THE 10 KEY ISSUES WITH CHILDREN'S LEARNING IN PRIMARY SCIENCE IN ENGLAND

by Dr Lynne Bianchi, Christina Whittaker & Amanda Poole

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CONTENTS

INTRODUCTION

The experience children have learning science at primary school underpins their identity, ability and the subsequent choices and options that they have for further study in STEM subjects.

The Wellcome Trust (2017, 2020) and national school accountability (OFSTED 2020) reports, formally recognise primary science as a concern. The profile of primary science has in recent years dwindled and it is frequently taught for fewer than the recommended hours with a reduced curriculum status than that which should be expected of a core subject. Primary teachers lack confidence and skills in science, which means that the sequencing of the curriculum is not always sensible and misconceptions are not corrected. Such issues are further reflected in the annual OFSTED commentary and are similar to the issues found through regional primary science improvement programmes and initiatives.

> *'Our curriculum research this year showed that, in a number of primary schools, head teachers had decided to focus on English and mathematics over other subjects, including science. This was often done explicitly to improve test results in English and mathematics. We saw that both quantity and quality of science teaching were reduced. In these schools, pupils were often given little access to science content. Little consideration was given to developing scientific concepts and skills and the vocabulary that comes with being taught science.'*
> **Amanda Spielman, Her Majesty's Chief Inspector, Commentary on the annual report. January 2020**

The increased focus on school strategic development for curriculum, including science, means that schools are actively seeking information that helps senior leaders make the right decisions on effective approaches to improve experiences for children. Whilst there is much information that is current and survey based on teacher perception about primary teaching there is limited primary subject specific evidence of the child centred learning issues.

The disconnect between organisations supporting school improvement means that there is no single easy reference to see what is going well and to establish what issues should be the focus for improvement. Having this report will support organisations and schools to create or tailor their support or interventions against known learning issues.

It has been the intention of a team of subject specialists from SEERIH (Science & Engineering Education Research and Innovation Hub, The University of Manchester), Science Across the City (Stoke-on-Trent Opportunity Area) and The Ogden Trust to collaboratively bring together insights from University of Manchester 'Deep Dives' (Bianchi 2015) and other subject review equivalents in primary schools.

This report presents for review existing knowledge and experience from the subject specialist team, and findings from a targeted survey to wider stakeholders (n=72) which identifies the issues impacting on children's learning experience within the primary science curriculum in England. By triangulating the insights, 10 key issues have been identified that can impact on children's science learning experience at this time.

The observations shared aim to inform debate and increase coherent connectivity towards the improvement of pupil outcomes in primary science across the sector. It is expected that senior leaders in schools, the Department for Education, and the wider primary science education community will make use of these insights, in particular consultants, stakeholders and specialists offering school improvement support and guidance to teachers and head teachers.

This study which was conducted between May-October 2020, thereby aimed to:

- represent the reality of current children's science learning experiences in mainstream English schools;
- guide school leaders in their identification of effective practice in primary science, enabling prioritisation of investment, effort and time;
- inform school science improvement, programmes and offers by having grounded understanding of the explicit needs within primary classrooms;
- provoke debate and challenge the status quo, with a view to strengthening coherence and connectivity across the primary science education sector, informing practice and policy nationally.

USING THIS REPORT

This report presents classroom findings as seen through the eyes of primary science specialists. As such the information will be useful to a range of stakeholders, to inform of validated and cross referenced realities and so stimulate debate across all parties committed to developing science in primary schools. The report invites stakeholders to reflect upon the findings and to consider the implications to their area of activity or focus.

School leadership teams, including subject leaders and governors may use the report to undertake strategic dialogue about children's science learning, with increased specificity and sharper focus to identify issues of concern. Many primary school head teachers are very experienced in monitoring teaching and learning and the quality of education, but do not have a science specialism or recent strategic professional development related to science subject pedagogy. This report enables strategic teams, including governors, to develop action planning that is science specific and targeted. There are increasingly fewer science specific advisers and consultants to support school review through a science lens and as such a decline in the practice based understanding of what it means to have great science provision.

School leadership teams, along with science subject leaders, are encouraged to use the table of issues (**see page 6**) to scaffold a conversation. The table detail could be used to rank strengths and priorities as related directly to their own school and evidence. Key questions to consider:

- How do our school's science monitoring outcomes, including lesson observations and pupil voice, compare to national reported findings?
- Do our current systems allow for comparisons or should the tools for monitoring be adapted to a science focus? How might the structure of monitoring and reporting tools be adapted to be increasingly subject specific?
- Are science reports to governors sufficiently specific?

The authors appreciate that this report is hard hitting and there is no expectation that all 10 issues will be addressed immediately; it is anticipated that strategic leadership can make justified changes that will impact hugely upon the experiences for children. Making comparative judgements against national issues has the potential to support staff in doing less to achieve more by taking an increasingly targeted approach to school improvement.

STEM stakeholders and organisations investing in 'offers' to schools may use this report to increase the value added from financial investment in primary science professional learning and school support. Various offers of resources and opportunities for grant funding are available to schools on a regular basis and yet the challenge remains to attain the anticipated benefits of these. This report will support STEM organisations to review their offers to schools in light of understanding how their opportunity benefits schools against the identified needs. Key questions for STEM organisations:

- How does your offer to schools match the school needs identified in this report?
- Where do you see the gaps in provision and which issues could be better supported by your organisation?

The STEM community may consider how this report feeds into analytical tools to prioritise investment, effort and time, in order to create a strong rationale and justification of the provision and intended impact. The focus for future development would become increasingly specific and targeted through consideration of the stakeholder's collective voice in the survey summary findings (see page 10).

Inspectorate and senior advisers including Ofsted may use this report to broaden expertise, learn from and contribute to a wider body and forum of primary science specialists. School improvement is increasingly taking place in small teams with some myths and mixed messages about expectations of good practice. The quotes and scenarios as told through the eyes of practising advisers support a better understanding of the issues through exemplification (see page 14). The key questions for school improvement bodies:

- How do localised findings about children's science learning experiences align with national trends?
- What explanations and insight for differences between local and national issues can be addressed locally?
- How do priorities differ between generic observations and those focused on making judgements specific to primary science subject pedagogy?

Education policy makers, local, regional and national, may use this report to influence the strategic value of science in the curriculum and ensure its place and status as a core subject. Policy is informed by research and should seek to address the barriers that limit or reduce successful experiences for all children in science - a subject that opens doors for so many. Accountability and outcome measures often fail to scrutinise science reported data and as such there is often less active debate or direction from governance for this core subject compared to English and mathematics. Key questions for this group, when responding to the report are:

- If these are common and prevalent issues for primary science, what can we change and implement to improve the experience of children for whom we are responsible?
- How will we know if any policy changes result in improvement? What will policy success look like in practice? How will the rationale behind policy changes be explained, justified and prioritised by those expected to take on change?
- How will organisations report to school governors to show primary science development and pupil success? How will the reported data around science outcomes be responded to and valued?

STEM Continuous Professional Development (CPD) providers may use this report to justify and explain the intended learning objectives of CPD against the impact on children's science learning experiences. The literature links interspersed and aligned to each issue start a thread for further investigation during the development and scoping of CPD. The references list signposts an easy link to desirable core information underpinning consistent messaging across the sector. Furthermore, the report, particularly the issues (SLIPs), could be presented to subject leaders, including those in PSQM hubs, to reflect upon the relevance of actions and to decide what they need to do more of and what they might do less of. The key questions to consider are:

- Could professional development offered or in development be further improved by mapping to current and trusted literature pertinent to school needs?
- How can CPD increase teacher engagement in deeper understanding and reflection on theory as well as ideas and tasks to complete?

