approach to improve something. An educational AR project designed to support professional development can involve an individual teacher, a department of colleagues, a whole school or even a group of schools.

What is Action Research?

AR is more commonly understood as a particular form of practitioner research that is usually centred around a teacher wishing to develop or transform their practice (Brydon-Miller *et al*, 2017) in some way. It is a research project designed to investigate the impact of some kind of intervention or change in pedagogy. It is assumed that the changed teaching will impact on learning in some way. In science classrooms, this could involve changing a scheme of work for a particular topic; trying out a new questioning strategy; or adopting a fresh formative assessment approach and judging (through varied kinds of evidence) how the changed teaching tactics influence students' learning. AR projects could also explore whether or not boys and girls respond in similar ways to different aspects of learning science or whether disadvantaged children benefit more from one intervention than another. Evaluative measures of impact, though, require careful planning. A little like the commonly adopted view of a fair test, all variables apart from that which comprises the intervention need to be controlled. This is often a pitfall with AR. Deciding what matters and how to change something identifiable to make a difference is not always straightforward. There are often dilemmas in deciding what that 'something' is, such as, for example, 'motivation' or 'ability', and how to measure it in a quantifiable way to assess impact.

As a research approach, AR requires a systematic methodology. The altered practice needs to be clarified so that assessment of the effects measure only the impact of that and not also the use of different teaching media, materials or presentational approach, for example, if looking at a new science scheme. AR therefore requires criticality to ensure that the research is focused, and evaluates the outcomes that are directly related to the new approach. Exploring *how*, for example, the use of two stars and a wish, or comments, rather than simply numerical marks, through formative assessment might improve students' practical or written work would require careful focus to elicit whether practical skills and/or knowledge and understanding are being developed through the new approach. Findings from the research could then confirm that 'y' change in a teacher's practice had resulted in 'x' outcomes.

When setting up an AR project, McNiff and Whitehead (2005) suggest that there is a series of questions to consider. Thinking about these questions can be the first step in preparing for AR.

Scaffolding an AR project

As an individual teacher, or with a group of colleagues or even a group of schools, it is possible to frame or 'set up' an AR project by thinking about

Figure 1. A sequence of questions useful to consider when planning an AR project.

1. What am I concerned about?
2. Why is this issue a worry or concern? ?
3. What evidence do I have that illustrates the issue or concern?
4. What could I do to improve the situation?
5. What will I do about it?
6. What kind of evidence would show the situation has improved?

Questions to scaffold thinking about an AR approach

a series of questions (see Figure 1) that include considering what is of concern and why that particular issue is troubling. Thinking about the evidence (from different sources) that indicates that something isn't working well is also useful, as it might suggest what kind of data are needed to show that something is improving.

Planning what could be done differently to enhance attainment or provide equality for disadvantaged students, for example, can inform the nature of the intervention and highlight what changes to the current situation are possible. Deciding what course of action, such as providing a quick questioning guide to all staff, promoting storytelling across the curriculum, or adopting a new behaviour policy, comprises the intervention that is done differently. Deciding, too, what kind of evidence would show that the situation has improved is also important.

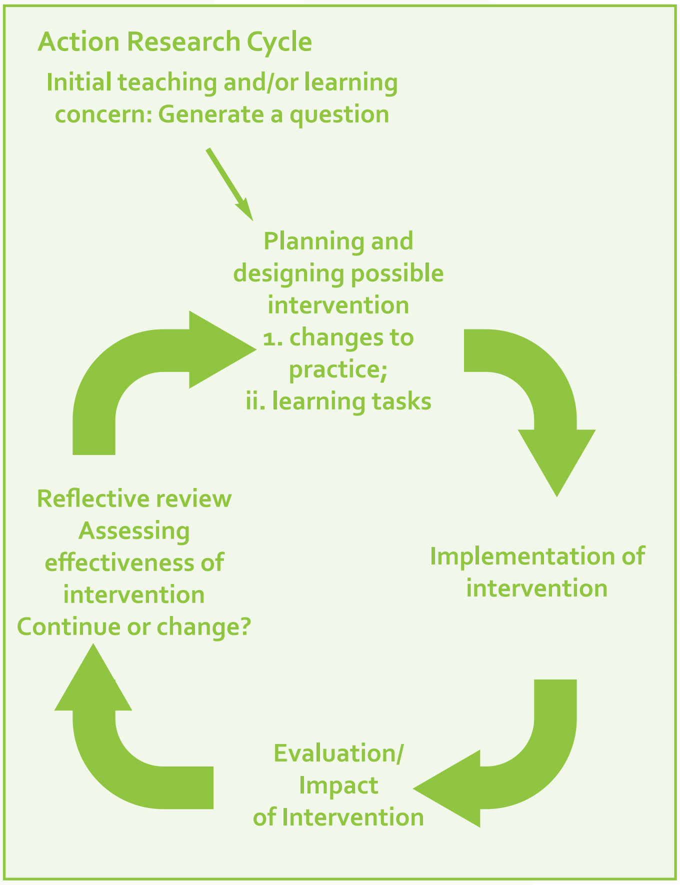
The types of questions that focus discussions and preparatory thinking about what is important to consider in planning a new 'intervention' or trying out a different innovation in the classroom are summarised in Figure 1 .

AR is a common (sense) approach for practitioners (Taber, 2013) to develop their teaching and research the impact of different pedagogic approaches to address a particular issue. The questions provided above (in Figure 1) could help teachers to plan and design an AR approach that subsequently transforms their practice (Brydon *et al*, 2017). AR, therefore, can enable teachers (McGregor & Cartwright, 2011, p.240) to:

- systematically examine an aspect of their teaching;
- collect information and evidence about a particular situation;
- enact a changed (or potentially improved) aspect of practice;
- evaluate and analyse the (new) information (or data generated) in order to review whether the situation has improved or not; and
- use the fresh evidence to substantiate the changed practice.

The steps outlined above inform the diagram (Figure 2), which maps out the cyclical nature of AR. This kind of research is not characterised by particular forms of data or, indeed, specific data collection techniques, but by collating evidence of impact after changing some aspect of practice. As McNiff and Whitehead (2005:1) corroborate, it is '*...a common-sense approach to personal and professional development that enables practitioners everywhere to investigate and evaluate their work, and to create their own theories of practice'.*

Figure 2. Mapping out the cyclical nature of AR (adapted from McGregor & Cartwright, 2011, p.244).



Evidencing impact to improve performance

The recent BERA (2018a) statement, which centred on close-to-practice educational research, presents strong arguments for teachers engaging in research to develop their practice. This builds on the Carter Review, published in January 2015, which identified how research could be employed to develop evidence-based teaching that contributes to high quality teacher education (BERA, 2014). Carter emphasised how *'high-performing systems induct their teachers in the use, assessment and application of research findings'* (DfE, 2015: 8). The review also highlighted how teachers could and should research their own practice and that 'teacher as researcher' is important for curriculum development, pupil assessment and school improvement.

Practitioners introduced to new sets of science materials that claim to improve pupils' test performance might wish to validate the impact on their classes. Similarly, teachers might wish to examine how much an innovative approach to encouraging peer assessment or a different way to teach about particles can improve science learning. Researching how the application of these new ideas might improve pupils' academic attainment would need careful thought and preparation to ensure that the data collected provided the correct 'evidence' of impact.

Usually, classroom-based research like this will inevitably be small-scale. However, it is possible to engage groups of schools in different forms of AR (McGregor, 2014; McGregor *et al*, 2020) to offer more generalisable findings that might apply to other teachers' practice in similar contexts or situations. Individual teachers' findings will not be directly generalisable for others, but they can offer credible information to help practitioners transform their practice (with particular classes or groups) and for other teachers to consider how it might impact on their pupils.

The ethics of any study should be considered if the intention is to share outcomes with colleagues (within or beyond the school). Gaining permission to conduct data collection with younger pupils will be required through the Headteacher, pupils' parents and the pupils themselves. Anyone participating in the research process should not cause discomfort or disadvantage to particular groups in any way. It is the responsibility of the teacher-researcher to carry out the study in an ethical manner (BERA, 2018b). Widely disseminating significantly improved test results, for example, may dismay the children (and parents) who are not in the (successful) experimental group! Thinking about the type of data needed to evidence impact will be closely linked to the research intentions. Clarity about what data will evidence the positive impact of an innovation is needed before embarking on the AR.

Collecting data to inform impact evidence

Data, collected through various means or methods, which can be used to inform the evidence of impact, are usually thought of as either quantitative or qualitative. Very simply, quantitative data are numeric (such as the proportion of students achieving a grade A, B or C, for example) and qualitative data are not. Qualitative data tend to take a wider variety of forms: textual, auditory (and subsequently transcribed), or visual (including photographs, video or even examples of students' written work or images of work-in-progress). For example, if assessing the impact of a new science programme, collecting results from pupils' test performances would elicit more quantitative data. The numerical averages and ranges of the test scores could 'evidence' the improvement (or not) of the new science programme. Alternatively, eliciting students' views about peer assessment would provide more qualitative data, in the form of responses to questions such as 'How did it help to have a peer assess your practical work?'.

The *ASE Guide to Research in Science Education* (Johnston & Toplis, 2012) is a helpful guide to initially support you in thinking about what data to collect, together with Thomas (2017). Also, Hopkins' (2002) *A Teacher's Guide to Classroom Research* offers pictorial illustrations of different research tools, including a range of in-depth observational instruments that can be adapted by teacher-researchers to directly collect data in class.

There are many different ways in which research data can be collected for an AR, including questionnaires, interviews, observations, pupil work and pupil voice (narratives). Some of the more common ways of eliciting data are outlined below and those most often used are summarised in Table 1 (see p.9).

Questionnaires

When considering questionnaires, teachers usually think of a series of questions with several options possible to be chosen as the response. This is referred to as a Likert (1932) scale, multiple-choice rating or rank ordering. These may be best used with older pupils, but it is also possible to elicit views from younger pupils, where more creative approaches to present the options may be needed. Pictures or illustrations can be presented and the questions can be read out for the children to respond to by selecting the picture that best represents their views (Figure 3). These pictures are often used to try to discover emotional feeling and this is referred to as sociometry (see Hopkins, 2008).

With very young children, there may be pictures around the classroom and they could be asked to stand next to the picture showing how they are feeling at the time of the lesson. With older children, it is possible for questionnaires to be completed online, which would give more autonomy in responding. Google Forms and Survey Monkey (https://www.surveymonkey.com/) can provide teachers with tools to develop online questionnaires.

Interviews

Interviewing individual children is often tricky, as they often want to share what they want to say rather than respond to the questions being asked. Thinking about the location and timing of the interviews, as well as who asks the questions, is as important as the questions themselves. Also, thinking about the sequence and ways of simply posing questions is important. Providing stimulus material or recollecting events with which you know they are familiar can sometimes help with both one-to-one and group interviews. Interviews carried out immediately after experiences that are the focus of conversations are more likely to elicit rich data.

Thinking about how to capture the data from the interviews, usually by audio-recording, is helpful in enabling repeated listening and analysis (with ethical approval, of course). Transcribing the audio data provides a version of the data that is much easier to analyse.

Observations

Observations can be made directly in real time, or from videoed lessons or activities (again with ethical approval). Preparatory thought about what data to collect through observations can be open (unstructured), focused, structured or systematic. Hopkins (2002; 2008) offers many different frameworks to consider for this. Collecting video data requires thinking about the location and angle of the camera if the recording of a whole lesson or small group is required. Consideration also needs to be given to the quality of dialogue, as one camera may not be sensitive enough to capture the detail needed.

Pupil work and pupil voice

Scrutiny of pupils' written work can provide indications of pupil progress at the moment of collection and be compared with earlier work (from other classes or cohorts). This might be class work, homework, pupil presentations, displays, project work, tests and exam marks. Pupils could record an activity and provide a narrative of what they are doing and why. They could also photograph things that they are thinking about, or they could be asked to capture specific aspects of what they perceive to be the most important part of a practical and then analyse what they perceive/ understand about these photographs (an application of photovoice). Pupils' views could be elicited through adult-pupil conversations or even discussions between peers (pupil voice, see Flutter, 2007). Pupils could draw diagrams (see Chambers, 1983, or http://www.pstt.org.uk/ext/cpd/a-scientist-in-your-classroom/hosting-scientist-pupils-perceptions-of-scientists.htm), which can be used directly as evidence or as a stimulus to further question the pupils. Asking pupils to do some 'free writing', for instance, can provide another source of data, for example, about what makes a good scientist (see Beishuizen *et al*, 2001).

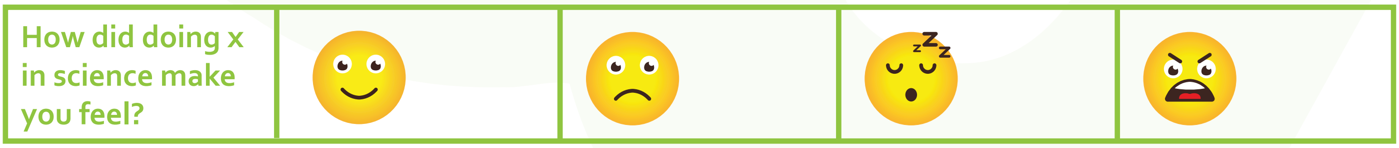


Figure 3. Excerpt from a questionnaire with pictorial representations of the children's views.

Journals/reflective logs

This is an increasingly popular way of teacher-researchers recording their plans, thoughts and reflections to inform their research. Reflection-in-practice, or after practice, can be related to the work of Schön (1983). Reflections could take the form of written notes, jottings on lesson plans or recorded voice memos on smart phones. These types of tools can be used to capture observations and thoughts as they emerge through the AR project. These you can then use to reflect back upon and pull together threads that link closely with your research questions. As the AR project develops, ideas and reflective thoughts will emerge. Ensuring that these are noted somehow and inform the collation of evidence is important.

Research approach	Nature of data commentary
Questionnaires: This is probably the most common method used to collect data in research. It is generally perceived to be an easy and quick way to gather copious amounts of data. Planned well, however, this tool can be adapted to garner a range of different kinds of data, including quantitative data (through large-scale surveys and evaluations); semi-quantitative data through choices of responses to 'agree' or 'disagree', such as Likert (1932); test or attainment data reflecting conceptual understandings (like multiple choice options) or more qualitative informative insights (through gathering personal views, beliefs or opinions about something) by posing more open questions.	Quantitative data can be gathered (e.g. the number of 'categories', options to choose from in a LIKERT scale or multiple choice to discern knowledge/understanding about science concepts or themes of responses), as well as textual responses to open questions (recognised as qualitative data).
Interviews: This is also a common method used to gather data. Usually, though, it is adopted to probe for more 'in-depth' information than from a survey or evaluative questionnaire. These can be carried out one-to-one or be organised to harvest several people's views about something (often referred to as a 'focus group'). This method often takes much longer to gather the data (and then process it).	Discussion that can be audio-recorded and transcribed. The transcription can offer 'text' that can be scrutinised for 'literacy', use of particular words, general themes or threads of argument, etc.
Observations: These can be made in a variety of ways, depending upon the focus of the AR. Many frameworks are offered in Hopkins (2002) that can be adapted to collect data exploring responses of pupils to questions, gender differences in behaviours, etc. Videoing lessons is increasing in many schools (through study lesson approaches, for example) and the use of IRIS Connect http://www.irisconnect.co.uk/. However, in order to make sense of, and focus on, the data to respond to a research concern, careful preparation is needed. Scrutinising discussion or dialogue between pupils is not easy without the correct kind of microphone, for example, to capture clear recordings. The audio recordings also then need to be transcribed prior to analysis. Images and photographs can also provide research evidence: for example, the way that students have written about or illustrated their thinking in some way.	This can range from collecting recordings of actions (presentations or performances), talking (during practical activity or working as a small group), and actions (whilst tackling particular tasks) from either the learners' or the teacher's (or even teaching assistant) perspective. It can enable a focus on specific groups of students or even particular individuals.
Interrogating existing data (ex post facto): A wealth of secondary data (that is not collected by teachers) can be used in AR. Examples include: in school information (e.g. behaviour logs, attendance data, statistical performance data from departments, pupil premium data, socio-economic data, SATS test results, phonics/reading/writing data). Research data:https://www.nfer.ac.uk/ https://educationendowmentfoundation.org.uk/ Governmental data http://www.education.gov.uk/schools/performance/ Ofsted Inspection data and Ofsted Research data https://www.gov.uk/guidance/school-inspection-data-summary-report-idsr-guide and https://www.gov.uk/government/publications/exploring-ofsted-inspection-data-with-data-view	This type of data already 'exists' and has been collected for a different reasons (Ofsted inspections, school league (performance) tables, etc.) other than teacher-researcher projects. The data can be interrogated for AR projects, but consideration should be given to the 'tools' and reasons that the data may have been collected initially. The focus (and therefore emphasis) may be quite different to the teacher-researcher's intention.

Table 1. Collecting data for your AR project: Some common sources to consider.

Once the data are collected, analysis is the next phase. Hopkins (2008), Cohen, Manion and Morrison (2018), Johnston and Toplis (2012) and Thomas (2017) are all useful sources of guidance for this phase, but the bespoke nature of ARs means that it is difficult to suggest generally how to complete this phase. In Table 1, there is a summary of more common research approaches or methods that could be considered for use in AR projects. There is also commentary about the nature of data that can be collected through these means.

Extending the initial AR cycle

Once an AR cycle has been completed, teachers may decide to modify further a particular aspect of their teaching, assessment or classroom environment (Figure 4). In the case of a new science teaching scheme, further AR might delve deeper into why test performance was improved, or not. If particular questions in the tests were all answered well or badly, it could be helpful to find out more about how the pupils understood those specific questions, through pupil discussion, thus developing the AR into a second iteration. This second phase would then involve collecting qualitative data. A peer assessment AR project could also be extended further by considering the impact of different kinds of grouping, all-boy or all-girl groupings, or mixing friendship and non-friendship groups, for example.

However, a teacher, department, a whole school or even a group of schools may decide that several iterations of AR are needed before they reach the level of improvement that they need. So, it is possible to focus on a particular area of development and refine it several times through consecutive AR cycles before achieving the final goal.

