Primary Science

Number 178 | May/June 2023

Chemistry in Primary

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

The ASE's journal for primary science

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The Association for Science Education

Primary Science

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Future themes

Generally each issue of *Primary Science* focuses on a theme, but also includes other articles on a range of topics, so if you have something to write about that is not on a theme or responds to a theme already covered, don't be deterred. All contributions are very welcome. Shorter articles are particularly welcome.

Issue 179 (September 2023) Open theme (deadline for submissions 9 June 2023).

Issue 180 (December 2023) Continuing Professional Development (deadline for submissions 8 September 2023).

Issue 181 (March 2024) Biology (deadline for submissions 8 December 2023).

Issue 182 (June 2024) Open theme (deadline for submissions 8 March 2024).

Writing for Primary Science

Primary Science publishes articles on all aspects of primary science education, including early years, and we welcome articles that:

- support effective classroom practice in teaching, learning and assessing science;
- give practical classroom ideas;
- interpret (rather than simply present) research;
- address issues relating to primary science education;
- comment on controversial articles, issues and debates;
- challenge teachers' thinking about important changes.

Short contributions are very welcome, including notices, letters and short responses to other articles. It may help you if you read one or two articles in *Primary Science* before beginning your own.

The Editor is very happy to advise and support new authors. Contact: **editor.primaryscience@gmail.com**

Detailed guidelines for writing for the journal are available on the ASE website: **www.ase.org.uk/submission-guidelines**

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Primary Science is the primary journal of the Association for Science Education and is published five times a year as a benefit of membership.

Safety: Reasonable care has been taken to ensure that articles in this journal do not suggest practices that might be dangerous, and safety warnings are given where appropriate. However, the Association for Science Education has not tested the activities suggested and can therefore give no guarantee of safety. For further advice on health and safety matters in primary science education see *Be safe! Health and safety in school science and technology for teachers of 3- to 12-year-olds* (4th edition, ASE, 2011)

FOCUS on...

Chemistry in primary

Avid readers of *Primary Science* will quickly realise that there is something subtly different about one or two things in Issue 178! Chemistry is all about structure and restructuring, so when the Editorial Board decided that the focus of this issue should be chemistry, it was thought that it might also be good to revisit and restructure some of the more familiar formats of the journal for this issue.

With this in mind, our *'In conversation with…'* piece this time is longer than usual and allows us to take a closer look at an inclusive range of people who have made chemistry their life and to ask them what advice they might have for children and teachers. Interviewed by Alison Eley, the contributors are asked what advice they would give to their younger selves and what they wish their primary teachers had known about them as young learners in order to enhance their experiences and support their personal interests in primary science. There is much food for thought in the personal testimonies from current career scientists here, and also included is a helpful summary of chemistry career information that may be of interest to all potential future chemists sitting in primary classrooms around the country!

Bringing the voice of chemists into the classroom is also featured in the next piece by Ross Cundy and Verity Jones, which focuses on the classroom creation of digital artefacts giving voice to famous and historical chemists. This is an engaging concept and one that will undoubtedly deliver fun into the classroom – as well as scope for interdisciplinary learning, especially within history and literacy.

Although we have brought in some format changes, as always, practical activity in science is at the heart of this issue. In the next article, Ben Rogers offers some interesting and challenging insight into the preparatory 'hinterland' of chemistry in primary science and how attention to this concept, so prevalent in early years' practice, might be helpfully extended across all primary stages. This is followed up by a suggestion from Jess Strain for a fun, fully practical and immersive chemistry experience involving natural and sustainable plant matter in the familiar chemistry application of fabric dyeing. Investigation into how chemistry is employed in the world of archaeology is the focus of Anita Radini and Kate Sutton's article and they offer both information and really useful links to help support classroom study in this field.

The final article in the chemistry theme in this issue is from John McCullagh and Andrea Doherty. In a slight change from our usual format, this excellent piece about their Royal Society of Chemistry funded project offers evidence and challenge on how schools and initial teacher education establishments might work together to further enhance the science practice of teachers and students alike.

This issue also features an article by Ian Turner and Lewis Morgan presenting a series of lesson ideas that capture the excitement of a forensic investigation in a fun and light-hearted scenario, while the final article, from Nicola Gliddon, suggests a different way of teaching life cycles using dock leaves and dock beetles.