This report supports CPD providers to articulate how their learning offer is focused on the right issue, for the right teacher, at the right time and in addition, supports subject leaders through CPD guidance to be focused on the right action, for the right class, at the right time.

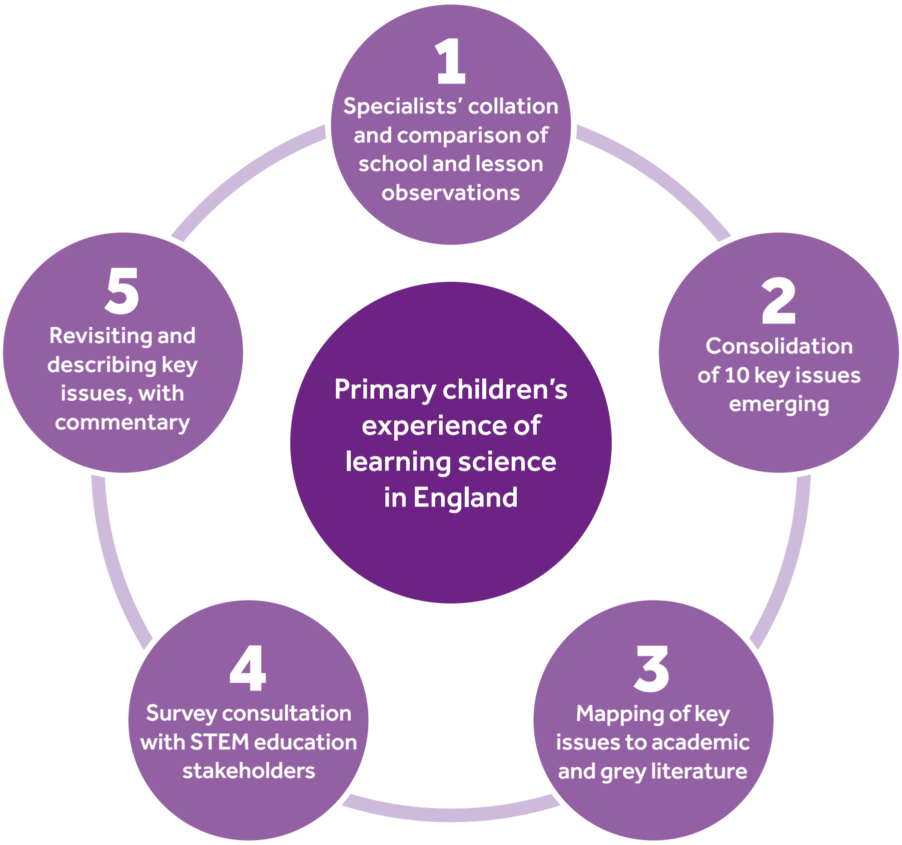
10 KEY ISSUES

The issues are not hierarchical – each are of equal worth.

Issues identified	Implication	Observations
1 CHILDREN'S SCIENCE LEARNING IS SUPERFICIAL AND LACKS DEPTH	Children are not developing a deep understanding of the big ideas of science.	o Lesson planning lacks sequence: the 'Why this? Why now?' isn't clear o Teachers and senior leaders align success in science with vocabulary recall, often using age-inappropriate terminology o Overload of inappropriately selected science
2 CHILDREN'S PRECONCEPTIONS AREN'T ADEQUATELY VALUED	Children are not able to process or build on their prior learning.	o Staff have limited science subject knowledge relevant to their year group teaching o Assessment does not inform next step teaching
3 CHILDREN'S SCIENCE LEARNING LACKS CHALLENGE	Children do not meet their full potential which limits their opportunities and aspirations.	o Assessment practice does not inform teaching leading to insufficient response to pupil needs o Resources are selected with insufficient professional critical analysis
4 CHILDREN ARE OVERRELIANT ON TEACHER TALK AND DIRECTION, THEY LACK AUTONOMY AND INDEPENDENCE IN LEARNING SCIENCE	Children's learning outcomes in science mimic those of their peers, as such not supporting individual feedback and progression.	o Teacher talk often dominates the lesson o Learning is not structured to be truly collaborative with decisions on groupings steered mainly by organisation of equipment, or behaviour issues o Talk for learning is compromised o Children's work lacks value and ownership
5 CHILDREN EXPERIENCE 'FUN' SCIENCE ACTIVITIES THAT FAIL TO DEEPEN OR DEVELOP NEW LEARNING	Children retell the 'magic' moments in science learning and aren't able to explain what they have seen or the concept explored.	o Teachers misunderstand the point and purpose of practical work
6 CHILDREN ARE NOT ENCOURAGED TO USE THEIR OWN CURIOSITY, SCIENTIFIC INTERESTS AND QUESTIONS IN THEIR SCIENCE LEARNING	Children lack motivation towards working scientifically.	o Inconsistent understanding of how to model working and thinking scientifically o Contexts for learning science relevant to children or of public interest are poorly utilised or seized
7 CHILDREN ARE ENGAGED IN PRESCRIPTIVE PRACTICAL WORK THAT LACKS PURPOSE	Children experience working scientifically that is formulaic and lacks authenticity.	o Being 'hands on' dominates being 'minds on' o Teachers are working harder than the children
8 CHILDREN DO NOT DRAW ON THEIR LEARNING FROM PRIOR SCIENTIFIC SKILLS, THEY DO NOT BUILD ON REPEATED AND REGULAR EXPERIENCES	Children have gaps as they move to the next phase of learning.	o National curriculum coverage is not met o Formative assessment is not focused on developing skills o Availability of equipment or its accurate use when available is ad hoc o Inappropriate scheduling or timetabling for science
9 CHILDREN RARELY SEE THEMSELVES, THEIR FAMILIES, COMMUNITY MEMBERS OR THEIR TEACHERS AS SCIENTISTS	Children believe that science is about other people making a difference, not them.	o Unconscious bias reinforces messages of scientific stereotypes, gender and BAME (Black, Asian and Minority Ethnic groups) o The needs of disadvantaged children are not met o Contexts for science learning are poorly utilised
10 CHILDREN DO NOT APPLY LITERACY AND NUMERACY SKILLS IN SCIENCE AT THE STANDARD THEY USE IN ENGLISH AND MATHEMATICS	Children fail to see the interconnectedness of their science learning.	o Limited opportunities for children to transfer, practise and embed skills

IDENTIFYING THE ISSUES: METHODS

A five part process was undertaken to elicit, compare, consult and review the key issues in this study.



Phase 1:
Specialists' collation and comparison of school and lesson observation

As a starting point for establishing a definitive list of the current key issues with children's learning of primary science the authors undertook a collation exercise aimed to identify key issues emerging from observations of science learning in primary schools in Greater Manchester, Stoke-on-Trent and Coventry (England).

Comparison of the ways in which school monitoring and evaluation activities took place revealed commonality in approach, in that scrutiny of children's learning experiences in science involved lesson observations, reviewing children's work and discussions with science subject leaders and senior leaders. Each author drew out themes across their own experiences before sharing this list of key issues and supporting observations with each other for review.

Phase 2:
Consolidation of 10 key issues emerging

The three lists of issues were brought together, clarified, compared and amalgamated into a list, identifying the 10 issues which emerged most regularly, and also impacted most heavily on children's learning experiences. No ranking was placed on the issues at this stage, although identification of the potential causes and implications furthered the development of the process.