Examples of AR in science classrooms

AR in the science classroom carried out by an individual teacher who is also 'the researcher' can work, either on their own or working collaboratively as part of a wider team. Many Initial Teacher Education (ITE) programmes now include Masters' level credits and these trainees are asked to research the development of their own practice. AR provides a useful methodology for beginning and qualified teachers to develop research skills and to reflect to develop and/or transform their own practice. Carefully planned AR can provide a clear theoretical guidance for systematic research of phenomena in the classroom. This type of research therefore can enable curriculum innovations, greater understanding and a confidence to develop and test new teaching ideas. These kinds of studies can be small-scale, but are useful for individuals, whole-school and even clusters of schools interested in improving a particular aspect of their pupils' academic performance.

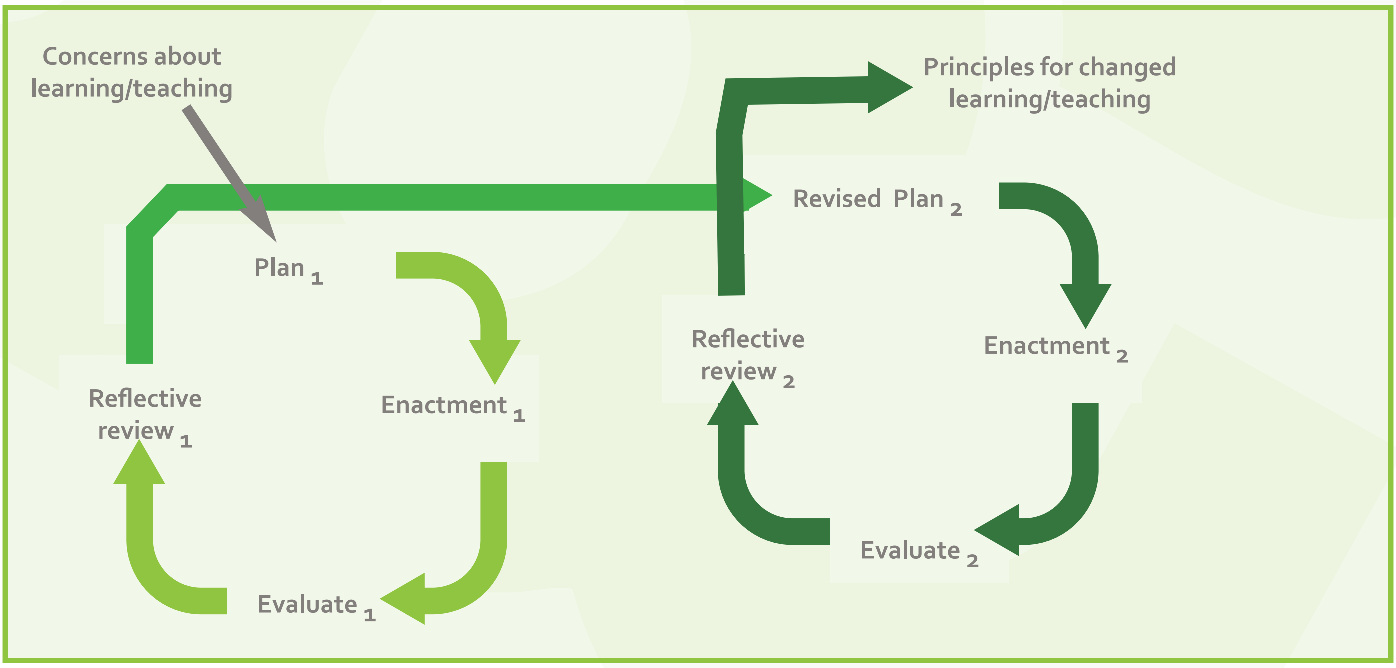


Figure 4. Two cycles of AR (1 = 1st cycle of AR; 2 = 2nd cycle of AR).

The range of areas that teacher-researchers have researched through AR include the following:

- Hewson *et al* (1999) applied AR to support prospective teachers in becoming more reflective about what it means to teach for conceptual change.
- McGregor, Frodsham and Deller (2021) have shown how, through AR, conceptual understanding of evolution is possible with 9 and 10 year-olds through the adaption of drama pedagogies.
- Mallinson (2011) examined the impact of a Researcher in Residence Programme in her school.
- Hutson (2012), concerned with ways of helping science pupils with low levels of literacy, evaluated the impact of different teaching strategies.
- Dollive (2012) critically assessed how to develop more active learning through the use of practical work.

These small-scale studies carried out by practising teachers adopted AR to structure how to improve teaching and learning in their classrooms. As BERA (2018a, p.3) suggests, these types of small-scale investigations do not necessarily produce '*insights about practice in general*'; rather, they generate outcomes that are '*useful and acceptable to the practitioners themselves*'. However, Halai's (2012) meta-study of 20 AR science dissertations identified common issues that these teachers faced when combining their roles of researcher with teaching. Similarly, a three-year teacher enhancement project funded by the National Science Foundation summarised a range of outcomes from AR projects to provide guidance for teachers to develop their own action research (Spiegel, 1995).

Teachers have also worked in collaboration with other researchers to develop curriculum innovations or enhance learning, for example:

- McGregor, Frodsham and Deller (2021) illustrated how adopting scientific stories from history can innovate enquiry pedagogy and also promote learner creativity.
- The ARIELS (Action Research Inspiring and Enhancing Learning in Science) project (2011) involved an AR partnership between the University of Exeter and the Exmouth Area Learning Community (one secondary school and 14 primary schools) to improve teaching and learning in science, focusing on the planning and delivery of lessons at the Key Stage 2/3 transition (ages 11-12).
- The Institute of Physics (2010) initiated the Girls into Physics AR project, involving 100 teachers who were supported to understand issues related to girls' participation in physics and then to evaluate interventional changes in their own classrooms, departments and schools.

Sometimes AR projects can offer significant insights and contributions to knowledge. For example, Concannon *et al* (2013) considered pre-service teachers' conceptions of science theories before and after interventional input on misunderstandings of scientific 'theories and laws'. Findings from this study provided new perspectives about ways to develop teaching this central aspect of science.

Occasionally AR projects can be seen as pilot studies and develop into a more significant research project. The adoption of the *Thinking, Doing, Talking, Science (TDTS)* interventional lessons has informed a Randomised Control Trial research design whereby thousands of pupils' performance in experimental classes have been compared with those in control groups (McGregor, Wilson & Frodsham, 2020). The combination of quantitative and qualitative impact evidence has shown how a focus on challenging thinking in science can improve attainment of 8 and 9 year-olds.

Conclusion

An AR approach not only offers versatility in close-to-practice research, but also provides a structure and systematic framework that enables teachers and researchers to examine the impact of a changed pedagogy or learning approach.

Not only is it applicable to individual teachers, but also consortia can adopt the framework to explore generalisability across schools and contexts.

Impact outcomes can also inform significantly larger projects, such as TDTS, and be adapted across the country by schools interested in achieving the same kinds of research aims.

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Careers education at primary

● Kate Sutton

Abstract

In this article, I explore my Masters' action research on STEM careers education. From September to December 2019, I introduced STEM careers to my Year 6 (ages 10-11) class through a range of visits, visitors and activities. Findings from pre- and post-surveys, together with class work, demonstrated improved attitudes, engagement and understanding of STEM careers. I also draw upon core reports including: Young People's Views on Science Education (Wellcome, 2017), Dream Jobs (OECD, 2020) and Drawing the Future (Chambers et al, 2018). This article highlights the positive impact of primary careers education and also the need to ensure that it is taught in a relevant, hands-on, local, informative and non-discriminatory way to be most effective.

Keywords: Careers education, STEM careers, stereotyping

Introduction

Throughout 2019/20, whilst working full time as a Year 6 teacher and Science Lead, I studied for a Masters in Education. I learned about the historically stereotypical views held regarding females in Science, Technology, Engineering and Maths (STEM) roles and the STEM skills gap, with the *'low take-up of STEM careers due to a decline in interest in these subjects during education, particularly by girls'* (RAEng, 2017). I developed an understanding regarding possible future effects of evolving IT; misconceptions regarding academic challenges in science plus social and cultural capital; and social mobility, having particular pertinence to me due to working in an area with low socio-economic status. Transition to Year 7 (ages 11-12) was also part of my Year 6 role and negative effect on the take-up of STEM subjects in secondary school was a clear interest. The Careers Strategy (UK Gov, 2017) and Industrial Strategy (UK Gov, 2017) were developed to address this gap.

I felt dismayed by the seeming lack of social justice mindset and Equity Compass (Archer, 2020) as pupils went through national testing in our education system. In addition, the National Curriculum in England and lack of Key Stage 2 (ages 7-11) links to careers information were also highlighted. At secondary level, the Gatsby Benchmarks (2017) had been introduced but, at Key Stage 2, the issue was not being addressed. Unaware of other initiatives/professionals in this field, I decided to base my research project and dissertation on this subject.

My aim was to investigate if improving understanding of career opportunities would help children to engage, to identify the relevance of what they were learning and to form clear aspirational links to their future selves, building confidence without forcing them to pigeon-hole themselves into one particular future profession. Andrews and Hooley (2018) discuss the view that careers learning could support the functioning of the education system, including student engagement and attainment, the economy (by improving transitions to and within the labour market), social mobility and inclusion (Andrews & Hooley, 2018).

I gathered research from papers, journals, trusted news outlets, websites and organisations, primarily: The Wellcome Trust, The Sutton Trust and STEM Learning. These reports highlighted that many children felt that their education was lacking vital science learning and quality experiences

(Wellcome, 2017). Teachers felt less confident about teaching science and STEM (Wellcome, 2018), which further affected these issues, along with a lack of Continuing Professional Development (CPD) take-up and embedded cultural opinions regarding women in STEM careers. In addition, many children lack support at home and their science/cultural capital is low (Archer *et al*, 2016), meaning that they have not had enough science experiences out of school to have developed an affinity or interest in the subject. As illustrated by the Sutton Trust's *Elitist Britain* (2019), it is absolutely vital to widen opportunities and make level the chances for all individuals to increase social mobility. Frey and Osbourne (2013) identified STEM skills as 'highly required' for a wide range of future careers.

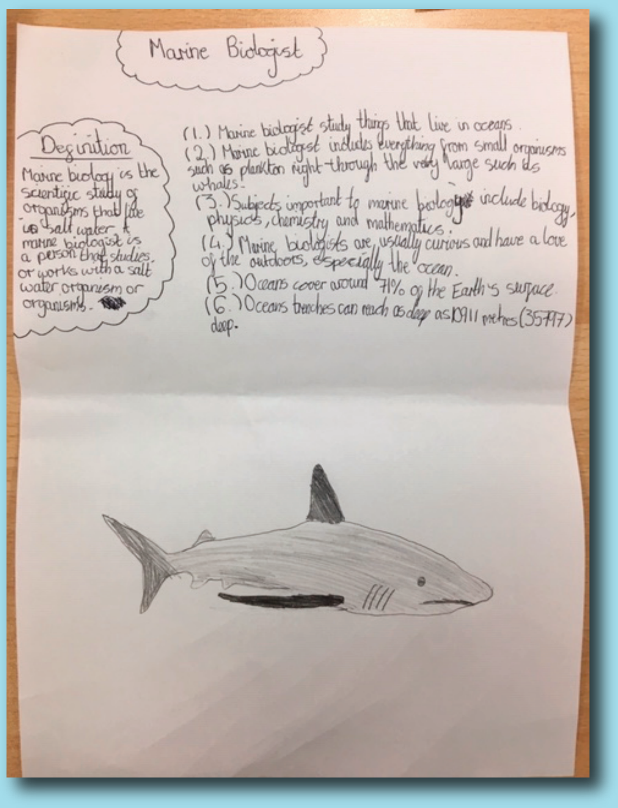
Methods

My Action Research (AR) project was undertaken during autumn 2019 and the subsequent analysis and dissertation in spring/summer 2020 in order to answer the following research question:

- *To what extent does the introduction of careers information during Year 6 STEM lessons have a positive effect on children's motivation, enthusiasm and engagement?*

I chose to focus on my Year 6 class; a small-scale project would maximise access and help with consistent data collection, although with four classes in Year 6, comparisons could also be drawn. My class consisted of an inclusive group of 20 children, many with various barriers (physical, academic and mental health-related).

A mixed methods approach was used to gather empirical evidence and data (Lauer & Asher, 1988). Qualitative and quantitative data were collected throughout proceedings (ASE, 2012), including a quantitative pre- and post-survey, and a range of qualitative classroom data such as pupil voice, questions they raised during visits, interactions from visitors, careers-related project and class work. Repeat collection of data allowed for correlation, analysis and ultimately conclusions to be drawn. Attainment data could also be compared



Marine Biologist

Definition
Marine biology is the scientific study of organisms that live in salt water. A marine biologist is a person that studies or works with a salt water organism or organisms.

(1.) Marine biologist study things that live in oceans.
(2.) Marine biologist includes everything from small organisms such as plankton right through the very large such as whales.
(3.) Subjects important to marine biology include biology, physics, chemistry and mathematics.
(4.) Marine biologists are usually curious and have a love of the outdoors, especially the ocean.
(5.) Oceans cover around 71% of the Earth's surface.
(6.) Oceans trenches can reach as deep as 10911 metres (35797) deep.

Photos 1 & 2. Children independently researched their careers of interest at school using BBC *Bitesize*, for example: NHS paramedic (photo 1) and Marine Biologist (photo 2).

to previous academic performance. Permissions were obtained and surveys were completed by my class, school staff and parents/carers (online) at the beginning and end of the autumn term. During the term, many opportunities for careers education were provided, including visits from STEM professionals and outside visits to places of work. Employment and careers links were also made in class work, making learning relevant, for example, when learning about the environment; professions explored included marine biology, air pollution control and electrical engineers investigating carbon omissions.

Careers education is closely aligned with Personal, Social, Health and Economic (PSHE), where children focus on their character traits and become more thoughtful about what possible careers would suit them and make them happy as an adult. They learned more about salaries, interview processes and career progression through BBC *Bitesize Careers* and the National Careers Website, and by accessing resources from the Centre for Industry Education (CIEC) to learn more about working in industry. They played activities such as Careers *Top Trumps*, where they created information cards about their professions of interest to play in groups.

The aim was to expose my pupils to a wide range of careers information, visits, visitors and activities, to enable them to consider the jobs market of the future and their own suitability regarding personal characteristics.

Findings

Surveys

In the initial survey in September 2019, colleagues stated that they felt that STEM careers information is appropriate for primary school students, with an average score being recorded of 4.9 out of 5. They also stated that pupils were enthusiastic about STEM subjects. Only 7 parents initially responded. This was repeated at the end of the project in December 2019. There was a marked increase in parent participants upon recompletion, which highlights improved understanding and engagement. The survey results from children demonstrate improved understanding and appreciation of STEM careers (Figures 1-4).

Following the wide range of careers information, visits, visitors and activities, the pupils in my class showed an increased engagement and understanding of STEM-related subjects and careers. They showed motivation to progress

Figure 1. Children's survey: *'At school I learn about different career choices that use STEM'.*

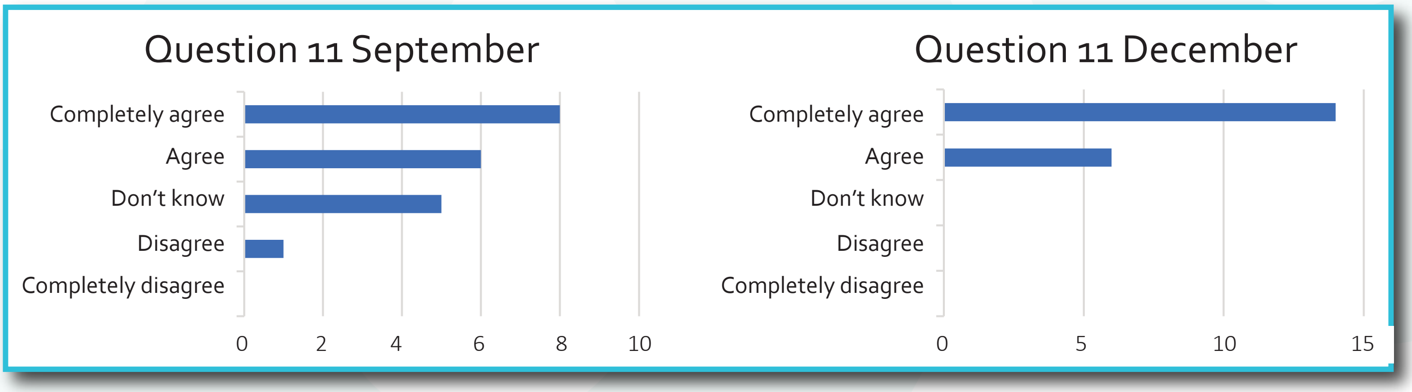


Figure 2. Children's survey: *'I know what qualifications I need for a STEM job'.*