From inclusive reflections on primary science experiences by current chemists, through activities and advice that embrace traditional practical and modern digital literacies, to blue-sky thinking on partnership enhancements in primary science, this issue of *Primary Science* strives to offer a more-than-usual coverage of what's new in primary chemistry. I hope you enjoy it!

Robert Collins

In conversation with… People in chemistry

What kinds of jobs are there in chemistry? Who works in chemistry? Through bringing together the experiences of seven different chemists, **Ali Eley** illustrates the diversity found in jobs that are based in chemistry, as well as in the people that do chemistry

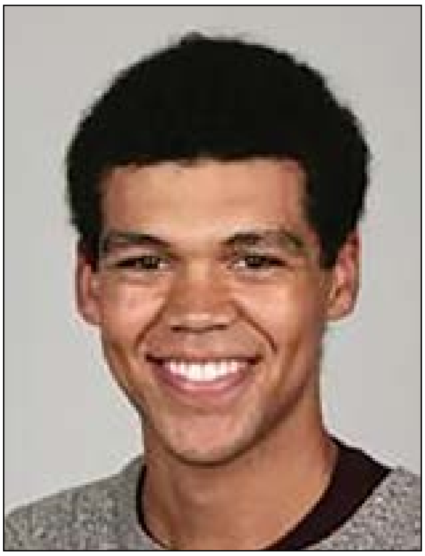
What is chemistry and why is it important?

Chemistry is the study of the composition, properties and behaviour of matter. It is concerned with understanding the structure of atoms and how they react, as well as substances and how they can be changed and new ones synthesised. It involves creative thinking and innovation. New substances are constantly being created, usually for a particular purpose.

Chemistry has wide-ranging applications and is central to many industries, as well as to research in key areas such as healthcare, food production and climate change. It also underpins understanding of other scientific disciplines, such as biochemistry, pharmacology, forensics and meteorology.

The nature of chemistry and its wide applications is evident in these stories from the chemists who have contributed to this article. Each of them describes what they would say now to their 10-year-old selves, and what they wish their primary school teachers had known about them. Their responses offer support to teachers with understanding their children better, and with recognising and nurturing particular interests, attributes, ambitions and worries that the children might have, but that might not be immediately obvious.

***Haydn Francis** is a researcher at the University of Cambridge. He develops new ways of measuring how and why batteries degrade over their lifetime.*



What would you say now to your 10-year-old self?

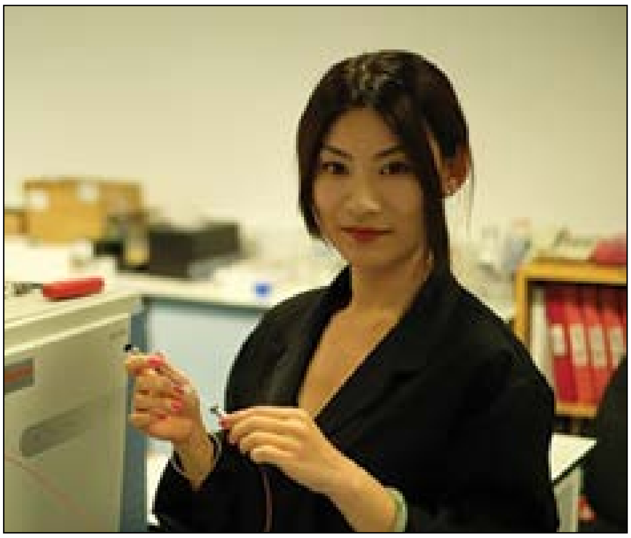
Studying science is the best way to keep as many doors open in your career as possible. You enjoy all subjects at school, and it will be difficult to choose what to study when you are older. You worry you will be closing doors to certain careers when picking what to study for GCSE, A-level or as a degree. But you will be very happy to find that studying science is considered a great platform for going into almost any career you could imagine. So don't worry too much, because studying science will provide you with skills that mean you're ready for jobs in business, law and government as well as science and engineering.

Things you wish your primary school teachers had known about you

Although I had some really great teachers in primary school, I do wish they'd known that I didn't actually know anyone at all who worked in science or who had studied science to a high level in my home and family life. I think it would have added a lot of value to lessons if we were able to speak directly to people working in science or at least see examples of people like ourselves who have ended up studying and working in science.