Phase 3:
Mapping of key issues to academic and 'grey' literature

To further substantiate the issues arising, published academic journal papers along with grey literature including reports and articles were reviewed. This scoping of the literature was based on the best-evidence approach (Slavin, 1995) allowing for a balance between haphazard selection and exhaustive inclusion of relevant texts. The purpose was to connect each key issue with a wider base of understanding, enabling the authors to consider how other studies and perspectives impacted on the findings.

Phase 4:
Survey consultation with primary STEM education stakeholders

An online survey was designed and administered in order to further build the evidence-base related to this study. By inviting sector colleagues to review the issues arising the authors sought to value and respect wider perspectives so as to validate the experiences and observations of the authors and to consult on those issues of priority.

The survey was anonymous and participants were invited through targeted emails from The Ogden Trust to:

- Ogden Trust Regional Representatives
- Primary Science Quality Mark Hub Leaders
- Primary Science Teaching Trust Regional and Area Mentors
- Association for Science Education: Primary Science Primary Committee; Primary Science Journal Editorial Board and Futures Committee
- SEERIH Professional Development Champions and consultants
- Stoke Opportunity Area School Improvement Advisors
- Authors' contacts involved in in-service teacher professional development, including higher education colleagues, teaching schools

All respondents were reflecting on their experiences with science monitoring activities in schools in England, with one month to complete the survey between June-July 2020.

Electronic data was automatically stored securely on The University of Manchester platforms, and analysed by collating numerical information and qualitative comments by issue. Selected comments were then integrated within **The Issues Discussed**.

Phase 5:
Revisiting and describing key issues with commentary

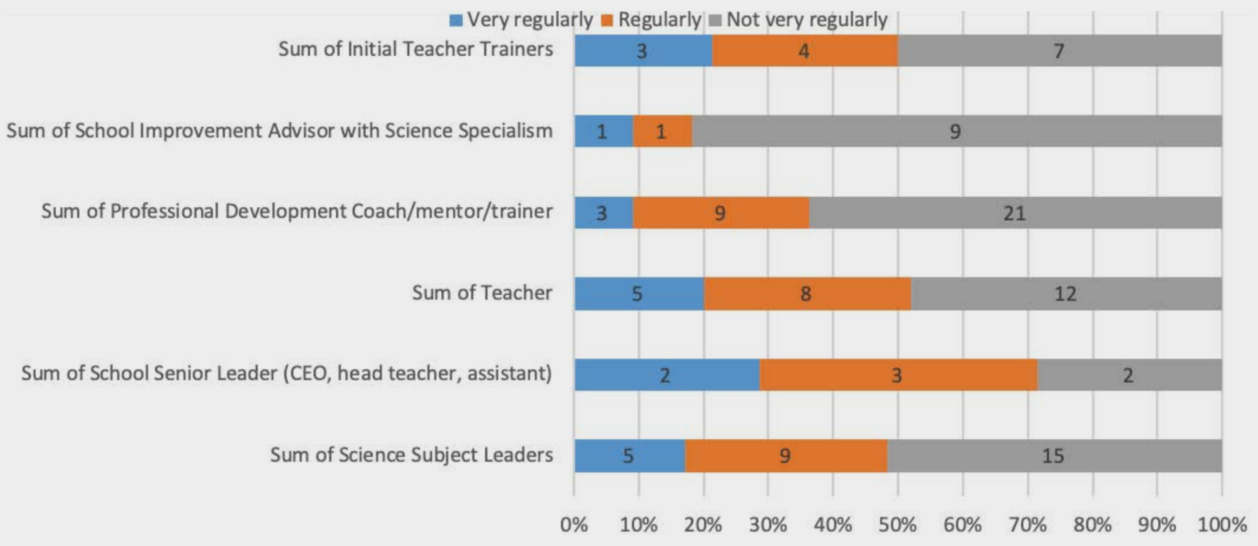
The final stage of the writing process was to bring all data together, such that each issue has commentary, description and experiences from specialists, literature and stakeholders. All issues were matched to qualitative comments from stakeholders and the report was submitted for review by the Ogden Trust before publication.

STAKEHOLDER SURVEY FINDINGS

The stakeholder survey quantitative data is presented in this section of the report. The survey drew 72 respondents of which 26 self-selected that they regularly or very regularly monitored children's learning of science.

Respondent's role Note: Respondents may hold multiple roles	**All respondents n=72**	**Self-selected respondents n=26**
Initial Teacher Trainer	14	7
School Improvement Adviser with Science Specialism	11	2
Professional Development coach/mentor/trainer	33	12
Teacher	25	13
School Senior Leader (CEO, Head Teacher, Assistant)	7	5
Science Subject Leader	29	14

Figure 1: How regularly do you get to monitor children's learning of science?



Of the responses in Figure 1, it is notable that over 50% of Science Subject Leaders stated that they did not very regularly monitor children's learning of science, in comparison to School Senior Leaders who undertook this more regularly.

Figure 2: Nature of monitoring undertaken

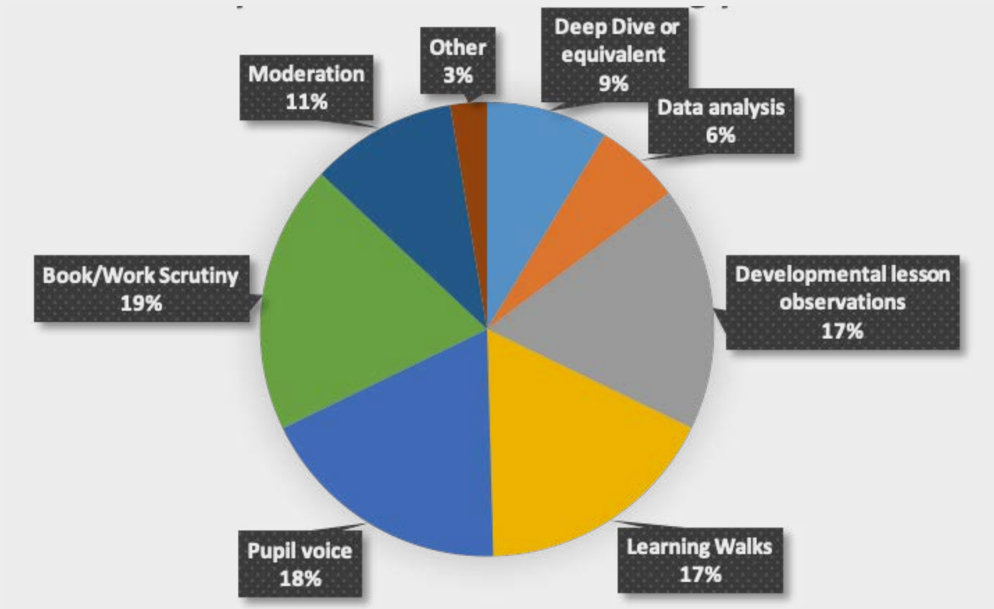
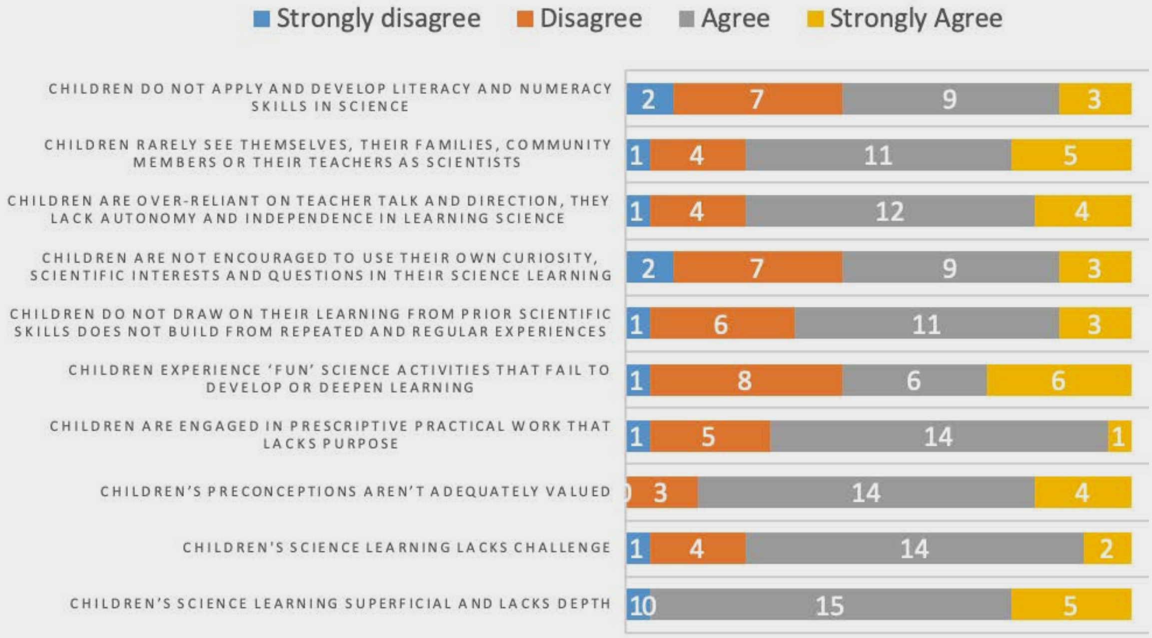