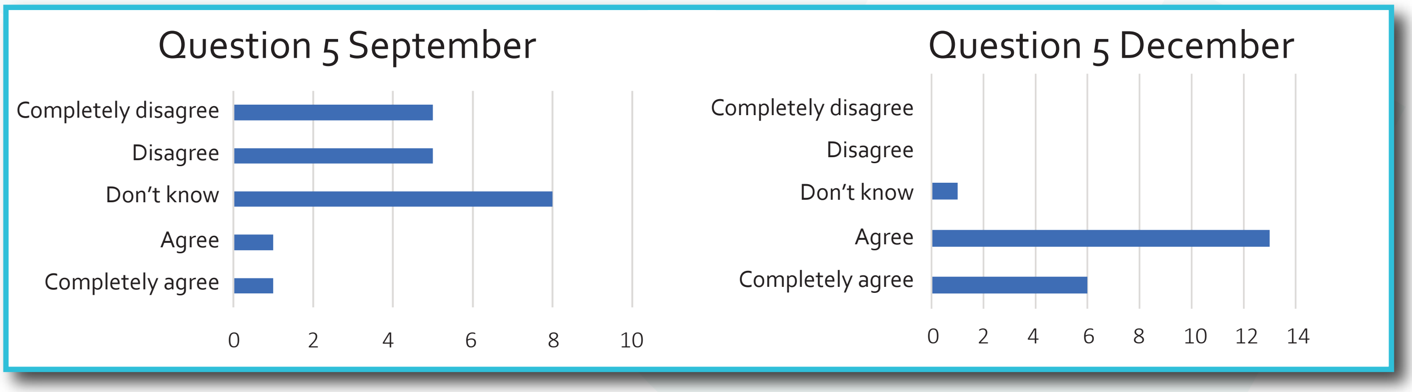


Figure 3. Children's survey: *'To have a STEM job you must be clever'.*

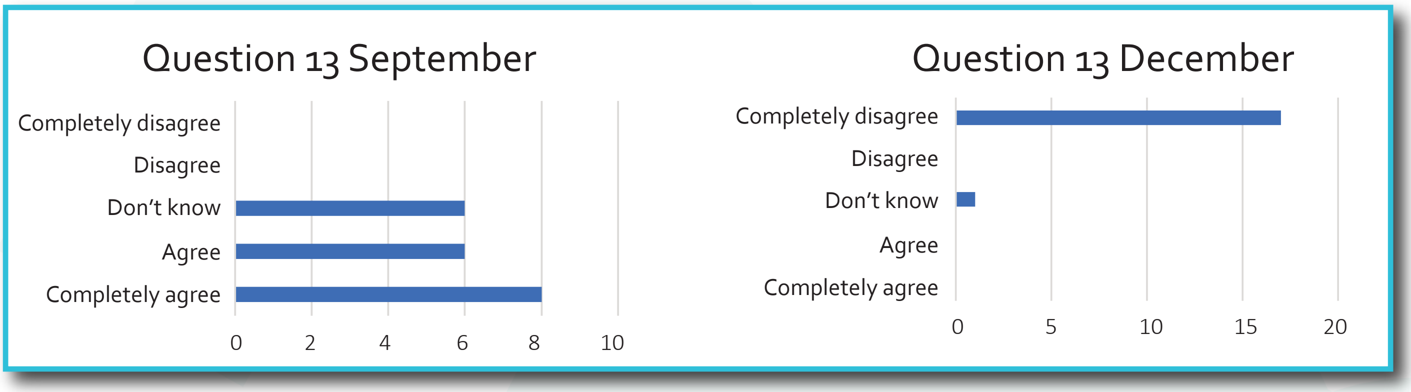
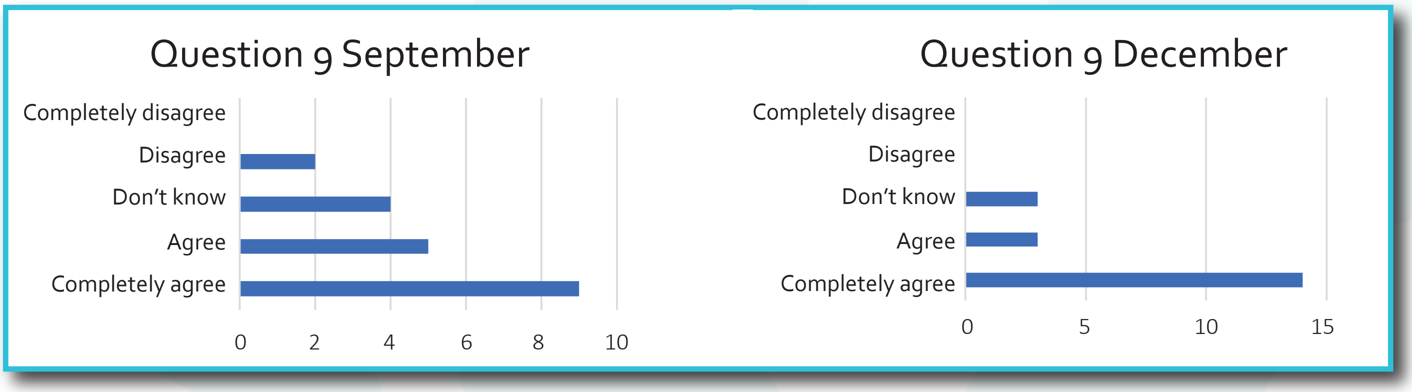


Figure 4. Children's survey: *'In future, we will need more STEM qualified people'.*



through pupil voice and questions that they raised during visits to college and at our careers event. Evidence was gathered from survey data analysis, together with examples of careers-related project work and interactions from visitors. Changes in attitude towards careers clearly highlight the benefits of careers information at primary school (in accordance with the aims of the Careers Strategy) in only one term of implementation.

Attainment within science lessons improved at an accelerated pace for most, but not all, in my class. This was evident through summative data. What could certainly be seen was a group of maturing children who were far more motivated to participate and who had more of an appreciation for and understanding of STEM-related subjects. Having an engaged, driven and enthusiastic role model had undoubtedly had a positive impact.

Examples of visits and activities

Local college visit

The whole of Year 6 visited our local college to experience career environments and develop an understanding about career availability and

Photo 3. East Riding College visit – Barbara Young (Tutor).

Photo 4. Primary Futures Careers Event. Chris Benson, Specialist Cardiac Physiologist, Yorkshire NHS answering pupil questions.

paths,apprenticeships and further/higher education. They took part in careers workshops and experienced various working areas such as the mechanics garage, the construction area, the Medical Department and more. They also visited the library and student support areas. Interest was enhanced and homework resulted in fact files about various careers. The college tutor also commented on how pleased she was regarding the interest shown by my class. She stated that there was a distinct increase in pupil knowledge and engagement compared to the other classes.

Primary Futures Careers Event

During our Primary Futures Careers Event, visitors included the CEO of the local council, an AI/robotics expert, a cardiac physiologist and an archaeologist/forensic scientist. Children played *What's my Line?* with the visitors (who had each brought a small prop as a clue). Subsequently, there were various sessions for classes, with the aim to develop an 'I can do' attitude. This was highly inspirational and informative for our pupils. A feedback survey for the careers event highlighted pupil positivity: 100% stated that men and women can be equally successful and also that maths, English and science can be useful in many jobs. They also concluded that the event had *'made me feel that I can become anyone I want when I grow up'*. This was in stark contrast to findings of the Wellcome Trust enquiry in 2017, *Young People's Views on Science Education*, which found that only 26% of pupils said that the work they did was *'relevant to their lives'*. Having the (female) CEO of our local authority involved was vital; providing real life examples of successful women in important roles certainly had a positive impact. Riley, aged 11, commented on what a difficult job she had and how surprised he was initially to learn of her 'high-powered' role: *'She has a hard job; there is such a lot to do. She wasn't wearing a suit but she was a VIP'.*

Other visitors

Visitors such as Yorkshire Wildlife Trust (YWT) employees talked about routes into careers plus challenges and characteristics that have helped them on their learning journey. 'Skype a Scientist' enabled Dr. Bence Viola, a paleontologist at the University of Toronto, to link with our class when a student found a fossilised mammoth tooth on the beach, estimated to be one and a half million years old. Dr. Viola and the pupils were equally thrilled.

Ross O'Brien (from BP) challenged children in a local, relevant way to create a device to improve the environment. They enjoyed utilising creative and collaborative skills: an excellent example of Equity Compass in action (Archer *et al*, 2020), whereby children were engaged in social action and learning through hands-on engagement and tinkering. In addition, we developed NASA links

Photo 5. Visit from paratroopers.

through the Challenger Learning Centre (CLC) in the USA: children asking questions during a live transatlantic link. Paratroopers also visited our school; one was a past pupil. Our children could see that someone just like them had achieved their dream in the world of work.

Farmer Time is an educational incentive created by 'Farmer Tom' Martin and LEAF. Farmer Colin is our allocated farmer who helps the children to understand more about farming, the countryside and environmental issues. The students enjoy the novel educational strategy and also asking questions. They followed *Bloodhound* during their attempt to break the world land speed record, via the *Bloodhound* website/ *Newsround.* We discussed the different jobs that would have been involved in the team surrounding the vehicle and qualities that they would have had to possess.

We have also been working with the Science and Engineering Education Research and Innovation Hub (SEERIH) at the University of Manchester, developing Engineering Habits of Mind (curiosity, open-mindedness, resilience, resourcefulness, collaboration, reflection, ethical considerations and a growth mindset) with our pupils (RAE, 2017). The children have undertaken various engineering tasks as part of a national movement regarding engineering at primary. They have thought carefully about the various aspects of engineering and how it affects every part of our lives, skills involved being highly transferable. They have learned to 'tinker' and learn by trial and error.

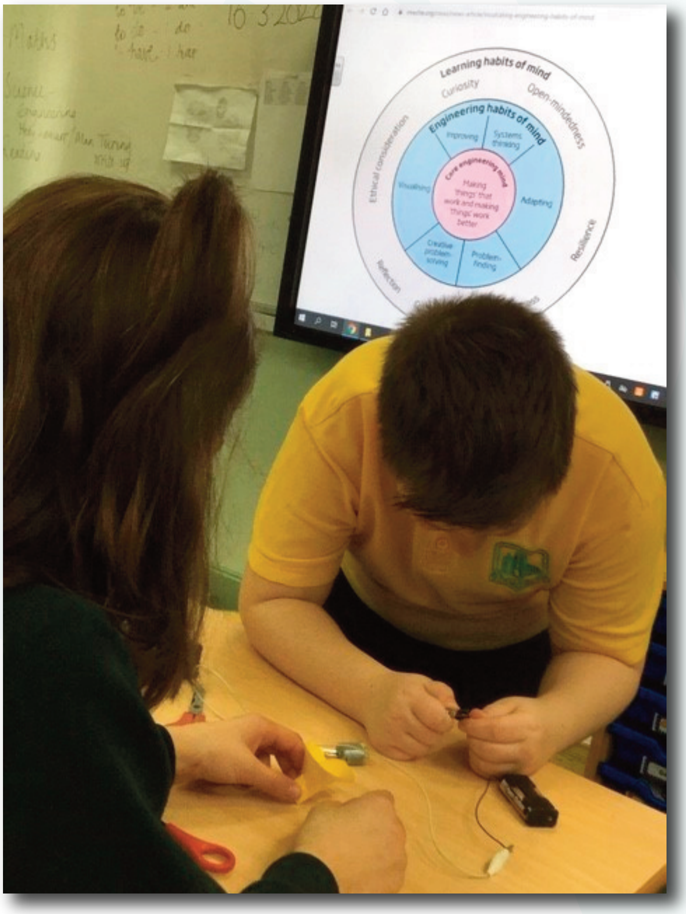


Photo 6. Progressing to be an engineer (RAEng, 2021).

Drawing the Future (2019) states that *'Children arrive in school with strong assumptions based on their own day-to-day experiences'*. With 'sportsman' (8%) and 'social media and gaming' (9%) being favoured careers for boys, and 'teacher' (19%) for girls, even at a young age gender equality needs to be pursued. This project has worked to develop confidence regarding STEM subjects and possible future careers. Encouragingly, preferences stated by females in my class included being an author, a lawyer, a marine biologist and a paramedic. Careers in IT such as graphic designer and animator were also highlighted by males in the class, as well as the desire to be a chef and a doctor. The types of jobs in which the children now have an interest definitely show more thought and aspiration.

The teacher questionnaire enquired about child opinions regarding careers. One response captures the general feeling in this regard:
'Children already state, "I'm not good at..." or "... it is boring". These opinions affect how they engage with the subject. Giving children full and varied experience in STEM /science subjects is essential to ensuring that they feel happy, engaged and confident, so that "I can..." and "I love..." become their opinions. Lifelong loves start in childhood' (Anonymous, Staff Questionnaire, 2019).

Conclusions

Gutman and Ackerman discuss that science-related careers are viewed by many as 'only for a the brainy few' and that there is an association of 'cleverness' with white middle-class masculinity: female working class and some minority ethnic students are less likely to imagine themselves following science careers, even though they like science and aspire highly (Gutman & Ackerman, 2008). This project has worked (in a small way) to challenge that view. However, in agreement with *Nothing in Common* (2013), I have come to the realisation that:

'Children are unable to understand the breadth of ultimate job opportunities across the economy... potentially identify(ing) unrealistic career aspirations. There is no desire to quash the dreams of children, but having some grasp of the difficulty/ realistic chances of attaining their goal should be understood – having a "Plan B"' (Mann *et al*, 2013).

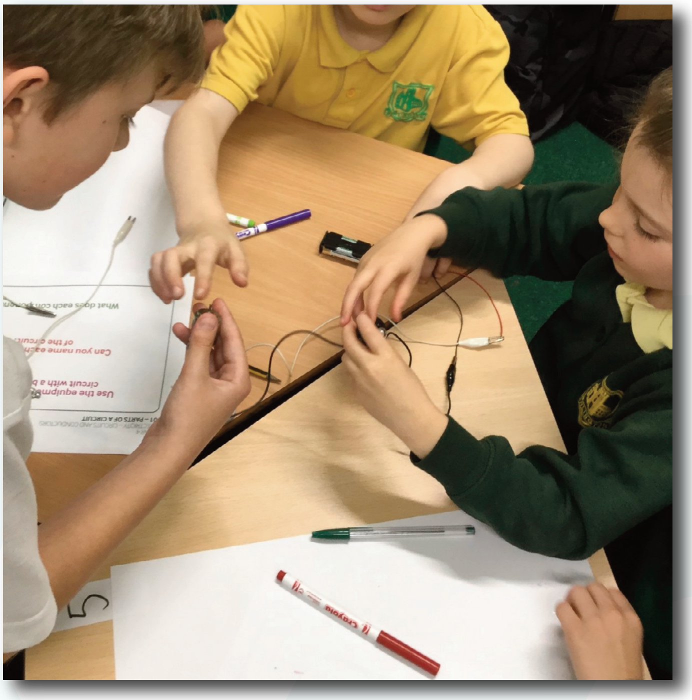
Developing resilience, confidence, belief and aspiration is key at primary school in order to enhance self-esteem and a positive growth mindset (Dweck, 2016). In addition, making learning local, relevant, achievable and accessible are seemingly the strategies to build knowledge and understanding for our pupils (OECD, 2020).

Whittaker and Booth (2020) discuss the potential damage of the pandemic, stating that the attainment gap could be widened by as much as 75%, which would have a very damaging effect on STEM careers take-up and bridging the STEM skills gap.

As a result of my findings throughout the research project, and after identifying other key researchers in this field, such as Carol Davenport and NUSTEM, our school engaged in the 'Careers Mark' @CompleteCareer: a national accreditation for primary schools. This was funded by the Skills Support for the Workforce project (SSW), European Social Fund (ESF) and Local Enterprise Partnership (LEP). The successful assessment took place across Year 6, which has laid the foundations to embed careers learning across all of Key Stage 2 going forward. This is recognition of the value and effectiveness of careers information.

In addition, we have developed further transition links with secondary schools in our town, in part through our ØRSTED-funded STEM Enthuse Partnership. These included cross-Key Stage 2/3 phase planning and team teaching, which was highly enjoyable and effective. Some of the Key Stage 3 (ages 11-14) pupils, including past pupils of our school, visited us to peer mentor our Year 4 (ages 8-9) children, and the Lower Key Stage 2 (LKS2) pupils visited the local secondary school, which started to develop transition links and dispel pupil concern regarding future education paths. This also developed an interest in Key Stage 3 science through sessions attended in the Key Stage 3 science labs.

Photo 7. STEM Enthuse Partnership: Team Teach/ Transition activity with Bridlington Secondary School – peer support (Year 8 with Year 4).



Going forward

In a fast-changing economy, it is essential that we make school and the workplace more closely connected than ever before, so that young people from all backgrounds have the knowledge, skills and experience to succeed in work (DfE, 2017, p.35). It is about ensuring that young people emerge from the education system with the skills and knowledge that enable them to anticipate in post-compulsory education, in working life, and to become the workers, leaders, entrepreneurs and citizens of the future (Andrews & Hooley, 2018, p.3). I will continue to develop links with industry and organisations such as CIEC to ensure progression of careers learning going forward; our Year 5 (ages 9-10) children have taken part in Children Challenging Industry activities through CIEC this year.

As discussed by Elliot (1991), analysis in action research has led me to many more avenues for research. OECD Dream Jobs (2020) raises so many more questions: realistically, will pupil career choices still be viable in 15 years? These are often unrealistic, stating a job based on television influences yet not willing to continue learning to achieve the experience and qualifications required. How do we ensure that children are savvy regarding career choices going forward, so to ensure that they are not all in competition for the same jobs in a field with only limited chances of success? How do we inspire pupils to be more outward looking and how do we educate pupils with effective IT skills to meet future demand?

Effective career guidance should encourage children to reflect on who they are, who they want to become and to think critically about the relationship between their educational choices and future life (OECD Dream Jobs, 2020). I will strive to continue to support my pupils to the maximum of my ability as they progress on their journey to adulthood and a career that is fulfilling, appropriate to their needs and which enables them to achieve self-actualisation (Maslow, 1943).

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Why choose to learn outside?

● **Helen Spring**

Abstract

In this article, I put forward the case for learning outside, drawing largely on UK research around being outdoors, learning outdoors and specifically learning science outdoors. I will first consider the scope of 'outdoor learning' before exploring a range of research that highlights different benefits of learning outside the classroom, such as health, engagement and the development of social skills, as well as attainment. The aim is to support practitioners to consider their reasons for implementing outdoor learning strategies in schools and early years settings. It should be noted that much of the research concerning learning outdoors is based on reported impact or measures in curricular areas other than science, suggesting further research is still required.

Keywords: Outdoor learning, outdoor education, primary science, environment, nature

Introduction

Instinctively, most of us know that being outdoors is good for us in some way. As both a classroom teacher and a primary science and outdoor learning consultant, I have developed a passion for the outdoors and feel that it can be used to enhance a wide variety of learning. When choosing to teach outdoors, it is important to be aware of why this approach is being adopted. Equally, it is important to be aware of why we are choosing to teach indoors. If we know the intended impact of an approach or strategy, we are much better able to reflect on whether or not its implementation will have the desired impact, or whether we need to tweak our approach in some way. In this article, I have explored research, primarily from the UK, largely around curriculum-linked outdoor learning and often in school grounds, although outdoor and adventurous visits have also been considered. This raises the question of the scope of 'outdoor learning', to which we turn first, before considering the benefits of such experiences.

What is included in 'outdoor learning'?