Key words: Chemistry careers Case studies

Candy Jiang *is a postgraduate researcher in analytical chemistry at Bristol University. She focuses on analysing chemicals using various scientific instruments.*



What would you say now to your 10-year-old self?

Don't let anyone dissuade you from pursuing your passion. You might think you are more of a 'maths' person, but your love lies with chemistry. Although you might not be very good at it now, through hard work and persistence you will get to be a chemist. It is OK to doubt yourself, and sometimes you might think, *'Perhaps my family is right, chemistry isn't for a girl like me'*, but these doubts and fears will not last long. You will sometimes feel like you are walking down an unknown path by yourself, which might be scary, but it will all be worth it when you reach the end, and you are exactly where you need to be.

Things you wish your primary school teachers had known about you

I wish my primary school teachers had given me more chance to express my curiosity and ask questions. I wish they had known that I was quiet due to shyness, not lack of interest. When I was growing up, my family was very traditional, with boys' education being valued more highly than that of girls. Being a girl meant finishing university, getting a non-challenging job, marrying and starting a family. It was a good life, but not for me. My parents never believed that I could pursue anything in science. Balancing my family's expectations and chasing my own goal was difficult. I think my interest in chemistry was started by my grandad – he did chemistry at university and he told me that the process of making Tofu involves chemistry.

Amy Packer *is a pharmaceutical scientist who works in the NHS, focusing on the manufacture of medicines.*

What would you say now to your 10-year-old self?

Try not to compare yourself to other people in the class or care so much about what other people think. And don't worry so much about exam results as no one will ever ask you at any job interview for your year 6 SATs results! Exam results are stepping stones, but not the goal. You might not find it easy to work out what you want to do, but you have been interested in STEM from a young age, and it doesn't matter now if you have no definite aspirations about what job to do. You are keen to get a job that involves helping other people so the NHS might be a good fit as you can work in healthcare and be a scientist!

Things you wish your primary school teachers had known about you

As a Christian who was interested in science, I often felt like I was told that I couldn't believe in God and be a scientist. I wish my teachers had been more understanding of different faith backgrounds and recognised that I was being taught seemingly contrasting things like creation and evolution. As it is, I now believe that science and religion do not have to be mutually exclusive and can complement each other, but at the time I found it confusing. It's really exciting to see more women in science now. I am grateful to my teachers and my family for encouraging me to see a future in science, without discrimination based on my gender. This isn't true for everyone though, so female scientist role models are really important.

***James Mortimer** is a photochemist at Bristol University, working with LEDs to form new molecules purely from photochemical excitation and reactivity.*

What would you say now to your 10-year-old self?

Whatever you want to achieve, you can. Sometimes the idea of a career in advanced sciences can seem scary and you will think you aren't good enough many times, but you have to ignore those doubts and just work hard to achieve your goals. You may feel overly inquisitive, and like you don't fit in with certain expectations, like a scientist being an older straight man, but you can carve your own path in the world of science by just being yourself. Even if teachers imply that you aren't 'good enough' or 'clever enough' to be a scientist, do your best to prove them wrong.

Things you wish your primary school teachers had known about you

I identify as a gay man and I often didn't feel included in many school discussions as a student where heteronormativity was rife. I think I wish my teachers had realised that everyone is an individual and unique in many ways and they should adapt their teaching to suit individual students' needs. In the context of promoting a science career, I wish my teachers had known how to ease my fears about not being good enough or thinking I didn't fit the mould of a scientist. I think this lack of engaging with students' individuality led me to dislike my school years and become isolated in my mission to be a scientist. I didn't have science interests outside of school but was an avid reader and consumed most of my information and knowledge from books of various sorts!

***Dr Kirsty Anderson** is a medicinal chemist who designs and plans synthetic routes to make new small-molecule targets for biological testing for the treatment of neuroinflammation, in particular Alzheimer's disease.*

What would you say now to your 10-year-old self?