Figure 2 illustrates respondents reporting that a range of monitoring activities were used to a similar extent, including Learning Walks, Lesson Observations, Pupil Voice and Work Scrutiny. Fewer stated that Data Analysis or Deep Dives or equivalent were used.

Figure 3: Issues observed within the last three years



In seeking to validate the 10 key issues, respondents were asked to consider if they had observed them in classroom monitoring activities, within the last three years (Figure 3).

Figure 4: Issues observed and importance to address them

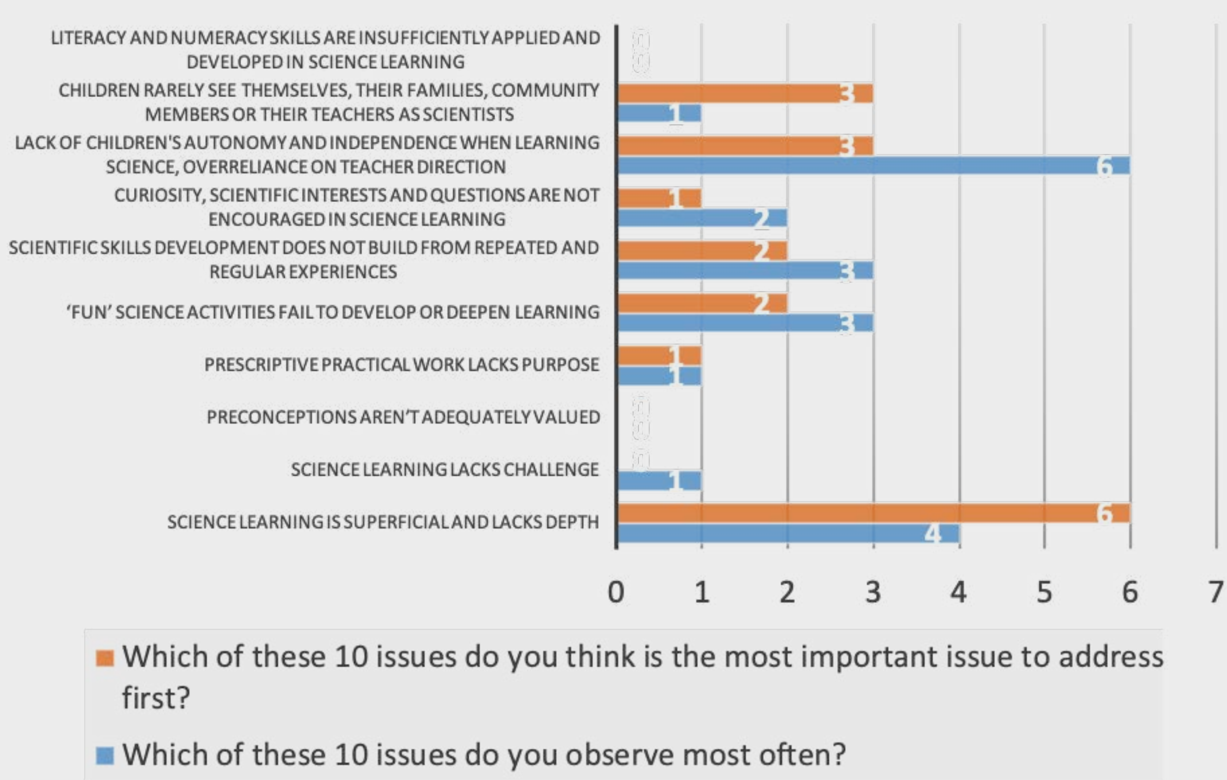


Figure 4 illustrates that of the 10 issues, the lack of children's autonomy and independence when learning science was observed most often. However, respondents considered the issue that was of most importance to address first was the fact that children's science learning is superficial and lacks depth.

The limitations of a small sample size are recognised within this report and further study would be of additional value.

THE ISSUES DISCUSSED

In this section, each issue is described in detail with first-hand experiences and anecdotes gathered through the stakeholder survey.

Commentary on the key issues is offered looking at the implications of each issue on children's learning together with observations that explain in more detail the impact of the issue in school and classroom settings. These are offered not by way of judgements being placed on teachers, but to shed light on where further professional learning and strategic development is required.

The issues are not hierarchical – each are of equal worth.

1. CHILDREN'S SCIENCE LEARNING IS SUPERFICIAL AND LACKS DEPTH
2. CHILDREN'S PRECONCEPTIONS AREN'T ADEQUATELY VALUED
3. CHILDREN'S SCIENCE LEARNING LACKS CHALLENGE
4. CHILDREN ARE OVERRELIANT ON TEACHER TALK AND DIRECTION, THEY LACK AUTONOMY AND INDEPENDENCE IN LEARNING SCIENCE
5. CHILDREN EXPERIENCE 'FUN' SCIENCE ACTIVITIES THAT FAIL TO DEEPEN OR DEVELOP NEW LEARNING
6. CHILDREN ARE NOT ENCOURAGED TO USE THEIR OWN CURIOSITY, SCIENTIFIC INTERESTS AND QUESTIONS IN THEIR SCIENCE LEARNING
7. CHILDREN ARE ENGAGED IN PRESCRIPTIVE PRACTICAL WORK THAT LACKS PURPOSE
8. CHILDREN DO NOT DRAW ON THEIR LEARNING FROM PRIOR SCIENTIFIC SKILLS, THEY DO NOT BUILD ON REPEATED AND REGULAR EXPERIENCES
9. CHILDREN RARELY SEE THEMSELVES, THEIR FAMILIES, COMMUNITY MEMBERS OR THEIR TEACHERS AS SCIENTISTS
10. CHILDREN DO NOT APPLY LITERACY AND NUMERACY SKILLS IN SCIENCE AT THE STANDARD THEY USE IN ENGLISH AND MATHEMATICS

1

Issue	Implication	Observations
CHILDREN'S SCIENCE LEARNING IS SUPERFICIAL AND LACKS DEPTH	Children are not developing a deep understanding of the big ideas of science.	o Lesson planning lacks sequence: the 'Why this? Why now?' isn't clear. o Teachers and senior leaders align success in science with vocabulary recall, often using age-inappropriate terminology o Overload of inappropriately selected science

There should be a clear progression towards the goals of science education, indicating the ideas that need to be achieved at various points, based on careful analysis of concepts and on current research and understanding of how learning takes place.
Harlen (Ed.), 2010

One reason for weakness in science provision is subject leaders having limited understanding of progression and sequencing of knowledge and skills in science.
OFSTED 2019

Observations

A. Lesson planning lacks sequence: the 'Why this? Why now?' isn't clear

There is often little or no reference to prior teaching or learning. Even where there is awareness of what has been taught before, children's knowledge is rarely effectively elicited and built upon. Repetition of activities and objectives are common, for example the frequency of cress growing or shadows on the playground with little advanced challenge.