Learning outside the classroom is defined by the Council for Learning Outside the Classroom (2021) on its website as '*The use of places other than the classroom for teaching and learning'.* The Association for Science Education (ASE) makes use of this definition to describe outdoor learning as that which '*takes place beyond the four walls of the traditional classroom environment'* (ASE, 2020: 1). This could be within school grounds, local green or urban environments, or further afield. These definitions encompass many possible examples of outdoor learning, from bushcraft and Forest School (Forest School Association), to rock climbing and kayaking, to simply reading a story or playing with toy bricks outdoors. Learning and Teaching Scotland (2007) state the following: '*Outdoor education is a process in which educators, students and others take part, and* outdoor learning *is the learning that accrues as a result'.* Robertson (2020) discusses confusion amongst teachers and youth workers concerned that what they are doing is not 'real outdoor learning' (p.5). Robertson concludes that all approaches to learning outdoors and outdoor learning are valid, but are different from one another. I take this to mean that no one type of outdoor learning is more valid than another: validity depends on the purpose of the lesson or activity.

Schools vary wildly in their approaches to outdoor learning. Some school leaders cite reasons such as health and safety, bureaucracy, a loss of curriculum time and the threat of litigation as reasons not to become involved in outdoor education (Hoath, 2015). Others, such as West Rise Junior School, have featured in national newspapers because of their innovative approach to learning outdoors (Lightfoot, 2016). In the UK, there is a noticeable decline in the amount of time that children spend learning outdoors as they progress through school (Bianchi & Feasey, 2011); children aged 3-5 years spend 50-90% of their time outdoors – this percentage decreases to around 10% by the end of primary school. There is also evidence that pupils in areas with high deprivation have fewer opportunities for out of classroom education than those in areas of lower deprivation, particularly by the secondary phase of education (O'Donnell, Morris & Wilson, 2006).

Health benefits

Research highlights the health benefits of simply being outdoors. A recent review (Twohig-Bennett & Jones, 2018) found health benefits in adults and children ranging from reduced blood pressure and reduced incidence of diabetes to reduced incidence of strokes and coronary heart disease. Engemann *et al* (2019) found that high levels of green space presence during childhood are associated with lower risk of psychiatric disorders later in life. These authors argue that policymakers should consider how they could create, maintain and improve green spaces for populations.

Impact on wellbeing has also been reported. The Natural Connections Demonstration Project (Waite *et al*, 2016) was a large-scale project aiming to stimulate demand for learning outside the classroom, support schools to build learning outside the classroom into their planning and stimulate the supply of high quality learning outside the classroom services. 72% of the 125 schools involved agreed that learning in natural environments had a positive impact on teachers' health and wellbeing; 92% agreed that learning in natural environments had a positive impact on pupils' health and wellbeing.

Attainment and performance

Recent research found that pupils who participate in adventure learning interventions make approximately four additional months' progress (Education Endowment Foundation, 2021). This research does not include activities such as Forest Schools or field trips, focusing instead on pursuits such as climbing, mountaineering and canoeing. The Education Endowment Foundation suggests that non-cognitive skills such as perseverance and resilience are developed through adventure learning and that these skills lead to an impact on academic outcomes. This is supported by Waite *et al* (2016), who propose a pathway model (Figure 1) with learning in natural environments leading to academic benefits such as engagement, self-regulation and raised attainment, which will be further explored in the sections below.

Figure 1. Pathway to raised attainment through outdoor learning (from Waite *et al*, 2016: 10).

Whilst Waite *et al* (2016) found that 57% of respondents to their school survey agreed that learning in natural environments had had a positive impact on pupils' attainment, this was based on staff reporting a higher quality of children's work, rather than an increase in 'measurable' attainment in external examinations. The authors acknowledge the difficulty in making direct causal links between outdoor learning and attainment. Two schools in the research did, however, report a measurable rise in children's attainment, which could be attributed to Learning in Natural Environments activities. One senior leader commented that: *'part of our journey with that has been to develop experiences for the children to write about, and a large number of those experiences are based in the outdoors...Our writing results are now slightly above national average whereas they were well below before'* (Waite et al, 2016, p.80).

One study that found a direct link between learning outdoors and attainment focused on two primary school clusters in West Lothian, Scotland. Harvey *et al* (2017) found that children who learned maths in outdoor hubs made significantly more progress than the control group who were learning in indoor settings. This study is of particular note because the majority of lessons started in the classroom, moved outdoors to the playground and finished in the classroom, a typical format in many UK primary schools.

Hamilton (2018) focuses on children's performance in the outdoor setting compared with indoors. Children from across the full primary age range were involved in this research, although the majority were early years school starters with an average age of five and half years. The children carried out similar tasks indoors and outdoors. These tasks were making a toy, building a den, conducting a puppet tour and imagining an adventure on an alien planet. Hamilton found that the outdoor tasks were recollected in greater detail than the indoor tasks. All teachers involved in the research agreed that children's task performances were better outdoors than indoors. Hamilton attributes the positive impact of outdoor learning to the complexity of the environment, the novelty of the environment and the extent (the quality of the natural space) of the environment. These factors impact on children's performance as a group, leading to more opportunities for group work.

Enjoyment and engagement

In my experience, children enjoy learning outdoors. Waite *et al* (2016) found that 95% of respondents to their school survey agreed that learning in natural environments had had a positive impact on pupils' enjoyment of lessons. In their pupil survey, 92% of pupils agreed that they enjoyed lessons outside 'a lot' or 'a bit'. Barnett and Feasey (2016, p.x) state that '*children prefer working outdoors: they enjoy the freedom the space offers and the fresh air; a change from classrooms, which can be stuffy and cramped*'.

Waite *et al* (2016) also found that 92% of respondents to their school survey agreed that learning in natural environments had had a positive impact on pupils' engagement. Waite *et al* argue that this is because learning in natural environments fosters a love of learning, offering a different way of learning that is perceived as fun and gives purpose to learning. Hamilton (2018) found that the effect of outdoor learning was particularly notable for underachieving pupils and for children with learning difficulties, proposing that the indoor setting was less motivating.

Social skills and self-regulated behaviour

Children's behaviour can be different when they are learning outside the classroom, and for some teachers this can present difficulties. Research suggests that children experience greater autonomy in the outdoor setting and are also more likely to collaborate with other children (Hamilton, 2018). Dowdell *et al* (2011) also found that learning outdoors provided children with more opportunities for social interaction than learning indoors. These two studies suggest that increased opportunities for group work can create changes in behaviour. As noted previously, these increased opportunities for collaboration can lead to increased attainment. Waite *et al* (2016) also found that 85% of respondents to their school survey agreed that learning in natural environments had had a positive impact on pupils' behaviour.

Researchers have highlighted that teachers may need support when considering their expectations and how to prepare for lessons outdoors (Dowdell *et al*, 2011; Hoath, 2015). This may alleviate concerns about behaviour. Dowdell *et al* (2011) emphasised the need for the teacher to maintain a supportive role in the outdoor environment rather than regarding it as a break from teaching. Hoath (2015) notes that, although teachers are aware of the differences between teaching in the classroom and teaching outdoors in relation to the children's behaviour, group dynamics, relationships and interrelationships, they did not approach their planning for outdoor lessons any differently from indoor lessons. Ofsted (2008, p.5) argue that '*when planned and implemented well, learning outside the classroom contributed significantly to raising standards and improving pupils' personal, social and emotional development'.* Note the importance of careful planning and preparation to reap the benefits of learning outdoors.

Success, wellbeing and confidence

In the Figure 1 pathway to raised attainment through outdoor learning (Waite *et al*, 2016), giving children opportunities to experience success and improve their wellbeing and confidence were highlighted as important factors leading to raised attainment. Waite *et al* (2016) carried out interviews with children, and found that learning in natural environments led children to have greater confidence in their own abilities, sometimes through taking risks, so that they felt able to try different challenges within and outside the classroom. This is supported by the Education Endowment Foundation's (2021) research, which suggests that non-cognitive skills such as perseverance and resilience are developed through adventure learning.

Hamilton (2018) found that the effect of outdoor learning on children's self-confidence was particularly notable for underachieving pupils, whose contribution and self-confidence matched that of their peers when learning outdoors. Hamilton also found that the positive impact of outdoor learning was particularly evident for underachievers and discusses how this could be attributed to feeling more empowered in an outdoor setting, as well as how an indoor classroom might be less motivating.

Transition

Transition between primary and secondary school is known to be a difficult period for many children (Kerr, 2016); issues can be both academic and social. Kerr (2016) discusses how a carefully designed programme of outdoor 'shared learning days' with pupils in primary schools and secondary schools working together is a sound model to help address transition issues, which relate to cognitive, affective, interpersonal/social and physical/behavioural outcomes, through learning science outdoors. Primary pupils involved in the project reflected on feeling more prepared for secondary school, learning more science, and feeling more positive about secondary school science. Secondary pupils enjoyed sharing their experiences with primary pupils, and secondary teachers commented on how much the secondary pupils benefited from being involved. The report also highlights the need for primary and secondary teachers to work together on transition projects, suggesting perhaps that there are benefits to shifting away from a curriculum-focused transition project towards something that draws out the aforementioned skills and benefits of learning in the outdoors.

Photos 1 & 2. Children exploring the components of soil.

Teaching *science* outdoors

Waite *et al* (2016) found that, after physical education, science was the curriculum area most commonly taught outdoors. There are clearly many opportunities for teaching primary science

Photo 3. Exploring forces by testing a seesaw lever.

outdoors, and some aspects of primary science are better taught outdoors. Harlen and Qualter (2014, p.141), writing about teaching science, state that *'Children's learning is enhanced where they see its relevance to their lives and to the world beyond school'.* Many primary science topics can be taught outdoors. These topics include not only the more obvious examples such as habitats and plants, but also topics such as forces, space and materials (Spring, 2021). Morgan (2019) argues that teaching outdoors allows children to develop a deeper and more secure understanding of what science, technology, engineering and maths are, and what scientists, engineers, technologists and designers have achieved in the real world.

In their 2013 report on science education in schools, *Maintaining Curiosity*, Ofsted discuss how good schools had embraced outdoor learning and used their outdoor learning areas to teach environmental science, allowing their pupils to experience science in action, regularly and at first hand.

However, just because it is taught outside often does not mean that this is always taught effectively. The final section will consider what makes for effective learning in the outdoors.

Effective outdoor learning

The need to properly prepare for teaching lessons outdoors was highlighted in the discussion about

Table 1. Some ideas for teaching primary science outdoors.

Topic	Lesson idea	Links / resources
Electricity	Conduct a survey of how electricity is used on the streets.	https://pstt.org.uk/resources/resources-available-through-tts/lets-go-stem-trails
Materials	Make a house for a pixie using suitable materials. Carry out a test to find out whether the pixie house is waterproof.	https://www.millgatehouse.co.uk/product/teaching-primary-science-outdoors/
Classification	Carry out a wildlife survey and create a classification key.	https://pstt.org.uk/resources/curriculum-materials/assessment
Parts of a plant	Dig up a plant, and label the parts of a plant.	https://www.ltl.org.uk/resources/parts-of-a-plant/
Grouping living things	Go to the beach, find samples of seaweed, group and sort different types of seaweed.	https://pstt.org.uk/resources/resources-available-through-tts/lets-go-stem-trails
Levers	Create a log seesaw, investigate what difference it makes when effort is applied closer or further away from the fulcrum.	https://www.millgatehouse.co.uk/product/teaching-primary-science-outdoors/

social skills and self-regulated behaviour. In addition to this, it is important to prepare for outdoor lessons effectively to ensure that children develop the knowledge and skills that we, as educators, expect. Dillon *et al* (2006) argue that, when properly conceived, planned, taught and followed up, outdoor learning provides children with opportunities to develop knowledge and skills that add value to their classroom experiences. Ofsted (2008) also state that *'learning outside the classroom was most successful when it was an integral element of long-term curriculum planning…'* (p.5).

Hoath (2015) examined the characteristics of an effective pedagogy in the outdoor setting in primary schools. Longitudinal research was carried out in two schools; this included observations of teaching indoors and outdoors, as well as interviews with teachers and the Senior Leadership Team in the schools. Hoath identifies five key characteristics of effective teaching in the outdoor setting:

- supporting children in making the transitions from within the classroom to beyond it;
- both regular and frequent use of the outdoor setting;
- preparing children for working in the outdoors by addressing the basic psychological and physiological needs of the children before leaving the classroom;
- teachers managing the transition back to the classroom as consciously as the move to the outdoor setting; and
- a shift to weaker framing: this would allow freer dialogue between the teacher and children and between the children; such off-task interactions are part of the dynamics of working in the outdoor setting.

The points above can be addressed by class teachers with their own classes. However, to develop a whole-school approach to outdoor learning, Waite *et al* (2016) highlight a number of factors that impact on whether schools are likely to engage with learning in natural environments. These include Senior Leadership support, confident, knowledgeable and enthusiastic 'Learning in Natural Environments' leadership and school leaders and staff being open-minded in their approach to teaching and learning. Hoath (2015) also highlights the need to challenge a dominant classroom-based pedagogy as a key to improving teaching in the outdoor setting.

Conclusion

As with any approach to teaching, outdoor learning needs to be effectively planned. This, in my view, means being clear about why learning is taking place in a particular environment, how curriculum objectives are going to be covered and how all children are going to be supported so that they have the opportunity to succeed. I am passionate about the outdoors, and especially about teaching science outdoors. The research shared here underpins some of the benefits of outdoor learning, as well as highlighting the need to ensure that learning outside the classroom is planned for as effectively as learning indoors should be.

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Engaging primary students with the issue of air pollution through citizen science: lessons to be learnt

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Abstract

This paper shares insights from an air quality research project that involved 258 primary school children aged between 5 and 11. The children attended a dedicated session led by scientists explaining the nature of air pollution. They then wore specially designed backpacks with built-in air quality sensors during their commute to school for one week to measure air pollution. The generated data were used by scientists to determine children's exposure to air pollution in and around their schools. To examine the children's understanding of both air pollution and ways to reduce exposure, participating children completed surveys (pre- and post- the monitoring week). Interviews with ten teachers were conducted to help contextualise the survey findings. Our findings indicate that contributory citizen science projects constitute a valuable approach to engaging children in environmental education. We also note the importance of ensuring the active participation of teachers, particularly so that misconceptions are rapidly identified and thereafter addressed.

Keywords: Air pollution, primary science, citizen science

Introduction

Air pollution – a complex mix of gases and particles – has been associated with a variety of health problems, from breathing difficulties to heart disease. Children are particularly susceptible due to their immature and developing immune and respiratory systems, relatively high inhalation rates and lower body weights. Air pollution can also adversely affect children's cognitive development (Gehring *et al*, 2013; Sunyer *et al*, 2015). In this paper, we reflect on the findings of a study designed to document children's exposure to air pollution, through a citizen science approach to data generation with the aim of giving the children themselves a prominent role. Specifically, we discuss the impact of participation on children's understanding of, and ideas about, air pollution and highlight key lessons learned with a view to informing further citizen science initiatives that involve primary schools.

The Breathe London Wearables Study

During March to July 2019, The Breathe London Wearables Study (BLWS) provided participating primary school children (n=258, from five London schools) with a backpack incorporating a small air pollution sensor[1] and a GPS tracker. By wearing the backpacks on their daily school commute over the course of a week, the children collected air quality data, including nitrogen dioxide and particulate matter exposure levels. Participating children also kept a travel diary, which included the mode of transport used to travel to and from school.
The involvement of children in this study is in keeping with a contributory citizen science approach to data generation (Bonney *et al*, 2009).

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[1] The N609 sensor unit used in the backpacks was developed by Dyson. The unit captures data on particulate matter ($PM_{2.5}$) nitrogen dioxide, humidity and temperature. Unfortunately, the Dyson unit is not currently commercially available, however there are other ways of measuring air pollution whilst also involving children in the research process, for example see (EEA) European Environmental Agency, (2019); and Morgan and Shallcross (2021).

At the outset of the study, air quality scientists gave a presentation to schoolchildren and staff to share the research aims and to highlight the causes of and dangers posed by air pollution. Scientists also returned to the participating schools at the end of the project to present the findings generated from the data collected by the children and to provide advice and information on how to reduce exposure to air pollution. The findings showed that children were most exposed to air pollution during the morning commute and that children who walked, cycled or scooted to school via residential streets were less exposed than those who walked on the main roads or travelled by car or bus (full findings are reported elsewhere, paper currently under review).

The BLWS provided an opportunity to better understand the impact of participating in an air quality-focused citizen science project. Children across school years 1–6 (ages 6-11) completed short surveys before and after wearing the backpacks, which examined their understanding of the causes and the health effects of air pollution, and potential strategies to reduce and avoid exposure. These surveys were completed at home. The second survey (completed at school two weeks after the results of the study were presented) additionally asked children to share changes made in their own behaviour to reduce exposure to harmful pollutants and to draw a picture for other children explaining the dangers of air pollution. 220 children (85% of those who wore the backpacks) completed the first survey, and 180 children (70%) completed the second survey (see Table 1).

Semi-structured interviews with ten teachers provided further contextualisation to the children's responses. Informed parental/carer consent and institutional ethical approval were obtained prior to the study.

Analysis of students' survey responses

The pre-surveys from each school were read by the research team to gain a sense of the children's understanding of air pollution. Unsurprisingly, this varied greatly, but most children initially had a limited understanding of invisible pollutants such as those caused by traffic, and did not consider their own schools to be particularly adversely affected.

Next, we read through the post-surveys and sorted them according to whether the children's subsequent responses and drawings indicated a relatively 'clear' conception of the risks associated with air pollution or, by contrast, a more 'ambiguous' or less clear conception of air pollution. Incorrect conceptions and incomplete surveys were also counted. In conducting this analysis, we acknowledge that there is a continuum between a clear or stable conception, through to a more ambiguous or mixed conception and, at the other end of the continuum, an incorrect conception. Further, we note that children (like all learners) may hold multiple conceptions at once (Taber, 2000).

Finally, we note that some children – especially the younger ones – may have misunderstood the directions on the survey, ticked several responses without distinguishing their particular views, or sought to please the scientists by guessing what they thought would be preferred responses. (Moreover, we acknowledge that we did not ascertain reading ability, or English language proficiency of individual respondents.) In this way, we do not claim that our findings outlined below indicate the complete extent of children's understanding. Rather, we highlight ambiguities in understanding to draw attention to common and potentially persistent misunderstandings that may impede behaviour change and limit air pollution amelioration.