Allow yourself to enjoy the subjects that actually interest you, no matter how many people tell you that they're 'too difficult' or not usually what a girl would like – i.e. STEM subjects. It's OK to be unsure which subject you enjoy; make sure you give all opportunities your best, since you never know what you might end up enjoying and excelling at! And remember that a scientist doesn't have to have crazy hair, be doing maths on a chalkboard, or be a man!

Things you wish your primary school teachers had known about you

I mostly felt that there was a disconnect with what was being taught and what you could do with that. I didn't have any interactions with scientists until I was leaving high school and starting university. The opportunity to have scientists visit (or *Zoom*!) into classrooms to share their jobs would be beneficial to show kids what they can do, as they may not have had the chance to learn about this at home or in their family. I was the first in my family to go to university and I know I would have benefited from more exposure to the science careers that exist; I also missed out on later opportunities by simply not being aware they existed, such as work placements in labs, rather than in retail.

***Dr Magdalena Wajrak** is a chemistry lecturer at Edith Cowan University in Perth, Western Australia, where she teaches general, physical and inorganic chemistry units and carries out research in electrochemistry.*

What would you say now to your 10-year-old self?

Be more confident in yourself and believe in your abilities. Don't let anyone put you down. Follow your passion in science, because you will succeed in having a career that you will love. Stay focused and work hard towards your goals and you will definitely achieve them. Also, it is OK to be ambitious as a female; don't feel pressured into following society's view that you need to be married and have a family if you feel that is not your path. Not having a family or being married does not make you less important or less valuable.

Things you wish your primary school teachers had known about you

I wish that my primary school teachers knew that, despite coming to Australia without any English when I was 12 years old, I did have a good understanding of science concepts and I was very good at mathematics. Unfortunately, because my English was very limited, I was placed in the lowest science and maths classes. That made me start to doubt my knowledge of science and maths subjects and, despite completing a Bachelor of Science majoring in chemistry and applied physics and a PhD in quantum chemistry, to this day I still doubt myself and lack confidence. Primary school teachers are so important for students' growth in confidence and to set them up for lifelong learning.

***Dr Zoë Ayres** is a chemist in the food and drink industry. She conducts experiments to identify contaminants and changes to ensure food and drinks are fresh and safe to consume.*

What would you say now to your 10-year-old self?

There are lots of jobs you want to have – archaeologist, lawyer, doctor, scientist – and you don't know yet what you will end up doing. But you don't need to worry that you are not sure what you want to do; it is perfectly fine to be unsure or change your mind depending on what you are finding exciting and interesting. The most important thing is doing something you enjoy! Sometimes life takes unexpected turns too – you will one day become a doctor, but a doctor of science rather than the medical doctor you are thinking about now!

Things you wish your primary school teachers had known about you

I was interested in a lot of different things in science, so having more idea of the possible careers I could have had, would have been really useful. I struggled with my confidence at school a lot, so someone saying, *'You could do that',* would have helped improve my self-esteem. I thought getting good grades was the most important thing in science, and a few bad test scores could mean that being a scientist would not be possible. I have also found out later in life that I am probably neurodivergent, and one of the things I really struggled with is doing school work just for the sake of doing school work; I always wanted to know why I was doing the work I was doing and what the bigger picture was and I think I still do. Being taught the practical reasons behind learning and why it is useful was essential to keep me engaged.

Themes emerging from these chemists' stories and experiences

The life paths and careers of these chemists are all different, but some common themes that are relevant to the primary classroom emerge from the thoughts and experiences that they have shared here. Many of them speak about a lack of self-belief and the importance of choosing something that you really enjoy as a career. Some have highlighted that studying science offers later opportunities, not just in science but in many other jobs that are not directly related to science. This is something that might not be obvious to children, but that teachers could explain. The views expressed about tests at primary school are also interesting. The emphasis on how much the results matter seems disproportionate, and there is a conviction that poor results, even at this early age, will rule out future opportunities. Another useful point that a couple of the chemists make is that children actively want to understand the purpose of what they are doing in science lessons.

Stereotypes around who does science clearly persist, and teachers continue to be an important part of challenging these. Some of these accounts illustrate how personal characteristics, cultural backgrounds and specific difficulties experienced can all be direct barriers to children developing an identity with, or even accessing, science. Again, the primary teacher has a key role to play: effective science teaching is not just about delivering the science curriculum, but also encompasses good pastoral care, empathy and knowledge about children as individuals.