B. Teachers and senior leaders align success in science with vocabulary recall, often using age-inappropriate terminology

Pupil demonstration of learning focuses on reciting and spelling scientific terminology accurately with little expectation that children elaborate on what they have learnt or how this will support future learning.

C. Overload of inappropriately selected science

Planning fails to consider the National Curriculum requirements relevant to the age group resulting in teaching including content that is beyond the expectations. As a result, children struggle to process the lesson content with the risk of becoming disengaged when the same content is revisited in future academic years.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"A very enriching carousel of activities related to sound for a Year 4 (8-9 years) class – children moved around it and levels of engagement were high, but the actual learning taking place seemed to be minimal. There was no supporting talk around the activities and the two additional adults were poorly prepared to facilitate this. The very experienced teacher afterwards was pleased with it and appeared to have no idea that so little learning had taken place. She was also exhausted - setting up the activities was very labour intensive, and managing the behaviour of the children was challenging."

"In a recent observation, a Year 3 (7-8 years) class were rote learning sentences about photosynthesis. The children were able to recite these scientifically accurate sentences perfectly and with absolute clarity but when questioned about what photosynthesis was, what plants need or how plants create food they were unable to answer. This led to an inability to excel in any of the other issues."

"Over reliance on worksheets and a lack of confidence in practical science especially can make science learning superficial, especially for those looking for greater challenge."

"When looking through books it was clear that a teacher had covered a knowledge concept in one lesson without linking it to any enquiry work. If this one knowledge objective had been introduced through an enquiry activity, and then applied and embedded in further enquiry activities, this would have provided a more in depth understanding of the concept, which would make it more likely for it to be understood and therefore remembered. It would have also provided greater opportunities for the children to be taught and develop their working scientifically skills, giving them greater autonomy and increasing the likelihood that they will be able to ask and answer their own questions."

"Children learning about circuits in Year 6 (10-11 years) are often encouraged to talk about electrons after being exposed to inappropriate models of electric circuits, this also can lead to children developing a variety of misconceptions about circuits."

One respondent provided a positive experience, explaining:

"The teaching of the 2 loop system of circulation in Y6. Children experienced modelling, testing linking to pulse rates, videos and research which all helped to contribute to the overall understanding of the human circulatory system. The different aspects of enquiry allowed discussion and a sharing of understanding which grew during each learning opportunity. Vocabulary was taught, modelled, practised and used verbally before then being used in writing. This all helped to build up their understanding of the concept both visually and in a way they could remember more effectively."

2

Issue	Implication	Observations
CHILDREN'S PRECONCEPTIONS AREN'T ADEQUATELY VALUED	Children are not able to process or build on their prior learning.	o Staff have limited science subject knowledge relevant to their year group teaching o Assessment does not inform next step teaching

Inaccurate ideas can be difficult to rectify because children strongly hold on to misconceptions that make perfect sense to them – carrying them into secondary education and adulthood.
Smith, 2010

Learning is encouraged by 'thinking aloud', when learners put into words, to make clear for themselves and others, how they are making sense of things; what they understand and do not understand.
Harlen and Qualter, 2018

Observations

A. Staff have limited science subject knowledge relevant to their year group teaching

Children's misconceptions, acquired from many unreliable sources, including TV, media and everyday commonly used phrases, are brought to lessons and remain unchallenged, and furthermore are often reinforced by teachers and other adults in the school. Incorrect science knowledge is taught or referred to in presentations and even marked with positive comments when it is factually wrong.

B. Assessment does not inform next step teaching

On occasions elicitation activities are used and children are encouraged to talk about their ideas, however the lesson direction is not influenced by what the children share. Teaching discreetly moves on to the next part of the lesson plan with the learning opportunity from retrieval of earlier knowledge is lost.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Looking at the Year 1 (5-6 years) Animals topic, a special educational needs child who lived on a farm could name different breeds of animals and explained their life cycles. They had lots of personal experience and did not need an exercise to name animals and their offspring. They already had this knowledge."

"Children were being given the same worksheet of a plant to label in Year 2 (6-7 years) as they were given in Year 1 (5-6 years) with no evidence of this being built on. Children already knew the names of parts before completing the worksheet."

"A teacher in a school provided an elicitation task at the start of a new unit of work on plants. The task was provided by the head teacher because the school was implementing a new policy of using elicitation tasks. The teacher asked the Y3 children to label a diagram of a plant. Once they had done this, the children's work was cleared away (without feedback) and the teacher started teaching without reference to the 'elicitation' task."

"The terms 'dissolving and melting' are used in classrooms interchangeably and yet have very specific and different meanings. Insufficient opportunities for children to talk about their ideas about science."

"Children are generally told seeds require light to grow, even though they are planted deep below the surface of the soil, or that plants 'adapt' to their environment. "

"When children ask questions about why astronauts appear to float in space they are told that there is no gravity in space. This offers children an incorrect understanding."

"Limited science planning at a whole school level leads to children repeating science activities and enquires across year groups without enhancement or progression in understanding, e.g. pushing/pulling shoes with a Newton metre to investigate friction in Year 3 (7-8 years) and Year 5 (9-10 years) or investigating shadows in Year 3 and Year 6 (10-11 years)."

3

Issue	Implication	Observations
CHILDREN'S SCIENCE LEARNING LACKS CHALLENGE	Children do not meet their full potential which limits their opportunities and aspirations.	o Assessment practice does not inform teaching leading to insufficient response to children's needs o Resources are selected with insufficient professional critical analysis

...interventions to enhance educational outcomes for underachieving students are more likely to be successful if they strengthen student motivation through messages from teachers that communicate high expectations for students in relation to specific learning goals.
Walkey et al., 2013

Observations

A. Assessment practice does not inform teaching leading to insufficient response to children's needs

Marking or feedback to children is not being linked to the intended learning outcomes of the lesson. Teachers are not finding opportunities to listen and react to children and so fail to adjust plans and approaches sufficiently to personalise learning. Learning outcomes or success criteria are unclear and often so broad that it is impossible to know if the lesson or the child has been successful. Teacher questioning, particularly in plenaries, is often closed and focused on recall, closed and an approach that relies on correctness or 'guess what's in my head'.

B. Resources are selected with insufficient professional critical analysis

There is an overreliance on easily sourced pre-designed PowerPoints that do not relate to the needs of the children and exemplify science as encyclopaedic. Teacher choice of resources can be influenced by how much can be shown to children, rather than how does the selected material meet the needs of the children in my class and for what reason.

C. Insufficient response to children's needs

Children's work and outcomes are the same or similar across the class with more able simply expected to write longer sentences or know more rather than know deeper. As such mastery learning does not focus on primary curriculum but instead simply gives more to do without depth. There is a lack of planned consideration for catching up support for those that need it or to deepen for those that already can do it. Some children regularly miss science to attend boosters, participate in peripatetic activities etc. often missing whole topics without any expectation of further science support.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Plants taught in Year 3 in which children are asked to label parts of a plant (e.g. leaf, flower, stem etc) as such not moving learning on by attaining children's prior knowledge and giving adequate challenge. In Year 5, the same topic was revisited and support was given to look into a more varied selection of animal life cycles (e.g. marsupials) instead of focusing on frogs and butterflies."