Table 1. Numbers of children per age group completing pre- and post-surveys.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Pre-survey	18	27	47	52	53	23	220
Post-survey	5	27	38	42	49	19	180

Findings

The post-surveys demonstrated a range of views and misconceptions, even though the children had attended an initial presentation explaining the nature of pollution and had engaged in collecting data during their commute to and from school. The scientists' presentations of the data analyses (via a written report, and an assembly) explicitly referred to the importance of travelling away from busy roads to reduce exposure to harmful pollutants and of the benefits of active travel (cycling, walking, scooting). Across all five schools, the number of clear conceptions outnumbered mixed or incorrect conceptions. However, in three schools, between a third and a half of children demonstrated some degree of confusion in their understanding. The ambiguous or incorrect responses were not dependent on year group (see Table 2).

Examples of clear conceptions on the part of students

The majority of the children expressed a clear understanding of the effects of traffic-related air pollution. When asked what they were doing to reduce their exposure (*What are you doing right now to make sure the air you breathe is clean?),* children offered the following types of responses:

'I am walking to school, telling my parents to turn off the engine when there (sic) stopping' (Child aged 9/10, School A).

'I walk to school on not so busy roads' (Child aged 9/10, School A).

'I cycle to school more regularly now' (Child aged 10/11, School C).

Figure 1. Clear conception of how best to reduce exposure to air pollution.

When asked what they thought could be done in the future, responses included:

'We can make rules to ban stuff that makes air polution (sic) and you could make filters to stop air pollution' (Child aged 7/8, School E).
'People could walk, cycle or scoot to school and people shouldn't use a car so much as cars produce pollution and it affects our breathe (sic)*'* (Child aged 8/9, School D).

We also noted that several children displayed nuanced reasoning in their responses. They had clearly considered the issues and come to their own conclusions about best practices. For example, one child expressed a view that might be shared with many adults faced with the issue of transporting their children to school:

'I don't think you should ban the dropping off by car/picking up because people live far from the school. I think they should just turn off the engine when they've stopped' (Child aged 9/10, School A).

Table 2. Clear and ambiguous conceptions of air pollution per school.

School	No of post surveys completed	Clear conceptions about traffic pollution	Mixed and/or ambiguous conception	Incorrect conceptions	Incomplete surveys	% of surveys indicating mixed or incorrect conceptions
A	38	30	6	0	2	16
B	49	22	22	0	5	45
C	19	13	2	0	4	11
D	30	14	12	3	1	50
E	44	23	15	0	6	34

Examples of mixed and/or ambiguous conceptions

Surveys categorised as mixed and/or ambiguous did not necessarily display misunderstandings about air pollution. Rather, they demonstrated that children held a number of conceptions and, in some instances, appeared to be fusing such conceptions with other ideas related to health and the environment. For example, when asked about what they were doing now to ensure that air is clean, a child aged 9/10 from School D responded *'do not smoke or make pollution. And walk to school'.* However, when asked about the impacts of air pollution, the same child wrote that *'it kills sea animals because they can eat the rubbish'* and, when asked to draw a picture about the air pollution, the child drew a large cigarette and a 'skull and crossbones' symbol.

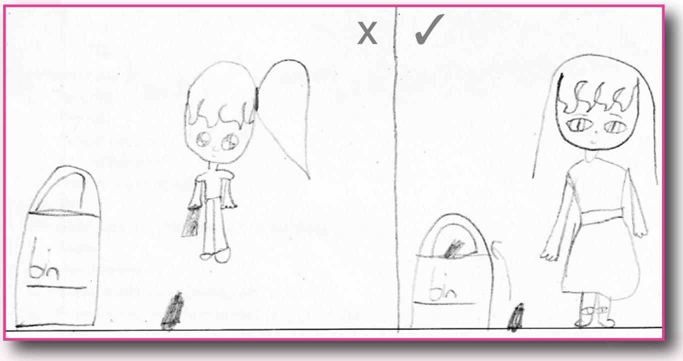
A child aged 7/8 (School A) expressed a variety of environmental messages. When asked what could be done to improve air quality, they wrote *'Don't litter. Plant more trees. Recycle more'.* Their drawing, however, depicted someone coughing in a cloud of fumes.

Another 7/8 year-old (School E) displayed an amalgam of health messages in their conceptualisation. They wrote about the need to walk to school, drew a detailed picture of lungs and particulate matter but, when asked what to do to make air quality better in the future, wrote *'eat healthier food'.* Similarly, a child aged 8/9 (School B) appeared to conflate air pollution messages with other health recommendations: *'Persuade my parents to use the car less. Buy an electric car. Keep exercising'.*

Examples of misconceptions

Fortunately, examples of incorrect understandings or misconceptions were few and far between. One child simply referred to the need to put rubbish in the bin throughout their survey and, made no mention of traffic pollution or steps to avoid it. When one child aged 9/10 (School B) was asked how to ensure that they breathed cleaner air, they said *'not breathe that much, and brush your teeth'.* In categorising these instances as examples of misconceptions, we are aware that the confusion may have resulted from the wording of the question in the survey. Furthermore, we accept that individual children may not have associated the survey questions with their earlier experience of taking part in the air pollution monitoring study. Such explanations notwithstanding, we think that it is important to highlight these examples to showcase the types of confusion that children may experience.

Figure 2. Example of incomplete or misconception relating to causes of air pollution.



Teacher interviews

The data gathered from the teacher interviews offer insights into the varied responses of the children. The conflation with other environmental issues such as recycling and ocean plastics may be due to children having engaged with such topics previously as part of their standard curriculum, as a teacher at School B explains:

'The air pollution topic is new, there would usually be more things like plastic and deforestation which affects animals. With plastic, children can see: when you see it in the ocean and you know it is killing animals. Children often love animals and they are horrified that some actions are affecting animals, whereas I suppose with air pollution being quite invisible perhaps, it hasn't been such a big thing' (Teacher 1, School B).

The week-long nature of the air pollution research project, meanwhile, may not have afforded enough time for either the teachers or the children to situate the new ideas and content amidst other learning and to make sense accordingly, as the teacher at School E makes clear:

'Children didn't talk about the results very much, they didn't really understand. Timing is also an issue because towards the end of the term they have lots on and it is hard to remember' (Teacher 2, School E).

The complexity of the topic was noted by several teachers. Teacher 1 from School B highlighted that the technology used in the air pollution sensors in the backpacks should have been better explained, as the children had many questions about how the data were collected. One or two teachers appeared to struggle themselves in understanding the results. Teacher 2 (School E), however, clearly recognised the implication of the data and recommended that parents should be invited to join the sessions led by the scientists as this would encourage whole families to change their behaviours.

In terms of teaching practices regarding air pollution, some teachers shared their perception that the topic might only be addressed by colleagues with a specific interest and/or concern, as air pollution is not part of the science curriculum at Key Stages 1 and 2 (primary years) in England. When asked how they themselves might introduce the topic, most were inclined to immediately link it to recycling, highlighting that teachers, like children, tend to group environmental topics together.

Implications for teaching about air pollution

From the analyses above, it is apparent that the majority of the children who participated in the study have a clear understanding of causes, risks and ameliorative measures associated with air pollution. However, some children appear to have experienced some confusion. We acknowledge that this may be due to the survey design, or children misconstruing instructions. However, we assert that the relatively high numbers of ambiguities in the responses may also reflect worryingly high levels of misconceptions in primary pupils' understanding of air pollution.

Misconceptions are common (Allen, 2014). Indeed, identifying and addressing typical or frequent misconceptions in the domain of science has long been the aim of science educators (Hewson & Hewson, 2003; Wandersee *et al*, 1994). However, misconceptions in the domain of environmental education are arguably more problematic.
As Palmer (1995) has noted, incomplete knowledge or even stereotypical thinking will constrain environmental understanding, which may in turn impede behavioural change.

And yet, misconceptions may be inevitable. This study clearly demonstrates that the learning – and teaching – of complex (multi-factor) environmental issues is not straightforward. Firstly, it is clear that messages that have been promulgated for longer – for example, anti-smoking, healthy eating, recycling campaigns – appear to be prominently fixed in the minds of children. Any new messages concerned with aspects of health may then be assimilated or conflated with existing ideas resulting in muddled or ambiguous conceptions.

Secondly, full comprehension of the issue of air pollution and its primary causes may be affected by children's conscious or unconscious notions of control. For example, air pollution caused by fumes from vehicles and smoke from big factories are essentially invisible. Cigarette smoke, on the other hand, is something that children can often see and smell at home, at the school gates, and at the bus stop. Moreover, smoking is seen as something that individuals do, and that individuals can stop (or be persuaded to stop). Previous researchers have noted that abstract nouns and agentless processes can be difficult to understand (see Rickinson, 2001). Children cannot make decisions about car driving or cycling, but they can pester and persuade their parents not to smoke.

The wider research team continues to monitor air pollution and identify safer routes to school and collect data. Future studies are planned for Birmingham in early summer 2021, and other studies are ongoing in various African countries, including Ghana, Malawi, Nigeria, South Africa, Tanzania, Uganda and Zimbabwe. However, we also recognise that more is needed in our work with schools to ensure that messages take hold, are not misconstrued, and prompt meaningful lasting change. To reduce confusion, we recommend the following:

1. Ensure active inclusion/participation of the teacher. In our analysis of teacher interview data, we noted that most teachers described their role as gatekeepers and facilitators. They were not cast as active participants in the research, nor were they necessarily equipped with greater content knowledge. It is important that adults – teachers, classroom assistants, parents – also participate in a study to help embed the message.

2. Be alert to and thereafter actively address common misconceptions. We have known for a long time that there is confusion in distinguishing between environment-related phenomena. Dimitriou and Christidou (2007) documented that environmental concerns, including ozone depletion, global warming, air pollution and acid rain, are confused and conflated. Indeed, Boyes and Stannistreet (1996, p.194) noted that the word 'pollution' is problematic and that '*children need to be made more aware of the specific pollutants and the different problems that they cause'.*

3. Design initiatives that promote the trinity of environmental education: learning *about*, *in* and *for* the environment (Lucas, 1972). That is, we recommend that:

   - Children learn *about* air quality and the effects of air pollution;
   - Children conduct research *in* air quality by collecting and analysing data. This may involve backpack monitors, but could be as simple as counting cars and traffic flow at different times of the day; and
   - Children act *for* air quality by taking active steps to reduce pollution (e.g. lobbying for reduced car use) in their environment.

Given the findings reported above, we note that learning '*about*' needs more work if we are to unpick the confusion surrounding ideas about air quality and broader ideas around health. Fortunately, resources such as those produced by the Primary Science Teaching Trust are available (see https://pstt.org.uk/resources/curriculum-materials/citizen-science-air-pollution).

For engagement *in* issues of air quality research, we would point to the benefits that citizen science projects confer. Moreover, we note that the children in our study found gathering data by wearing the backpack to be the most exciting and rewarding aspect. Finally, and with respect to action *for* improved air quality, we would argue that, whilst citizen science projects offer considerable opportunity for developing active participation, the greatest benefits will ensue when teachers, and parents, are also actively involved in the research process.

Figure 3. A child's powerful illustration about the dangers of air pollution.

Figure 4. A child's commentary on air pollution amelioration.

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The nature of creativity in Arts and science teaching: views from the primary classroom

• Polly Bell • Deb McGregor

Abstract

This article considers teachers' perspectives of creativity in both their Arts and science lessons. It elaborates on the ways in which they reflectively report that they are creative in their teaching ***and*** *how they foster learner creativity. Drawing on questionnaire data from over a hundred teachers recognised for specialist excellence, this article contemplates the extent and nature of these teachers' varied views. The questionnaire responses were collated and analysed to present descriptive statistics and a thematic analysis. Comparison across teachers' perspectives of creativity in Arts and science suggests a sophisticated picture, describing features that characterise creativity across subjects as well as subject-specific contrasts. From these findings, propositions are offered about ways that teachers could promote creativity across subject disciplines and ideas for supporting it specifically in science. An outcome from this study is a proposed framework of creative teaching practices, which could be drawn on to develop pedagogies to support learner creativity within and across science and the Arts.*

Keywords: Science, Arts, learner creativity, creative pedagogies

Introduction

The Durham Commission (2019, p.74) highlighted *'growing national and international interest in the importance and value of creativity and creative thinking in our society'.* Despite this, creativity receives scant mention in National Curriculum Science policy documents (McGregor & Frodsham, 2019). In addition, the UK has decided not to participate (TES, 2019) in international PISA tests to formally recognise creative skills (OECD, 2019), thus leaving the task of identifying and developing learner creativity to educators themselves.

Creativity can be understood and thought about in various ways. PISA defines creative thinking as '*the competence to engage productively in the generation, evaluation and improvement of ideas, that can result in original and effective solutions, advances in knowledge and impactful expressions of imagination'* (OECD, 2019, p.8). Often it is described as something related to the Arts (Mullet *et al*, 2016), connected to performance of some kind: for example, *playing* a musical instrument, *painting* a picture, *acting* a part in a play, or *writing* a unique song, poem or story. However, without the creative thinking and innovative problem-solving of scientists, we might not have COVID-19 vaccines, plastic digesting bacteria, hybrid cars or even hydroponics that may feed the world in the future. Initiating creative thinking in schools to inspire future scientists has long been advocated by the Organisation of Economic Cooperation and Development (OECD, 2019). In England, Ofsted (2010, p.5) has described how creative approaches can be incorporated into school science teaching as well as 'traditionally "creative"' Arts. Clarity is needed to enable teachers to appreciate and adopt common principles for creative teaching (Sawyer, 2012) or recognise where subject-specific approaches might be more effective.

The OECD (2019, p.9) also acknowledges the unresolved question of: '*Is creative thinking in science different from creative thinking in the Arts?*' Glaveanu (2018) argues that there may be ontological divides in creativity, with artistic approaches associated with creative transformation of materials, thoughts and feelings into a particular medium (visual, musical, for example). Whereas, creativity in solving problems, discovery and inventiveness is, Glaveanu contends, more closely associated with science. He does advise, however, that if educators are to successfully nurture a range of forms of creativity, there needs to be wider recognition of contrasting characterisations across disciplines. Mullet *et al* (2016) reiterate that teaching for creativity in disciplines beyond the Arts (in science, for example) requires more specific pedagogical guidance. The research discussed here takes steps towards addressing this.

Focus of the research

The intention of the questionnaire research in this article was to explore teachers' thoughts about and experiences of creativity in the classroom. This formed the initial phase of a mixed-methods doctoral research study connected to a larger PSTT (Primary Science Teaching Trust)-funded project exploring creativity in science (McGregor & Frodsham, 2021).

Research questions

- How do primary teachers with specialist excellence in Arts and science characterise creativity in their lessons?
- What features of practice do these teachers associate with nurturing creativity?
- In considering creativity in Arts and science lessons, are commonalities evident?

Research approach

Primary school teachers were purposively invited to participate because of their involvement with Artsmark, PSQM (Primary Science Quality Mark) or the PSTT award schemes relating to Arts or science teaching. Ethical approval was gained before a questionnaire exploring their views about creativity in Arts and science lessons was distributed through the gatekeepers of these organisations. The total number of respondents was 104, with relatively balanced numbers representing Arts and science specialists (N=51 and N=53 respectively). All responses were collated and de-identified for anonymity.

There is no claim that the views and experiences collected represent all values, experiences or practices of primary teachers, particularly because participants were chosen for their specialist excellence. However, for precisely that reason, the expertise of these individuals meant that they were well placed to emphasise common features of creative pedagogies across disciplines and highlight effective approaches for nurturing pupil creativity in these subjects.

The questionnaires

The questionnaire design involved defining aims, devising and piloting questions, before distributing, collating, coding and analysing results (Gray, 2018, Ch.10). Hetherington *et al* (2019) explain how, in their creativity research, Likert questions enabled the description and comparison of perspectives between groups, while open-ended questions facilitated the emergence of unanticipated themes.

Similarly, in this questionnaire Likert scale questions queried how often different features of creative pedagogies were employed in Arts or science lessons, with options offered of '1-never', '2-rarely', '3-sometimes', '4-often' and '5-always'. Suggestions from Craft (2005), Davies and McGregor (2016), Sawyer (2012), QCA (2005) and Jones and Wyse (2013) were merged to form 15 distinct features representing creative teaching (Figure 1).

There were also five open text questions seeking unfettered responses about the nature and enactment of creativity, focusing on teachers' memories of creative lessons in Arts and science. Care was taken to avoid leading questions, ambiguity, stereotyping and assumptions (Gray, 2018, Ch.14). Most of the open questions were divided into two parts for separate focus on the (a) teacher and (b) learners.

Three academic colleagues checked the questions for face validity and subject bias before the questionnaire was piloted with two practising teachers and two groups of seven student teachers, inviting their comments. Any ambiguous and problematic wording was resolved before administering the final questionnaire.

Data analysis

The quantitative data was statistically analysed using SPSS. Cronbach's alpha was used to assess the internal consistency of the Likert scale items (Gardener, 2017) to ascertain the scale reliability. Despite some variations in factor loadings, all the individual features of creative pedagogy showed acceptable correlations (> r =0.3), with an overall Cronbach's alpha of α = 0.864. Modes were then calculated to provide an overview of the frequency of use of each creative practice in lessons.

Following this, non-parametric Pearson Chi-square testing was undertaken, because the collated Likert scale responses were essentially categorical (Gardener, 2017). These tests were chosen because they could determine the extent to which teacher ratings fitted the null hypothesis that features of creative pedagogies would demonstrate the same distributions for frequency of use in science and Arts: in other words, whether distributions of ratings appeared independent of subject discipline (Arts or science). A result above an accepted significance level of .05 implied that subject discipline and the use of that particular creative practice might be related. Counts for ratings for science and Arts lessons were compared where significant results were found to tentatively consider the possible nature of any relationship.