Perhaps one way of highlighting different science careers to children is to consider first the personal qualities and skills they have and in which jobs and industries they would be valuable. Table 1 gives an outline of a range of jobs that are based on chemistry, alongside some of the personal qualities and skills that people who do these jobs typically have. Children in your class who love science may already demonstrate these qualities and skills, and therefore might be interested to find out more about the chemistry careers where these attributes are valued.

Table 1 Personal qualities and skills that could be useful in different careers in chemistry

Job	What do they do?	Some of the personal qualities and skills valuable in this field of work
Chemical engineer	Develop new substances and products, and design new production facilities able to make them	Enjoy practical work using equipment Good at thinking logically Good communication
Environmental chemist	Conduct research into the impact of human activity on quality of air, water and soil, and design systems for waste disposal and to minimise pollution	Cares about the natural world Interested in human behaviour Good at seeing the big picture
Meteorologist	Study the Earth's atmosphere by analysing data from weather stations and satellites, and make predictions about weather and climate	Interested in the weather Good problem-solver Good communication
Pharmacist	Administer a medication service for the public and complement healthcare provided by doctors	Enjoy interacting with people Strong physical stamina Good attention to detail
Pharmacologist	Investigate the effects of drugs on living systems and design new drugs to prevent illness and disease	Enjoy finding out new things Good at thinking logically Good attention to detail
Doctor	Diagnose, treat and prevent medical disorders, diseases and injuries	Caring about other people Good memory Good at solving puzzles Strong physical and emotional stamina
Dentist	Diagnose, treat and prevent diseases of the mouth and teeth	Caring about other people Good manual dexterity Strong emotional stamina
Veterinarian	Diagnose and treat diseases and injuries in animals	Love of animals Good memory Strong physical and emotional stamina
Pathologist	Study tissues or fluids taken from the human body to determine the cause of disease or death	High attention to detail Good emotional strength Good at practical, hands-on work

Forensic scientist	Analyse crime scene evidence to determine the composition and nature of material samples	Interested in law and justice Good manual dexterity Good communication
Nanotechnologist	Perform research and analysis of structures at the sub-atomic level to develop new applications and processes	Good hand-eye coordination Good imagination and visualisation Patience and persistence
Toxicologist	Study the harmful effects that substances such as drugs, food additives, pesticides and industrial chemicals have on living things	Care about the natural world Enjoy finding out new things Patience and perseverance
Colour technologist	Develop dyes and pigments for use in the manufacturing industry	Interested in art and colour Creative and flexible Good communication
Cosmetic scientist	Test and evaluate aromas of new toiletries and perfumes, and develop efficient production processes for new cosmetics	Well-developed sense of smell Patience and persistence Good communication
Food scientist	Improve the quality of foods and ensure that they are safe to eat by studying the properties of food ingredients	Interested in food and flavour Methodical Good at working in a team
New food developer	Design, manufacture, and test new foods and plan for their sales and marketing	Interested in people and marketing Good at working in a team Creative and original
Flavour technologist	Study the interaction of food ingredients with human sensory systems, and develop new flavours to improve the taste of food and drinks	Interested in food and flavour Resilient – happy to keep trying new ideas and approaches Good communication
Textile chemist	Apply chemical understanding to the development of functionally and aesthetically pleasing new textiles and materials	Interested in fashion or furnishings Resilient Good at working in a team
Analytical chemist	Support understanding of new and existing substances across many industries and in research	Good manipulation of number High attention to detail Good communicator
Nuclear chemist	Research and development in radioactivity and nuclear processes, including their application in medicine and in disposal of waste	High attention to detail Very good levels of concentration Good at working in a team
And then there is teaching science – the best career of them all of course!		

Further support for careers in chemistry

- **A Scientist Just Like Me** (https://pstt.org.uk/resources/curriculum-materials/ASJLM). A series of free-to-download slideshows and videos, each telling the story of someone working in a science-related job. The slideshows focus on what the people like about their jobs, challenges they have faced and how their work makes the world a better place. The focus is on the habits of mind and personal qualities needed to do the particular job, rather than on the science knowledge needed. There is a slideshow about each of the chemists who contributed to this article, and there are videos featuring both James and Candy.
- **Steps into Science – Meet the Scientists** (https://edu.rsc.org/primary-science/find-resources/meet-the-scientists). The Royal Society of Chemistry's new collection of resources to introduce primary children to STEM careers and historical and modern-day scientists. These include *Faces of Chemistry* – *Women in Chemistry*, a set of stories about the achievements and inspirations of a diverse range of women in the chemical sciences.