"Sorting activities I have seen are often closed towards the right answer e.g. sort into living and non-living or sort into mammals, reptiles etc. This misses opportunities for the children to identify how to sort them according to their own ideas. i.e. similarities and differences that they observe, think about. Open ended sorts give a wealth of information on where the children are in their learning. Fur/hair/feathers/scales, fins/legs those that move grow, where they live. This can then lead to the way to sort to achieve the knowledge. KWL grids are often done dry without practical experiences first so children find it hard to ask real, relevant questions."

"Plenary activities, such as thumbs up or thumbs down, relate to knowledge recall, and do not encourage children to review the progress they have made, e.g. 'I used to think... and now I think..."

"Naming the parts of the skeleton goes into excessive detail for the age of the children, as opposed to knowing the functions of a skeleton."

"Year 6 pupils learning about circuits observe the effects of increasing the number of batteries in a circuit but a lack of focus on explaining observations fails to challenge children to think deeply about what is happening and secure new learning."

4

Issue	Implication	Observations
CHILDREN ARE OVERRELIANT ON TEACHER TALK AND DIRECTION, THEY LACK AUTONOMY AND INDEPENDENCE IN LEARNING SCIENCE	Children's learning outcomes in science mimic those of their peers, as such not supporting individual feedback and progression.	o Teacher talk often dominates the lesson o Learning is not structured to be truly collaborative with decisions on groupings steered mainly by organisation of equipment or behaviour issues o Talk for learning is compromised o Children's work lacks value and ownership

It is a fundamental misunderstanding of teaching pedagogy in primary science to suggest that the teacher plays little or no role when children are working scientifically, or indeed that exploration or enquiry is simply about children having fun! On the contrary, the teacher plays a pivotal role when teaching scientific enquiry, to teach the skills involved as well as the scientific concepts.
McCrory, 2017

Observations

A. Teacher talk often dominates the lesson

There is an over emphasis on watching and listening to the teacher perform or deliver a lesson, rather than the children developing the self-regulated tools of learning to learn. Children too often wait to be guided rather than direct their own learning. Teacher praise and feedback comments celebrate the passive model of compliance.

B: Learning is not structured to be truly collaborative with decisions on groupings steered mainly by organisation of equipment or behaviour issues

Teacher decisions about who should work in which group, with what equipment is usually organisational and relates to many tables in the room, the layout of the room and getting equipment easily around the room. Less attention is given to effective group size, rationale for ability settings, and justification of approach, independent work, talk partners or group roles and responsibilities.

C. Talk for learning is compromised

Children talk 'at' each other rather than listen and reflect with each other. Children perceive listening as relevant to the teacher only and that talk partners are about taking turns to talk 'at' each other with limited question-asking or finding out more about the ideas of the talk partner.

D. Children's work lacks value and ownership

How individual learning is demonstrated and represented is poorly selected to demonstrate the intended learning. Standards in books or floor books reveal incomplete work or pupils are unable to articulate the point of the work done when looking back at their own work at a later date. Children perceive that they do the work to please the teacher.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Children being told which equipment to use, what to do with it, etc. Little evidence of independence or autonomy and children making their own decisions."

"After 2+ years of staff CPD on curiosity, and exploring how much teacher talk is necessary, encouraging that children promote their own questions and finding answers...I walked past a classroom to go to find the teacher 'teaching' all about the planets. After hovering for a little while, coming back and forth, after 25 minutes the children had not 'done' anything but had listened to the teacher. I don't know how much further it had gone on, it was painful to witness."

"I was asked by a Year 6 teacher how she could encourage children to be more communicative about their conclusions. After enquiring about the investigation I realised all children carried out the same investigation guided by her leading them to that set up. I suggested she allowed each group to follow their own question which would lead to an increase in data and an increase in communication as the children would be able to take ownership of the outcomes and therefore discuss in greater depth. Her response was but that will be messy and noisy, I won't be in control. I had reason to visit her classroom later that day and it was pristine, her approach was clinical thus restricting the children's creativity."

"Children in most classes don't necessarily want to participate and I think this is because most of it is teacher led. They don't take a role in their own learning."

"Pupil's books all contain exactly the same work, in some cases word for word the same due to the use of cloze exercises, over scaffolded worksheets and copying whole class writing – writing does not reveal pupils thinking, ideas or misconceptions to allow teacher assessment of understanding."

On a positive note one stakeholder stated:

"One of the loveliest Great Science Shares was a group of permanently excluded children. They were looking at healthy eating. Their teacher gave them his old teeth to look at and they wanted to see which was the worst drink. So they tested his teeth…. The children had complete ownership of this investigation and were utterly proud and pleased as punch to share this with us last year. They had been allowed to run with their question, investigate it and communicate their findings. All of these children were accessing learning and seeing the power of finding out for themselves…. yet had not been able to in the school environment."

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Issue	Implication	Observations
CHILDREN EXPERIENCE 'FUN' SCIENCE ACTIVITIES THAT FAIL TO DEEPEN OR DEVELOP NEW LEARNING	Children retell the 'magic' moments in science learning and aren't able to explain what they have seen or the concept explored.	o Teachers misunderstand the point and purpose of practical work

All science curriculum activities should deepen understanding of scientific ideas as well as having other possible aims, such as fostering attitudes and capabilities.
Harlen (Ed.), 2010

OFSTED (2019) suggest that one reason for weakness in science provision is that teachers' subject knowledge and depth of planning was not strong enough to sequence the knowledge and skills when pupils were engaged in 'working scientifically' activities, leading to issues with the deepening pupils' conceptual knowledge.
OFSTED 2019

Observations

A. Teachers misunderstand the point and purpose of practical work

Teachers prioritise the need to provide fun, awe and wonder moments that ensure children enjoy science. They are actively seeking to use and find great wow activities from internet ideas, video platforms and social media etc. These activities often stand alone and lack a relevant or appropriate curriculum rationale, with many relevant concepts inaccessible because the scientific explanation would be too abstract or complex. A clear rationale and articulation of why this activity is in this sequence of learning is not evident to the children or articulated by the teacher.

B: Learning is not structured to be truly collaborative with decisions on groupings steered mainly by organisation of equipment or behaviour issues

Teacher decisions about who should work in which group, with what equipment is usually organisational and relates to how many tables are in the room, the layout of the room and getting equipment easily around the room.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"I observed a moon crater investigation that looked at dropping balls into trays of flour/cocoa powder. The children enjoyed the investigation but weren't entirely sure why they were doing the investigation and what application it 'could' have. They had been learning about Space in Y5 but hadn't been supported to make the connections."

"Observing a lesson with EY exploring ice balloons with lots of hands on activity. Two weeks later I returned and there was now a superb display of photos of activity lots of children having fun and laughter. When talking to children about the activity using photos as stimulus they had very little recall or development of science vocabulary beyond being cold and fun . They did not build on their experience or want to explore more questions."

"Children experiencing activities where interesting things happen, e.g. food colouring and carnations, Coke and Mentos, string telephones, however do not lead to question-led enquiries."

"Such activities rarely link to children's discussions focused on sharing and develop ideas about concepts such as dissolving."

"Practical activities linked to the refraction of light are often included when pupils learn about light in Year 3 and Year 6 as a wow moment, such as inverting writing with a jar of water. This practical activity doesn't support any curriculum statements for light at KS2 and the idea behind the phenomena is far too abstract for younger learners."