Teachers' open textual responses were thematically analysed through 'initial coding' involving reading and assimilating, before developing themes and categories based on notable patterns (Saldana, 2015). Systematic rounds of coding and refining of categories were undertaken in 'focused coding', comparing '*data*

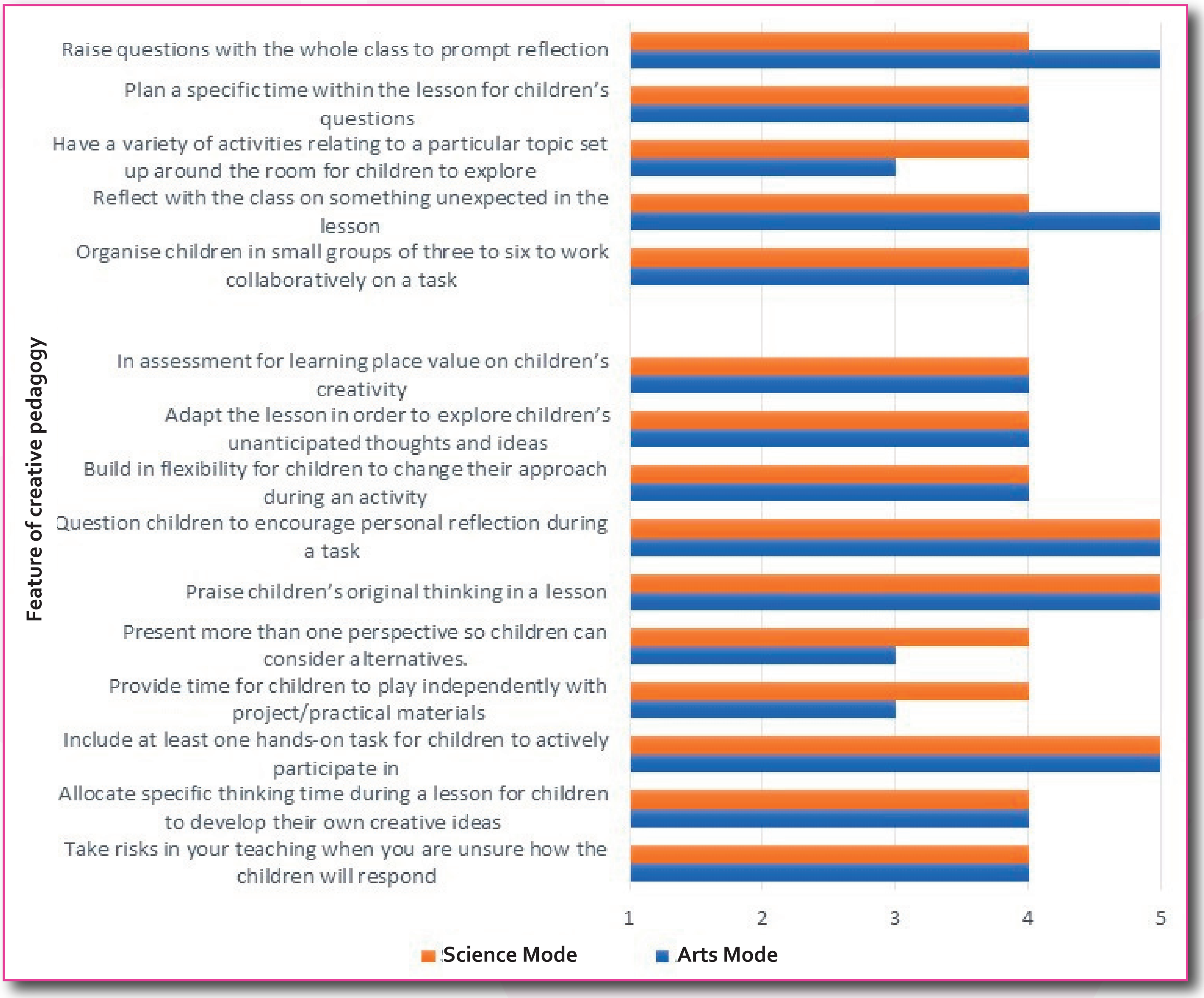


Figure 1. Teachers' use of features of creative pedagogy in lessons (N=104).

with data, staying close to and remaining open to exploring what they [the researcher] interpret is happening in the data; constructing and keeping their codes short, simple, precise and active' (Thornberg & Charmaz, 2014, p.156).

Findings

Findings from the Likert scale items

Figure 1 indicates the extent to which teachers reported adopting each of the different features of creative teaching. For all items, the mode was at least '3-sometimes' for Arts and science lessons.

The last ten features of creative teaching displayed in Figure 1 produced non-significant values in Chi-square testing, implying that their pattern of use was reported to be independent of subject discipline (broadly similar in Arts and science).

However, the first five items produced statistically significant values, thus implying a distinction in the distribution of ratings between Arts and science lessons. Counts were examined to describe the possible nature of this. Figures 2a and b (shown with the associated Chi-square statistics) present higher counts centred on modes of 4 (often) in science. These differences could indicate a trend towards their more frequent use in science in comparison with the Arts.

In contrast, in Figures 2c, d and e, ratings appear more spread out across the Likert scale for Arts compared to science (where teachers more consistently selected 'often' or 'aways'). These differences in distributions could suggest higher variation between teachers in the frequency that they use these creative pedagogy features in Arts lessons.

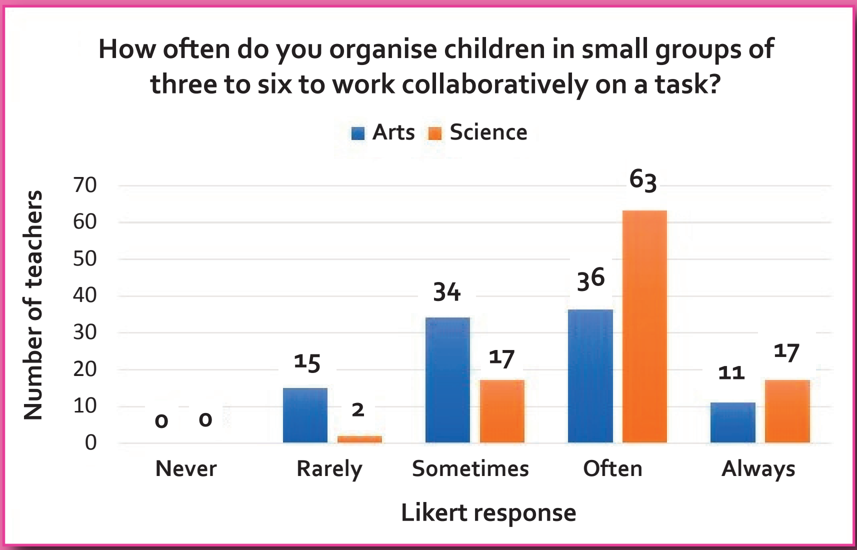
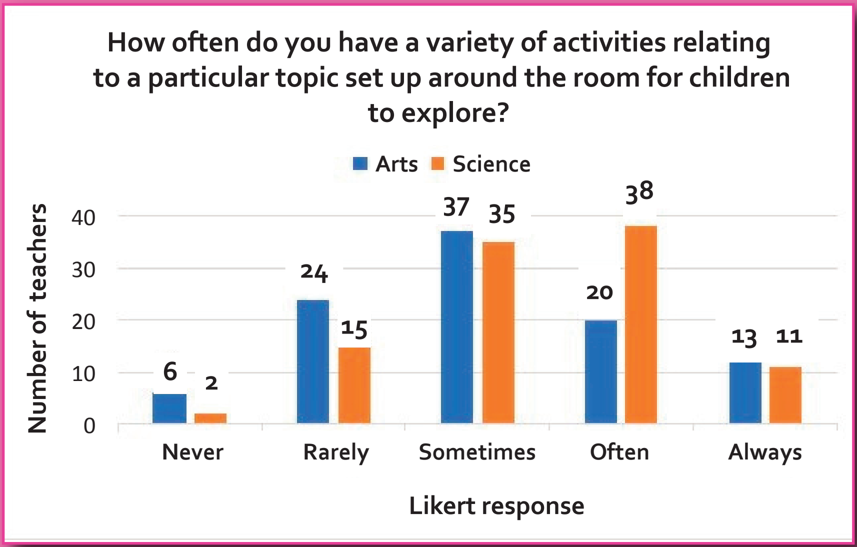


Figure 2a. Teachers' responses relating to collaborative group work. $\chi2$ (3, N = 195) = 24.22, $p < .001$

Figure 2b. Teachers' responses relating to a variety of activities. $\chi2$ (4, N = 201) = 9.88, $p < .05$



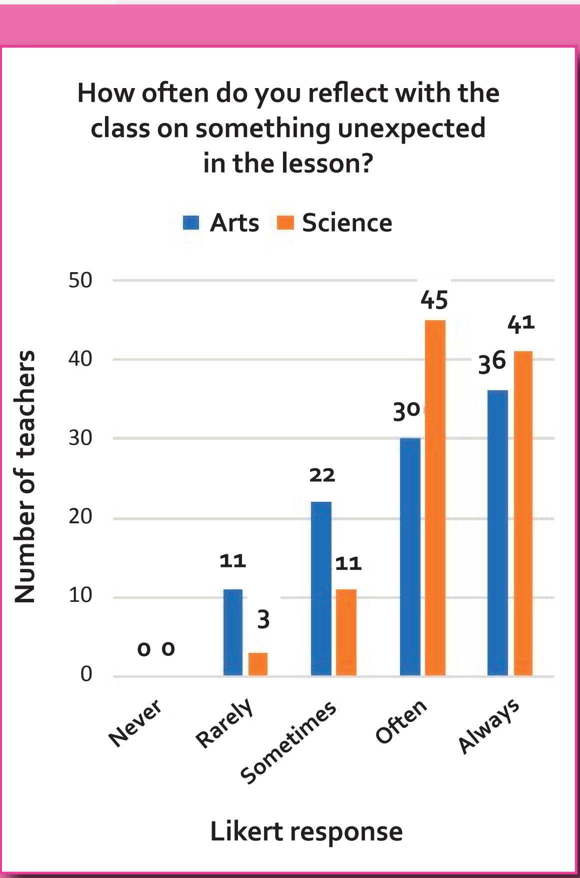


Figure 2c. Questionnaire responses relating to reflecting on the unexpected
χ2 (3, N = 199) = 11.56, p < .01

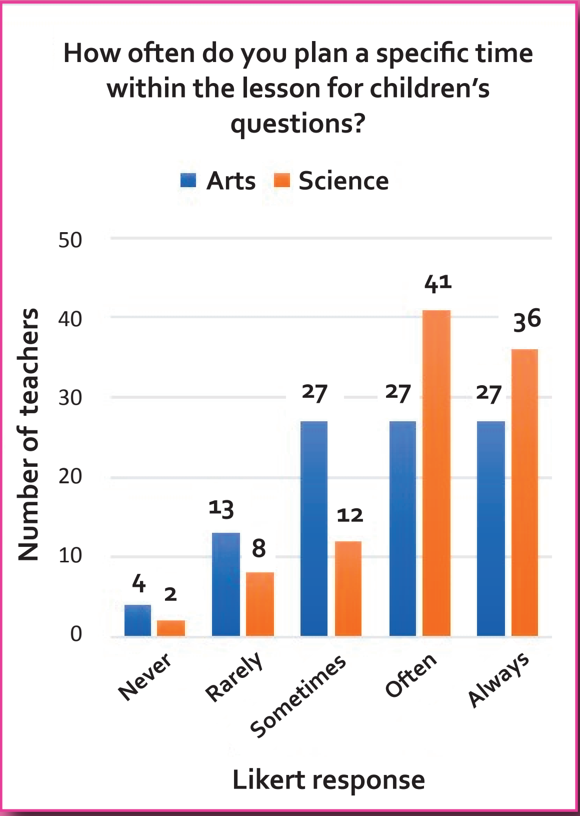


Figure 2d. Questionnaire responses relating to time for questions
χ2 (4, N = 197) = 11.79, p < .05

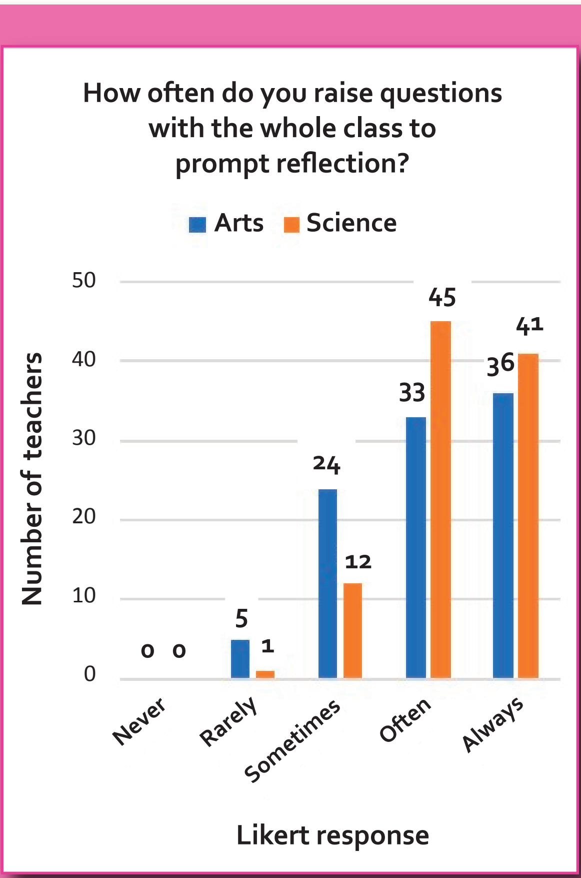


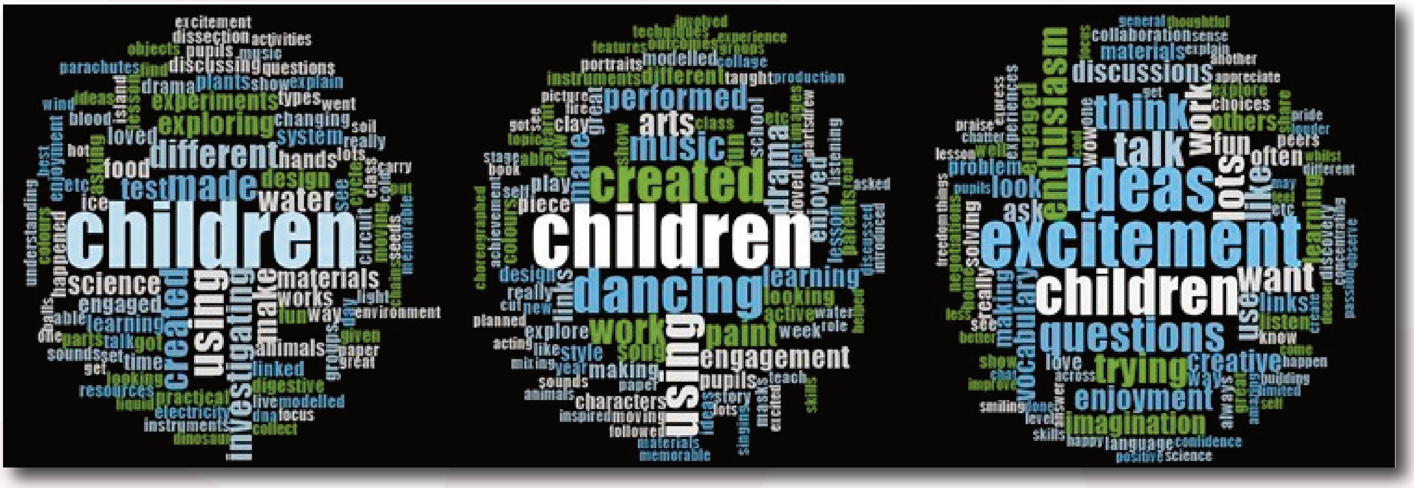
Figure 2e. Questionnaire responses relating to questions for reflection
χ2 (3, N = 197) = 8.83, p < .05

Findings from the qualitative data

In teachers' responses to the open questions, word clouds were produced using NVivo software from teachers' collected descriptions (see Figure 3) to indicate what they perceived characterised creativity in Arts and science lessons. Default stop words were excluded from frequency counts of words, as well as the defining stemmed words 'Science', 'Arts' and 'lesson' to avoid obscuring results.

The word clouds for science and Arts appear broadly comparable, with 'children' centrally placed, illustrating its frequent mention. In addition, numerous words emphasise hands-on, practical activities, such as 'using', 'made', 'performed' and 'investigated'. Subject-specific words are also apparent, such as 'portraits', 'paint' and 'draw' (for Arts), and 'experiments', 'electricity' and 'system' (for science), although some of these occur within both word clouds, for example 'drama', 'water', 'music' and 'instruments'.

Figure 3. Word clouds illustrating teachers' descriptions of creativity in (from left to right) science lessons, Arts lessons and children's talk.



This could represent the creativity recognised in cross-curricular STEAM lessons. For children's talk, words relating to positive emotions and active engagement feature prominently, with teachers frequently discussing the excitement, enjoyment and enthusiasm of learners when being creative, thus highlighting their positive educational experiences.

Further thematic analysis of teacher descriptions of creative lessons identified themes of: '*investigation*', '*performing*', '*making a product*', '*discussion*', '*group work*', '*cross-curricular*', '*practical*' and '*agency*'. In learner creativity, pertinent themes included: '*discussion with peers*', '*engagement*', '*ideas*' and '*questioning*'. Notably, teachers often did not differentiate between creativity in teaching and learning, providing mixed descriptions despite being prompted to address each of these aspects individually.

Developing practical guidance for teachers

The centrality of the word 'children' (depicted in Figure 3) emphasised that teachers recognised the important contribution of learners to the creativity emerging in lessons, despite often neglecting to see this separately from creative pedagogies. Figure 4 was developed to conceptualise the key characteristics of learner creativity informed by exploration of teachers' open questionnaire responses alongside consultation of the literature (Robson, 2014; QCA, 2005; Lucas & Spencer, 2017; Redmond, 2005; Littleton & Mercer, 2013; Craft, 2000; Ofsted, 2010). Table 1 (p.43) elucidates how these characteristics might be observed by teachers in the classroom.