Acknowledgements

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Let's talk significant people in chemistry

Ross Cundy and **Verity Jones** consider how we can bring significant scientists to life in our teaching and learning

Gaining knowledge about the amazing work of people in chemistry is a great way to get children engaged and enthusiastic about the field. We have found that just asking children to 'find out' about someone to develop knowledge and or research skills can be a dry task. Creating a fact sheet isn't that much more exciting. However, when you ask children to bring their scientists to life using digital technology, eyes widen and classes tend to take notice.

The activity we present here takes a digital image of a chemist and allows the children to bring it to life and make them talk about their life and work. This relies on schools having access to tablets. We use the free app called *Talkr* (this app is available for iOS; other photo talk apps are available for iOS and Android). We have found that *Talkr* is an easy-to-use app for children and teachers. As with any tech, we highly recommend testing out the app before the lesson to make sure you are familiar with it. In fact, we recommend making a talking chemist of your own on *Talkr* so you can use it as a model (as you will see below). If you need help, there are some really useful short clips on *YouTube* made by other teachers (see *Resources* below).

The photo talk activity

Step 1: What's the purpose?

We find that quality learning needs a purpose, and the children need to know what that purpose is. Consider whether the knowledge children find about a significant chemist might be used in a school assembly, or perhaps be shared with another class or visitor. Once you have shared the purpose, show your own talking image on the app. It might be useful to use the face of someone familiar to the children – perhaps a sportsperson, politician or member of staff! Seeing the app in action helps the children visualise what their end product will be. This modelling is also useful if you want to show the expectation in quality, content and length.

Step 2: Find me a chemist

In pairs or small groups, challenge the class to find out about a chemist. You may want to provide pre-prepared information sheets or a list of names for children to use as search terms.

Digital images of chemists Rosalind Franklin (top) and Patricia Bath brought to life on the *Talkr* app

Key words: Famous chemists, Digital literacy, Photo talk app

Top tips for working with tablets

- Double check that all tablets are fully charged.
- Double check that all the devices have the app you need downloaded.
- Check that there is space on the photo reel for images to be saved.
- Try out mirroring your screen onto the interactive whiteboard so that you can model what you are doing on screen with the whole class.
- Always reinforce classroom expectations when using and putting away tablets with the children. This will make for smoother transitions through different stages of the lesson.

Remember to think about the diversity of representation in these lists. Here are four possibilities to get you started:

- **Rosalind Franklin** (UK 1920–1958) was the first to use x-ray crystallography to see the structure of DNA. Watson and Crick used her data in their proposal for the double-stranded helical structure of the DNA molecule. Unfortunately, Nobel Prizes are only awarded to living persons, so she wasn't recognised in 1962 when they received the prize in medicine or physiology.
- Today, **Henry Cavendish** (UK 1731–1810) would be recognised as neurodiverse. He is famous for his identification of hydrogen (though he called it inflammable air).
- Black American, **Patricia Bath** (US 1942–2019) developed the Cataract Laser Probe that was able to painlessly remove cataracts. She also founded the American Institute for the Prevention of Blindness.
- **Edwin Krebs** (US 1918–2009) didn't let his hearing impairment stop him. He was a biochemist who made monumental discoveries about cell activity to help us understand why the body rejects transplanted organs.

Children can be challenged to find out specific information (such as date of birth, where the scientist lived and worked, what projects they worked on, what difficulties they had to overcome, etc.). Ability and time are key here: it is up to you as the teacher to work out who might find a pre-prepared table to fill in useful, or whether to let the group have more freedom to explore and develop their own ideas.

Step 3: Put words in the chemist's mouth

This is the stage where we draw on English skills and consider writing in the first person. The children will be writing a speech, as if they are their chemist. Children should practise their oracy skills and rehearse their speeches so when it comes to recording they are delivered with fluency and expression.