"Teachers seem unaware of health and safety issues and hence lack adequate risk or don't do practical at all."

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Issue	Implication	Observations
CHILDREN ARE NOT ENCOURAGED TO USE THEIR OWN CURIOSITY, SCIENTIFIC INTERESTS AND QUESTIONS IN THEIR SCIENCE LEARNING	Children lack motivation towards working scientifically.	o Inconsistent understanding of how to model working and thinking scientifically o Contexts for learning science relevant to children or of public interest are poorly utilised or seized

Experimentation gives science its identity. Science uses experiments to discover the realities of the world, and this practical approach seems to be as intrinsic to young learners as it is to professional researchers.
Gatsby, 2017

Child-led and child-designed investigations are undertaken 'occasionally' or 'never' in 47% of schools.
Wellcome Trust, 2017

Observations

A. Inconsistent understanding of how to model working and thinking scientifically

Lack of teacher confidence and the perception that they should be the expert in the room limits opportunities for learning to be framed by children's questions. When questions are asked they are often captured and displayed but not developed into scientific questions or testable questions that would provide evidence on which to scaffold new thinking.

B. Contexts for learning science that are relevant to children or of public interest are poorly utilised or seized

Children's aspirations, interests and relevant experiences are not maximised in science lessons, instead lessons are prefabricated and led by simple and dry curriculum topic titles. As a result learning does not relate to children's experiences, leading children to consider science as something that you do at school which is often enjoyable but not useful to their lives.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Using a PowerPoint to demonstrate what plants need to grow and then pupils drawing what they saw on one of the slides. No practical, no curiosity, no real engagement."

"Children not able to use a starting point to follow their own line of enquiry, choosing materials and designing their experiment. They were being expected to create a question, create a fair test and show results when these skills had not been previously encouraged. Children had always been provided with the correct equipment for a task and hadn't been enabled to make choices and question which equipment is suitable for different tasks."

"A school using a prescriptive scheme of work across school and insisting that each class across a year group has exactly the same lesson, taught in the same way. No adaptations were allowed to accommodate children's particular interests or questions. They saw this as a strength."

"Children are involved in using structures such as K-W-L grids at the start of a new topic but the majority of questions that children propose in the W column are closed and can be answered with a quick web search."

"Children are not taught enough to develop scientific questions that lead to a variety of enquiry types so that their own ideas authentically influence planning for the topic."

Three survey responses provided more positive anecdotes, explaining:

"When running a science club with Y1/2 (6-8 year olds), the children were investigating the best materials for making a tea bag. The children were working freely with slight intervention when necessary. One child stated they'd made great tea using a zip lock plastic bag. Another overheard and called out - 'that's ridiculous, water can't even go through a plastic bag'. This led to much more discussion and real exploration of the materials in front of them. As a result, the learning went deeper and will definitely stick."

"When learning about forces, a child was talking about himself on his push bike and how he could make himself go faster by ducking his head down because the wind went over his head rather than in his face."

"The teacher having the confidence to provide children with a range of different types of bread and allow children to discuss, explore and produce their own questions they wanted to investigate. Questions varied from 'Is white bread stronger than brown bread?' 'Can bread float?' 'How much water can different types of bread hold before they sink?' 'What is bread made of?' 'What does bread look like close up?'"

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Issue	Implication	Observations
CHILDREN ARE ENGAGED IN PRESCRIPTIVE PRACTICAL WORK THAT LACKS PURPOSE	Children experience working scientifically that is formulaic and lacks authenticity.	o Being 'hands on' dominates being 'minds on' o Teachers are working harder than the children

The attraction of practical science seems to lie in its appeal to the senses, its surprises and its unpredictability, as much as in its power to explain. The real world is not cut and dried, and neither is practical science. Experiments do not always go as expected, and we can learn as much from unexpected results as from expected ones. And the same is true of life.
Gatsby, 2017

Although practical work was found to be effective in terms of getting students, in both primary and secondary schools, to do things with objects and materials in order to produce desired phenomena, much of this effectiveness appears to be attributable to the widespread use of 'recipe' style tasks.
Abrahams & Reiss (2010)

Observations

A. Being 'hands on' dominates being 'minds on'

There is a misunderstanding that being busy and active is the same as investigative science. Teachers often believe that a successful science experience is one in which the children have done some practical activity but this is often following a set of fixed instructions rather than children making investigative decisions for themselves. As a result, children are able to give a description of what was done but do not appreciate the scientific process and the fascination of finding answers for themselves.

B. Teachers are working harder than the children

The equipment and organisation of resources is usually managed solely by the teacher; the equipment is pre-selected and organised ready for children. Although this helps with lesson organisation, children do not learn to think creatively about how to carry out their own scientific tests and enquiries to answer their questions.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Children making a variety of vehicles to see which one worked best. There was no correlation between real-life experiences or the different types of vehicle they were testing against each other."

"Children investigating air resistance in Year 5 were given parachute resources already prepared so reducing any opportunity for development of problem-solving skills related to working scientifically skills and consequently reducing motivation to engage in investigation."

"I was moderating some work produced by Year 6. Children were asked to investigate the effect of exercise on heart rate. They followed the teacher's instructions, did the same exercise and recorded their results (in a table they had drawn up themselves which was good!) They were then asked to explain what they noticed had happened to their heart rate. All the children could explain that exercise increased their heart rate but many were just describing what they saw in the data rather than interpreting it. However, the children were not asked WHY the heart rate increased, linking it to blood circulation etc., or encouraged to try out different exercises to compare the effects. Some children had detected a difference in the results of girls and boys but there was no evidence to suggest that the teacher allowed this to be explored. The teacher's focus had been on gathering data and analysing it on a very superficial level rather than using the data to explore the importance of fitness and health, why regular exercise was important for their bodies etc."

"Children experience science activities that have legacy and have 'always been done'. They 'work' but don't link to specific learning needs or contexts."

"Children experience 'cut and stick' activity which is viewed as hands-on or practical work."

"Children experience learning using films or digital demonstrations, e.g. watching an ice cube melt or plants grow as opposed to real-world experiences."

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Issue	Implication	Observations
CHILDREN DO NOT DRAW ON THEIR LEARNING FROM PRIOR SCIENTIFIC SKILLS, THEY DO NOT BUILD ON REPEATED AND REGULAR EXPERIENCES	Children have gaps as they move to the next phase of learning.	o National curriculum coverage is not met o Formative assessment is not focused on developing skills o Availability of equipment or its accurate use when available is ad hoc o Inappropriate scheduling or timetabling for science

The development of inquiry skills not only will enable children to build their understanding of the world around but also to understand the nature of science, scientific inquiry and reasoning, develop positive attitudes both within and towards science and appreciation of the contribution of science to society and of how science is used in technology and engineering.
Harlen, 2014

Observations

A. National Curriculum coverage is not met

Children, whilst sometimes doing the enquiry cycle, often are not learning or developing the skills of predicting, drawing conclusions, analysis, graph drawing and evaluating. Little or no reference is made to the last time that the skill was used or how what they learnt last time will help with the new task in hand. Breadth of enquiry is not included or mapped in planning so practical work often focuses on fair testing, even when the enquiry is not a fair test. There is a lack of clarity and depth of understanding of the different approaches to enquiry even though these are stated in the statutory guidance of the National Curriculum.

B. Formative assessment is not focused on developing skills

There is little attention to prior learning or age related success indicators for enquiry with no explicit planning for repeated, regular modelling of how to improve the parts of the enquiry cycle. Children are not developing the language of science enquiry. The term investigate is used generically and widely but as an overarching title without purpose.