The synthesis of teachers' views and experiences of creativity in the questionnaire verified existing themes in the literature, such as allowing choice, opportunities to think across disciplines, collaboration, discussion, openness and giving time for students to develop their creative ideas (Sawyer, 2012). However, the open responses also added the teachers' perspective and further detail to how themes such as affording pupils agency might be exemplified in primary school science and Arts lessons. The creative practice and learner creativity model (Table 1) emerging from the questionnaire analysis offers a theoretical framework that could support practitioners wishing

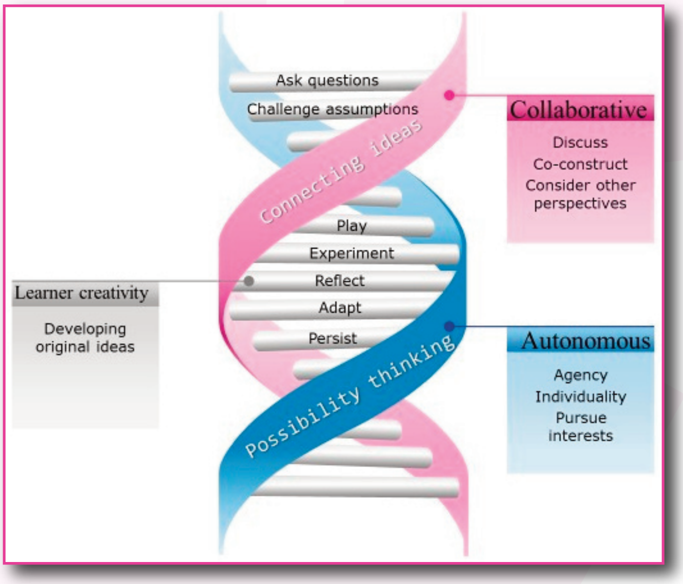


Figure 4. A conceptual representation of 'learner creativity'.

Table 1. Features of creative pedagogy augmenting development of learner creativity in Arts and science lessons.

Notable features of creative practice		Interactional space supporting creative development	Illustrations of learner creativity	
Teacher's practice	**Nature of practice**		**Characteristic of creativity**	**Nature of characterisation**
Affords pupil agency	Provide opportunities for play, discovery or exploration through genuinely open tasks that allow individual choice.		Autonomy	Explains or shows evidence of personal decisions and choices. Adapts work/ideas to their interests.
Makes possibilities visible	Highlight alternative perspectives, ways of doing or seeing things, ambiguities, or inexplicable phenomena.		Connects ideas	Generalises or finds patterns by linking multiple pieces of information. Highlights a connection or commonalities to previous learning, knowledge, or experience. Uses analogies or metaphors.
Values possibility thinking	Reflect thoughtfully or positively on pupils' ideas or questions without premature judgement.		Asks questions	Poses questions to seek new knowledge or deeper understanding, e.g. asking 'why?', 'how?' or 'what?' Speculates about possibilities, e.g. voicing 'I wonder…' or 'imagine if…' Challenges assumptions/generalities or raises exceptions/inaccuracies.
Encourages possibility thinking	Raise open questions or statements that invite various possible ideas and ask children to share their thoughts.		Imaginative	Articulates an original solution or idea. Proposes an alternative to the accepted way of doing or seeing things.
Includes incubation time	Include time and space for children to develop/ experiment with their ideas and flexibility with time to allow children to work at their own pace.		Risk taking	Tries out or experiments with an original or alternative idea/approach. Acts upon intuition or what 'feels' right. Plays with resources and materials or improvises without any obvious plan.
			Persistence	Reflects upon their approach, idea or emerging outcomes during tasks. Adapts or makes improvements to overcome problems. Critically evaluates the quality of their final performance or product.
Open dialogic space	Incorporate tasks that encourage peer collaboration, co-operation, and discussion.		Collaboration	Gives constructive feedback to peers to inspire improvement. Invites feedback. Considers alternative perspectives or ways of doing things. Extends others' ideas in discussion through developing them further or considering implications.

to develop their practice and promote greater creativity in their classrooms. In addition, the findings emphasised the inter-related nature of creative teaching and learner creativity. This vision of the emergence of creativity 'in relationship' between teacher and learner (Craft, 2005) is represented in the 'interactional space supporting creative development' shown in the Table. In this space, a reflexive two-way relationship shapes and transforms children's possibility thinking, the development of ideas and innovation in outcomes, as well as the teacher's ongoing creative practice in a lesson or topic. Furthermore, the framework encompasses the various phases of the creative process, recognising that children might be supported and encouraged (perhaps in distinct ways) during different stages.

Conclusion

The Durham Commission (2019, p.74) describes how integrating teaching for creativity will support young people 'in all aspects of their lives'. In this questionnaire research, primary school teachers (selected for their specialist excellence) reported using a wide range of creative practices regularly in their science and Arts teaching, evidencing how these strategies are relevant and effective beyond the Arts. These teacher participants have confirmed and detailed that there exist numerous possibilities for nurturing creativity in primary science and have added clarity and richness in understanding what this can look like. To address the lack of clarification in the Primary Science National Curriculum (McGregor & Frodsham, 2019), a creativity framework (see Table 1) has been produced based on the questionnaire findings and assimilated ideas from the literature (e.g. QCA, 2005). This table details features of creative pedagogies, which may augment the development of recognisable aspects of learner creativity in Arts and science lessons.

Crucially, results appeared to suggest that some features of creative practice were adopted more frequently or consistently in science lessons compared to the Arts. Statistical tests indicated differences in the distribution of ratings for the reported use of creative practices, including: incorporating collaborative group work, including a variety of activities for learners to explore, planning time for children's questions, raising questions to prompt reflection, and reflecting on the unexpected in lessons. More work is needed to determine what these apparent differences represent and what the implications of this might be for teachers. Questionnaire findings have highlighted how the relationship between teaching practices and creativity appears nuanced, challenging the assumption that creative pedagogies are synonymous between subject disciplines (Cremin & Chappell, 2019).

Future research

It is imperative that researchers continue to develop and translate findings and identified 'themes' into practical guidance for teachers and learners in the science classroom. The theoretical framework presented in this paper provides a useful starting point for teachers wishing to nurture learner creativity; however, it is only the first step. It must be trialled extensively to establish how it can be adopted and built upon as a practical tool for teachers' planning or assessment. This research has also highlighted the imperative to challenge the nature of assumptions that consider a direct, as well as similar, relationship between creative pedagogy and learner creativity across classrooms, levels of education and subject disciplines. More research is required to explore further how pedagogy and learning inter-relate to promote creativity across subject areas. This would clarify for teachers how they could better nurture creativity in their classroom, whether in a specific subject context such as science, or across a range of STEAM disciplines.

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“It isn’t a priority.” Will primary science learning loss be forgotten?

● Cherry Canovan ● Naomi Fallon

Abstract

This study is Part Two of an ongoing investigation into the impacts of the UK’s COVID-19-related school closures on primary science teaching and learning. In Part One, conducted during the closures of spring 2020, we found that science teaching had suffered in ways that were likely to entrench inequality in who can access STEM education and careers.

The research reported in this paper, conducted during the second round of closures in early 2021, found that little progress had been made in mitigating science learning loss at primary level, with less than 10% of parents aware of any efforts in this regard. Meanwhile, a concerning number of teachers were worried that reversing science learning loss was not a priority for schools, and/or reported that no efforts had been made to tackle this.

Parents felt that, in general, home learning in the second closure period was much more effective than in 2020. However, science provision, although somewhat improved, was still perceived by many to be disappointing in quantity and/or quality. Teachers were still finding science a challenge to teach, although one major barrier from the first closures, a lack of access to IT, had largely been addressed. The results show that a lack of ‘catch-up’ activity risks science learning loss being forgotten, while the second round of closures has likely exacerbated the relative learning loss in science over other ‘core’ subjects. Both these effects have negative implications for attempts to interest young people in STEM education and careers.

Keywords: Primary education, science education, COVID-19

Introduction

In January 2021, faced with soaring COVID-19 cases nationwide, the UK government decided at short notice to close primary schools in England. This was the second round of closures, following those of spring/summer 2020, and lasted for eight school weeks.

Since the first closures began in March 2020, evidence has been emerging of related missed learning or ‘learning loss’, both in the UK (Andrew *et al*, 2020; Cullinane & Montacute, 2020; Rose *et al*, 2021) and around the world (Engzell *et al*, 2021; Lichand *et al*, 2021; Maldonado & De Witte, 2020).

During the first closures, we studied how the move to home learning had affected science teaching and learning for primary-age children (Canovan & Fallon, 2021). Surveying teachers and parents, we found that science teaching had disproportionately suffered, particularly in areas of high deprivation. We also found that the situation was likely to exacerbate existing inequalities in who can access science – results that were reported in the ASE’s *Education in Science* (Canovan, 2020). Unease about primary science provision was rising in the pre-COVID era, with Ofsted warning in 2019 that *‘Science has clearly been downgraded in some primary schools’* (Ofsted, 2019), and these findings add an extra layer of concern to the picture.

Attention has now begun to focus on how best to repair the societal and educational damage caused by the pandemic, particularly in terms of heightened inequality (British Academy, 2021; Sutton Trust, 2021). Reporting on 380 interim school visits carried out in September-October 2020, Ofsted (2020) found that many but not all schools had returned to teaching all subjects, but most were adapting the curriculum in response to pupils' knowledge gaps. However, they added that: *'Nearly all primary school leaders said that they were prioritising reading and mathematics, with very few schools focusing on science'* (Ofsted, 2020, p.4).

This is worrying, as research shows (Archer *et al*, 2013) that young people's attitudes to science are largely fixed by the end of primary school. For young people from low-participation backgrounds, their only exposure to science may be through the school setting; removing or downgrading this at a point where they can still see science as a possible future could harm efforts to widen participation in the subject. In our earlier paper, we argued that reversing science learning loss should be prioritised in order not to miss this window.

With the sudden advent of another round of home schooling, we decided to go back to our participants. We wanted to know how much learning loss parents and teachers perceived children to have suffered in science, and how this was being addressed. We also wanted to know how science provision in Closure Period 2 (CP2) differed from Closure Period 1 (CP1).

We aimed to address the following questions:

- ❒ How much learning loss in science was observed after CP1 by teachers and parents? How was this mitigated during the autumn term when children were back in the classroom?
- ❒ How did primary-level home learning differ between CP2 and CP1, both in general and for science specifically?

Methods

To answer the above questions, we approached parents and teachers who had participated in our earlier study (henceforth referred to as Phase 1) and had agreed to be contacted again. Those who agreed then completed a survey about their experiences with primary science teaching and learning in CP2.

Our Phase 1 study design proposed that Phase 2 would be completed after schools return to 'normal teaching'. However, with another prolonged set of closures, we felt it important to gather real-time evidence of the impacts on primary science, together with a picture of how efforts to reverse learning loss had been progressing. The study outlined here is therefore Phase 2; we anticipate Phase 3 taking place during academic year 2021-22.

Our surveys contained both quantitative and qualitative items, with a mixture of multiple-choice and free-text questions. We received a total of 100 responses, 77 from parents and 23 from teachers, comprising 47% of the available pool. The original parent sample was skewed towards those with higher levels of science education, meaning that the current sample has the same bias. As the vast majority (74/77) of respondents were resident in England, this report is from the perspective of English education; differing education systems in the other UK nations mean that the results do not necessarily extrapolate to those areas.

To provide a uniform approach across both studies, we adhered to protocols from Phase 1 in which respondents remained anonymous. Both studies were approved by the appropriate ethics panel at the University of Central Lancashire.

Results

Learning loss

We asked parents and teachers what learning loss their class/child had suffered in a range of subjects during CP1. All teachers observed learning loss in the three core subjects[1] when children returned to school in September 2020 (Figure 1); although the option of 'no learning loss' was given, no respondents selected this. Significant learning loss was reported by more than half of respondents for science and maths, rising to 75% for English.

Types of learning loss that teachers reported tackling included missing topic knowledge, lack of appropriate progress and concerns over understanding of key concepts.

Parent respondents were able to choose from a variety of options, and to choose more than one. By far the most common response, chosen by 57%, was that children had experienced learning loss

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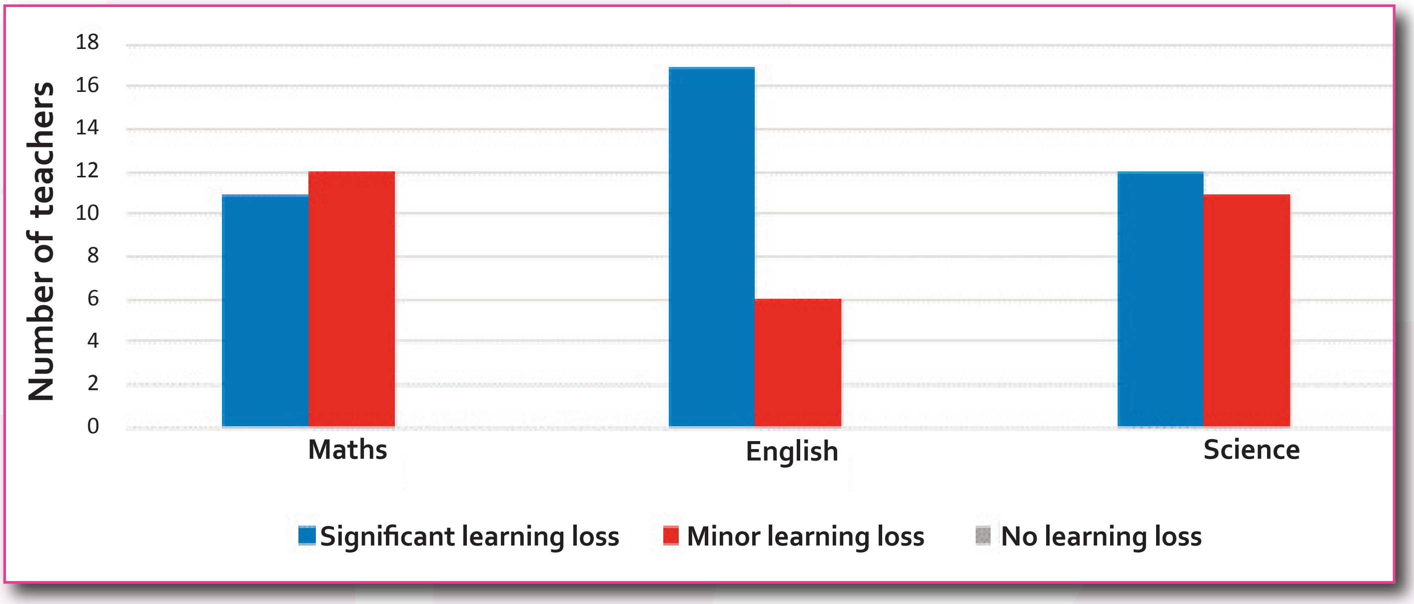
[1] In English schools, maths, English and science are defined as 'core' subjects, while other disciplines such as history, geography and music are categorised as 'foundation' subjects. Curricula differ across the other countries of the UK.

Figure 1. How much learning loss did you observe in the core subjects when the children returned to school in September?



across the board, while only a fifth said their child had experienced no learning loss. Science as a standalone option was chosen more frequently than English and maths, by around a fifth of parents. Parental reports of the type of learning loss issues being targeted included gaps in knowledge and bringing all pupils up to 'the same level'.

We then asked both parents and teachers what mitigation or catch-up work had been used to tackle the reported learning loss, both for general learning and science specifically.

First, we asked parents what steps their child's school had taken to mitigate general learning loss. Around 60% of parents who responded reported that school had taken action of some sort, with the remainder split between 'None/none that I am aware of', and 'Unsure/don't know'.

Opinions as to the efficacy of catch-up work varied widely. While some were very positive – *'A lot of support has been provided by the school for academic and mental health needs'* – others indicated that their child had suffered or been held

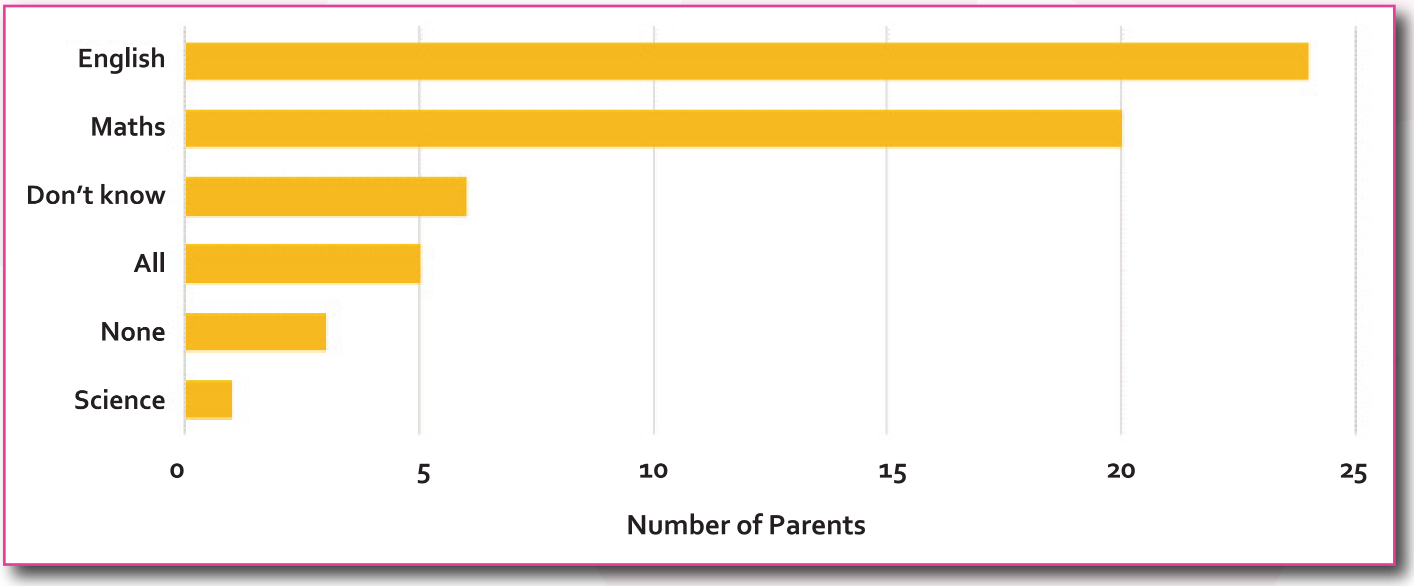


Figure 2. Parents citing catch-up work in subject.

back by efforts to make sure others were up to speed, or had been put under excessive pressure to catch up. Some knew that catch-up was happening but didn't know in what way: *'I'm not sure to be honest. They just reassured us they would catch them up'.*

When we asked parents to name upon which subjects catch-up work had focused, by far the most common were English and maths (Figure 2). Only one parent mentioned science, although a small number said that all areas had been covered. It is possible that school communications were focused on English and maths; however, our parent respondent group had an over-representation of those with advanced science qualifications, and it is therefore likely that they would be more aware of any science catch-up work provided than the general population.

We then asked parents: 'During the autumn term, what steps, if any, were taken by the school to mitigate SCIENCE learning loss?' There were two main groups of answers: those who said 'None' or 'None that I am aware of', and those that were 'Unsure/didn't know'. Only a very small number – less than 10% – were aware of any action taken by schools to counteract science learning loss. The difference between parents' reports of mitigation work generally and for science can be seen in Figure 3.

Teachers were asked to what extent they were able to mitigate learning loss, in both science and other subjects; overall, respondents felt that efforts to reverse losses in the core subjects, at least between September and Christmas, had been only partly successful. Maths was the only subject where a few teachers felt they had been able to mitigate all learning loss; of concern, in science, a fifth reported that they had been unable to reverse any learning loss.

When asked about strategies to tackle general learning loss, many teachers reported that the usual curriculum was replaced with what some called a 'recovery' curriculum, focusing on maths, English and areas identified as 'missed'. Additional work or catch-up groups were also introduced, alongside targeted support for some pupils.

For learning loss in science specifically, a few teachers reported having taken specific initiatives such as extra teaching or curriculum adjustment, whilst for others this was integrated into the school's broader strategy. However a significant minority of our respondents – 10/23 – reported that no catch-up work for science had been planned or attempted. Several used phrases such as *'I'm afraid it just isn't a priority'.*

Reflecting on how school closures had affected science teaching and learning at primary level, some teachers expressed concern that science learning loss would not receive the same attention as maths and English and so would persist: *'Science was already a struggling subject in many schools; my fear is that a lot of teachers won't see*

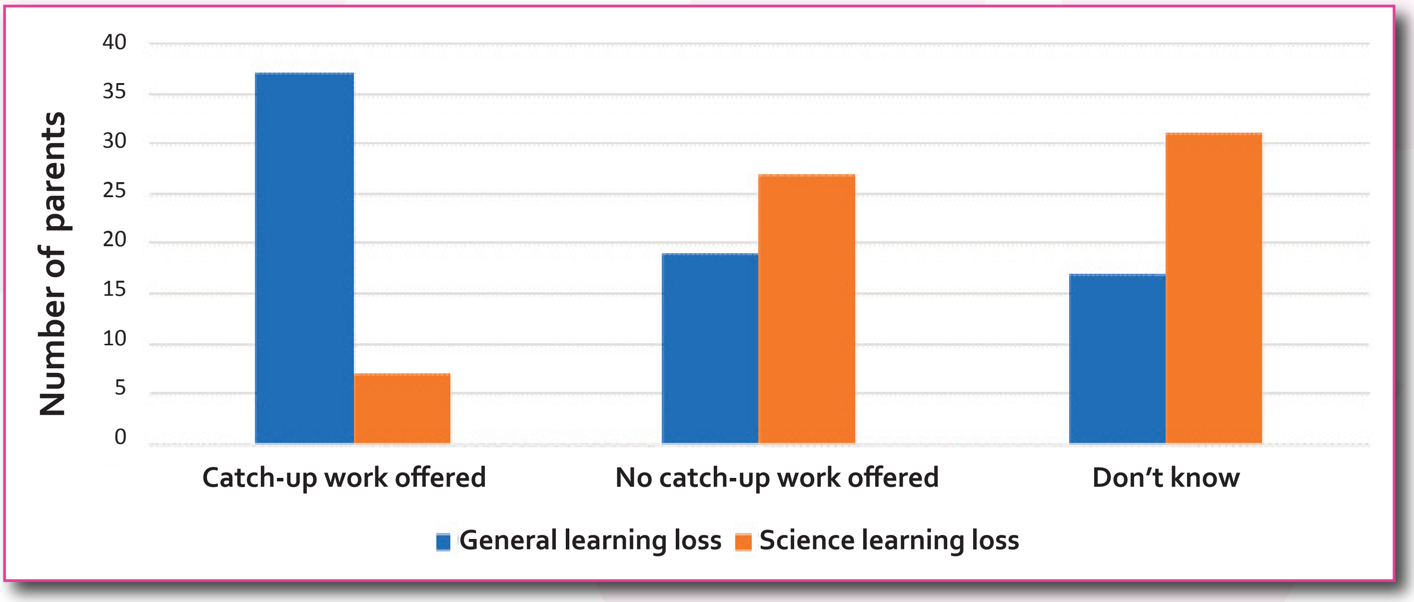


Figure 3. Parents' descriptions of catch-up work.

the importance of it and just see that focusing on maths and English is the most important'.

A couple of teachers reported secondary impacts on science learning through the loss of extra-curricular activities such as science clubs and science weeks, and some suggested that future lesson planning and curricula would have to incorporate missed subject knowledge and skills development.

Home learning in CP2

As well as learning loss from CP1, we asked parents and teachers about their experiences of home learning in CP2. There was a broad consensus among parents that, in general, home education resources provided during CP2 were an improvement on CP1, with only around 10% suggesting that provision had stayed the same or worsened.

Participants were asked 'How, if at all, does the remote education provided by your children's school during CP2 differ from that given in CP1?' Free-text responses yielded a number of positive themes, including:

- daily provision of content;
- live online lessons/meet-ups;
- schooling more structured/organised;
- greater volume of work provided; and
- teachers giving more feedback on assignments.

A typical comment was: '*...there was very little education in period 1. Now it is structured with a daily timetable, pre-recorded lessons, assignments to hand in with feedback given and live lessons every day'.*

In order to compare the two closure periods, we asked parents about the three core subjects, as well as one foundation subject, history, to act as a comparator. We asked parents whether they agreed that 'School provided enough work, of a good quality'; as can be seen in Figure 4, perceptions on this point improved dramatically between CP1 and CP2, with satisfaction very high for maths and English in CP2. However science, although improved, continued to lag behind, with scores comparable to history.

Although there was consensus that general teaching and learning in CP2 was greatly improved, there was much more variety of opinion when it came to the quantity and quality of science provision. Participants were asked two open-ended questions about science: 'How, if at all, does the science education provided by your children's school during CP2 differ from that given in CP1?' and 'Please tell us about any changes you perceive in the effectiveness of science teaching from CP1 to CP2'.

Although a small majority of responses stated that science provision was somewhat improved – being provided more regularly and/or of better quality – a quarter of responses stated that, during CP2, science was either not taught at all or provision was very minimal, while another group questioned the quality of work provided.

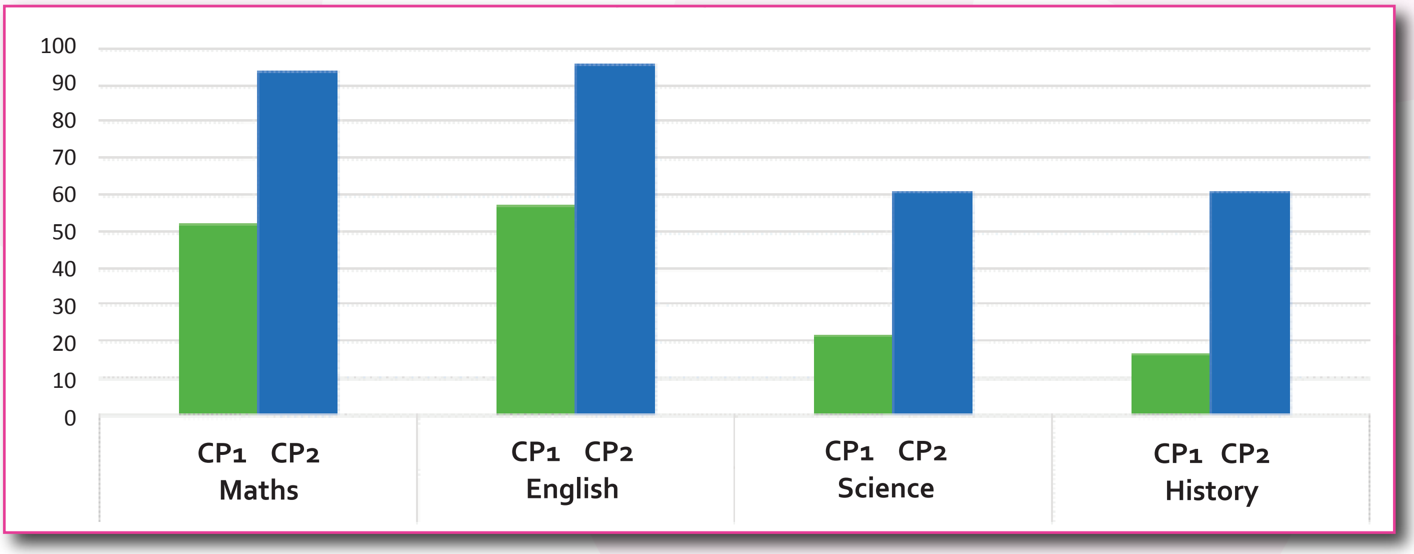
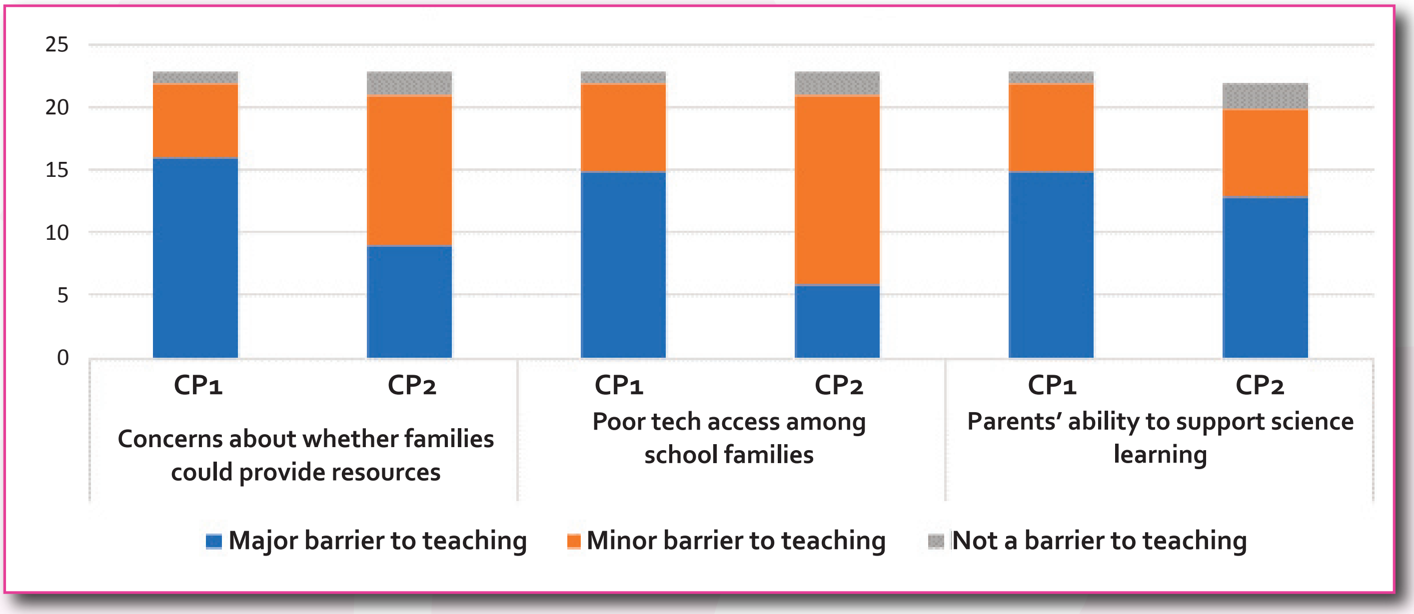


Figure 4. % agreeing that school provided enough, good quality work.

Figure 5. Barriers to teaching science.



Positive responses included '*There's more of it [science] and it's more structured*', and '*The work provided is much better quality and more doable at home'.* However, such views were, to a large extent, offset by negative perceptions of quantity and/or quality by other parents.

Reports of no science teaching in either lockdown were depressingly common, with comments such as '*CP1: non-existent. CP2: very minimal*', and '*I haven't been given anything for either lockdown'.* Where science teaching *was* provided, parents did not always find it satisfactory. The quantity of work was one issue highlighted:

'She gets maths and English everyday so it would be nice to get some more science work'.

'Science is only covered as part of the curriculum every fortnight.'

For other parents, quality was lacking. One reported that '*We have been sent links to a couple of Operation Ouch*[2] *videos*', while another noted that '*[Provision] has improved; however, I do believe science has taken a back seat overall to maths and English'.* Some parents were disappointed by a lack of hands-on science activities: '*…they haven't done anything very practical during CP2, more Internet-based games, videos, etc…*'.

Such responses may be due to continuing difficulties experienced by teachers in this area.

During CP1, teachers reported three major barriers to science teaching – poor access to equipment, whether families could provide adequate resources, and concerns about parents' abilities to support science learning. In our Phase 2 survey, teachers were asked to what extent they had experienced these barriers in each closure period. The overwhelming majority reported that they were still experiencing these barriers; however, there was some positive change (Figure 5). In CP1, all three aspects were cited as major barriers by the majority of teachers, while in CP2 parental ability to support science learning was the only barrier still cited as a major issue by more than half of teachers (59%). In particular, around two-thirds of teacher respondents reported that IT/tech provision had been given to families in need. However several teachers felt that a new barrier – prioritisation of English and maths over science by both schools and families – had led children to disengage with science.

When asked how changes to working patterns, such as more live teaching, had impacted on science in CP2, around a quarter of teachers cited benefits: '*[The] ability to question them effectively – explore what they already know and build upon'.* However, around one half expressed difficulties and/or negative impacts. These included practical difficulties in teaching science through remote channels:

'I am now completing a weekly live science lesson; however, as all of our topics this year are very

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[2] A popular BBC show aimed at children and focusing on medical matters.

practical, I am finding this very difficult to carry out successfully'.

Others reported being told not to include science in live lessons:

'Science I miss teaching...I have been told by my school to send out Oak Learning videos so I'm not even teaching it anymore'.

Discussion and conclusions

It is clear that parents and teachers are concerned about the learning loss arising from CP1. The majority of parents (57%) felt that their child had suffered learning loss across the board, with more perceiving this for science than for maths or English. Although teachers felt that learning loss was most severe in English, all respondents had also witnessed learning loss in science.

Mitigation work, however, was not focused on science. Teachers felt that learning loss had been reversed most successfully in maths, while some stated that they had been unable to reverse any science learning loss at all. Parents were generally aware of efforts within school to provide catch-up activity, but this was heavily focused on maths and English. Less than 10% of parents were aware of any attempt by their school to address science learning loss.

Whilst it is clear that, in general, primary-level home education in CP2 was a great improvement on CP1, the picture is again less positive for science. Although a small majority of parents reported that more science was being taught and/or was of a better quality, a quarter said that their child received no science teaching in CP2, and a significant cohort reported poor quality provision. Whilst most parents agreed that, in CP2, schools were providing enough, good quality work in maths and English, the figure was much lower for science and was more comparable to the assessment of history work, a foundation rather than core subject.

Meanwhile, as in CP1, teachers continued to find it difficult to teach science. Although some of the barriers identified by teachers in spring 2020 had been mitigated, particularly by the widespread provision of IT equipment to families in need, these were still all experienced to some extent by nearly all teachers. The increased demands of provision in CP2 had brought its own challenges, with half reporting that the new way of working had negatively impacted in some way on their ability to teach science.

In our earlier paper (Canovan & Fallon, 2021), we found evidence that teaching and learning science at primary level had been particularly difficult in CP1, and that teachers working in areas of high deprivation had faced particular challenges. We argued that this needed to be addressed as a matter of urgency, because young people's attitudes to science are largely fixed by the end of primary school (Archer *et al*, 2013). Sadly, our study of primary science in CP2 shows that, while provision was improved in some cases, many difficulties remained compared to other subjects, meaning that relative learning loss was likely exacerbated. Meanwhile, work to reverse learning loss has been heavily focused on maths and English, with very little attempt to turn things around in science. Unless concerted action is taken over the next academic year, primary science learning loss risks being forgotten, with the result that more young people will be excluded from STEM learning and careers.

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The ASE Schools' Exhibition has become one of the most popular elements of the ASE Annual Conference every January. Schools from all sectors of education are invited to present a science project happening in their classrooms or clubs. One teacher from each school is invited to provide a display, which can include artefacts and/or posters illustrating their school project, and is required to talk about their display on Friday 8th January 2022 from 09.00-12.00 at Sheffield Hallam University with other teachers. Two or three pupils can accompany their teacher to help demonstrate their activities and talk about their school project.

There is no charge for any school taking part in the Schools' Exhibition and the teacher will receive one full, free day place on that Friday. There will be an opportunity for the teacher and students to visit the main conference Suppliers Exhibition and also to attend one of the Frontier Science Lectures on Friday afternoon if they wish to do so. Places are limited and will be granted on a first-come, first-served basis. Interested schools should email conferences@ase.org.uk in the first instance, indicating their phase of education and their topic. The closing date for applications is 16th October 2021.
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Authors are invited to select the article type that suits the findings they would like to share:

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Contributions should be written in a clear, straightforward style, accessible to professionals. When writing your article, please follow this guidance (do get in touch if you would like further support with writing in an academic style):

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- There should be a section which considers the **implications** of the research for practice, provision and/or policy.
- Include information about yourself (e.g. job title, email) at the end of the article.
- Contributors should bear in mind that the readership is both national UK and international, so please use children's ages (not just school grades or years) and explain the context of the research.
- For in-text references, use (Author, Date) e.g. (Johnston, 2012). If there are three or more authors, the first surname and '*et al*' can be used.
- Include a reference list (examples below), set out in alphabetical order.

Referencing examples:

Book

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Chapter in book

Johnston, J. (2012) ‘Planning for research’. In Oversby, J. (Ed) *ASE Guide to Research in Science Education.* Hatfield: Association for Science Education.

Journal article

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