C. Availability of equipment or its accurate use when available is ad hoc

Teachers make assumptions about equipment use and are unaware of calibration or how to guide children in the correct use of science equipment. Many schools suffer from insufficient scientific equipment and have issues with quality, range, number of items per child, ease of access and storage of equipment. As a result, many practical skills are simply demonstrated or shared as video simulations.

D. Inappropriate scheduling or timetabling for science

It is very often the case that insufficient time is allocated to science in the school timetable, as a consequence children may get to plan an enquiry and go on to make observations or take measurements but are then unlikely to develop their work further through the higher order skills of analysis, drawing conclusions, justifying ideas and evaluating.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Teachers sharing books in moderation unable to demonstrate coherent progression in a skill and just ticking it off after seeing it once. Also unable to articulate the skills focus of the activity or identify where there might be other examples of it being taught to show progression. Next steps marking, even of enquiry, are not clearly linked to skills development or, if linked, not followed up by an opportunity to act on the feedback and further develop the skill."

"Planning of an enquiry is generally 'done for' or 'done to' children, focusing on what might be done or what might change or be kept the same. Children often don't get a chance to do most of what has been planned, including ideas they may have come up with."

"Failing to use equipment properly, e.g. not calibrating a Newton metre to zero, gives huge inaccuracies in data that can then not be interpreted with meaning."

"Practical activities are carried out that are not seeking to collect evidence to answer a question, e.g. Year 4 children learning that vibrations from sounds travel through a medium to the ear by making and using a string telephone yet not developing this into an enquiry to compare a variety of materials that sound can travel through."

"Opportunities to fully develop a range of working scientifically skills are missed when teachers lack confidence or awareness of the available measuring resources that can be used to support enquiries, e.g. metre rulers, tape measures, thermometers, scales, measuring cylinders, stopwatches, dataloggers, free apps for measuring light and sound or resources such as Google Sci Journal that can measure a variety of quantities."

"Science enquiries that are explicitly referenced in the Science National Curriculum are not experienced consistently by all learners e.g. measuring the volume of a sound source at increasing distances, measuring the brightness of a lamp and volume of a buzzer with increasing voltage – leading to missed opportunities for developing expected data analysis skills."

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Issue	Implication	Observations
CHILDREN RARELY SEE THEMSELVES, THEIR FAMILIES, COMMUNITY MEMBERS OR THEIR TEACHERS AS SCIENTISTS	Children believe that science is about other people making a difference, not them.	o Unconscious bias reinforces messages of scientific stereotypes, gender and BAME (Black, Asian and Minority Ethnic groups) o The needs of disadvantaged children are not met o Contexts for science learning are poorly utilised

...a key dilemma for science education [is] namely that children can report enjoying science (e.g., they may find it fun, exciting, important, and interesting) but they may still see it as "not for me"...even at this young age when children are mostly enthusiastic about science, some aspects of a "science identity" are beginning to be ruled out as not only undesirable but even "unthinkable" and other aspects are understood as possible or desirable only under certain identity conditions.
Archer et al. 2010

Observations

A. Unconscious bias reinforces messages of scientific stereotypes, gender and BAME

Whilst during lessons teachers seek to give contemporary contexts of scientists and there is increasing use of resources linking children to living scientists, stereotypes continue to exist in displays around the school, outdated books in libraries, images on websites and images selected by teachers for the resources they create. As a result, children do not get the opportunity to identify with role models and may not see science as something for them.

B. The needs of disadvantaged children are not met

Assumptions are made about the science capital that children bring to lessons. Children are frequently encouraged to talk to partners about their experiences and prior knowledge to help make connections with new learning in science. This can leave some children realising how little they know and increase their awareness of the gap between them and their peers. Pre-teaching is underused in science and home learning links not actively sought or built upon to overcome this situation. Children are not given opportunities to think and talk about what science is and what it means to them.

C. Contexts for science learning are poorly utilised.

Whilst the National Curriculum sets expectations that all children acquire an understanding of the uses and implications of science in the world around them, this is not planned for in lessons and occurs by chance when individual children build upon pre-existing science capital. Teachers do not select contexts for science learning that are localised and take into account what is relevant to the children in their class.

Stakeholder Survey
First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"As part of a 'deep dive', a child said that she wanted to be a nurse. However, she also said that she didn't like science and seemed not to have made any links between science and the career to which she aspired. Leading professional development into science capital with teachers from rural schools, a teacher described how he had not previously considered drawing on his pupils' experiences of farming in order to make links with the science curriculum. In this case, the teacher said that the children of farming families in his area were some of the most disengaged learners – not seeing school as relevant to their lives – as the children expected to go on into farming."

"When talking to a group of children, only a couple of children put up their hands when asked if they knew any scientists. I then asked them if any parents were gardeners, mechanics, builders, cooks... suddenly the room was full of children who knew a person who used scientific knowledge in their everyday lives. It also turned out the teacher had a degree in biology but the children didn't know."

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Issue	Implication	Observations
CHILDREN DO NOT APPLY LITERACY AND NUMERACY SKILLS IN SCIENCE AT THE STANDARD THEY USE IN ENGLISH AND MATHEMATICS	Children fail to see the interconnectedness of their science learning.	o Limited opportunities for children to transfer, practise and embed skills

Using mathematics in science enquiry can enhance children's understanding of science and also provide opportunities for children to apply their mathematical knowledge to 'real' contexts.
Marwick and Clark, 2016

Observations

A. Limited opportunities for children to transfer, practise and embed skills

Science writing and reading is not modelled. Teaching in English will include types of science writing – instructions, explanations, arguments and reading will include analysis to comprehend texts, but many teachers do not have the subject knowledge to appreciate what it means to read or write like a scientist. As such, opportunities for children to apply their English skills in a science context are missed. Age-related levels of demand for maths skills are not practised regularly in science through measuring and analysing data and children are not encouraged to peer review graphs with the same criteria that they would use with ease in maths.

Stakeholder Survey First-hand Experiences

The following anecdotes represent the open comments provided that relate to this issue.

"Trying to plan with a school who insisted the science in every year group was linked to the class novels being used each half term."

"Age-appropriate mathematical demands are not mirrored through data analysis in science enquiry e.g. Key Stage 2 (7-11 years) pupils aren't measuring to one decimal place or calculating the mean average of a set of repeated measurements. Children aren't getting regular opportunities to develop their skills in drawing charts and graphs independently when analysing data from enquiries."

"There are missed opportunities to develop science writing and apply specific skills e.g. chronological reports of how ideas about science have changed over time, argument texts on scientific themes, persuasive writing backed up by scientific ideas, using the passive voice when writing methods for planned tests/ enquiries and developing extended explanation texts."

RECOMMENDATIONS

Two recommendations are offered and seek to stimulate further exploration into primary children's experiences of science learning in England. This report invites ongoing consultation and research.

1: Continuation of monitoring children's experiences

A regular programme of Deep Dives/school reviews in order to gather insights into issues impacting on children's learning of science. Questioning – are we getting better at it? Are there priorities that are being addressed?

2: Annual consultation of data

Engagement with sector colleagues through surveys and conference in order to discuss and consider the key issues arising and how the sector can work collaboratively to mitigate them.

Where you may be interested to be part of future surveys, please email fascinate@manchester.ac.uk

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Science ACROSS THE CITY

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Science & Engineering Education Research and Innovation Hub
The University of Manchester
Oxford Road
Manchester
M13 9PL

Email: **fascinate@manchester.ac.uk**

www.seerih.manchester.ac.uk

The Ogden Trust
The Phoenix Brewery
13 Bramley Road
London
W10 6SP

Email: **office@ogdentrust.com**

www.ogdentrust.com

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