Step 4: Find me a photo of your chemist

Before children can go any further they will need a photo of their chemist (a painting will also do, as long as the face is clear). The image needs to be head on – side profiles won't work. These need to be saved onto the tablets the children will be working on.

Step 5: Make your chemist talk

Using the *Talkr* app, upload the photo of the chemist and record their speech. You will need quiet spaces to do this if you don't want recordings to be mixed up with a lot of background noise. Once recorded, hit *play* and watch your chemist come to life, telling you all about their life and work.

Step 6: Share and celebrate

Sharing the children's work and the work of great scientists is always worth celebrating. Reflect on what the children have learned and the importance of chemists to our everyday life. The video files can also be shared on the school's digital platforms and shared with parents.

Don't be daunted

This activity allows children to use scientific understanding in a new way. Using apps creatively in the classroom offers exciting learning opportunities and space to embed digital literacy. For some teachers this can be daunting. Many children in our classrooms can be more digitally literate than the adults. We suggest that such digital agility should be embraced. If you are keen to have a go at using new technology then consider asking a few children to explore the activity beforehand. They can quickly work out the stumbling blocks and can then support others as class assistants when a larger group is working on the project.

Ross Cundy is Senior Technical Instructor in Science Education and **Verity Jones** is Associate Professor of Education at the University of the West of England (UWE) Bristol.
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Resource

Useful *YouTube* video on how to use *Talkr*: www.youtube.com/watch?v=t5YieVWzCXo

A chemical hinterland knowledge curriculum

Ben Rogers suggests that play and physical experience are vital for developing understanding of abstract concepts in chemistry

Where does the mind stop and the rest of the world begin?
(Clark and Chalmers,1998)

A curriculum of physical experience

When we learn chemistry, we build on the experiences of our senses. We can't think about solids, liquids and gases, waterproof, transparent, elastic, hot and cold or particles without having physically experienced them. We build our understanding of flammable and acidic through adventures (and misadventures) with smell, sound, taste and touch. In other words, to be a successful chemist, we need a lot of physical experiences *before* we learn the chemistry. A curriculum design that aims to involve this embodied cognition to develop the physical knowledge children need therefore seems prudent.

The term 'hinterland' describes the knowledge children need to be able to access the core curriculum. In history, for example, children who have visited a castle, thought about how people lived in it and talked about their experiences are likely to develop a richer understanding of the Normans in class. Their experiences act as a foundation for their learning.

Hinterland is often applied to the humanities and to literature, but it is just as important to the sciences. When a teacher talks about the properties of a solid, or changes of state, those children who have physically experienced these things in a meaningful way will have a richer understanding of what the teacher means. Those who have only partial experience, for example through watching a video clip, or whose attention hasn't been directed to the relevant physical sensations, may struggle to develop a deep understanding. When our teaching deliberately enriches our children's science hinterland, we are preparing them for deeper learning.

This physical hinterland curriculum should be structured, planned and explicitly teacher led. However, this does not simply mean leaving resources out and allowing children to discover chemical properties for themselves. While some children might independently play and explore in a way that builds strong foundations for later learning, I would advocate that this should not be left to chance.

Instead, direct children's attention and thought to the meaningful experiences you have planned. Ask questions and model interactions to ensure each child is experiencing what you want them to experience. To build effective memories, they need to think hard about their experiences. Crucially, it is a key role of a teacher to select, plan and sequence learning to be purposeful, meaningful and efficient.

An example chemistry hinterland curriculum

With this in mind I present in Box 1 an example hinterland curriculum for chemistry. It is based on *Working with big ideas of science education* (Harlen, 2015), a useful document because it prioritises the key chemistry knowledge and sequences it. The key strand of ideas I have unpicked is *'All matter in the universe is made of very small particles'.*

Children should experience ice melting in their hands

Key words: Cognition Chemistry Hinterland

Box 1 An example curriculum for 'All matter in the universe is made of very small particles'

Stage taught	Hinterland knowledge
EYFS and KS1	*All the 'stuff' encountered in everyday life, including air, water and different kinds of solid substances, is called matter because it has mass, and therefore weight on Earth, and takes up space.* Space can be explored using balloons, bottles and other containers. Draw attention to the volume of the bottles and balloons. Mass is an important property of matter. You experience mass in how heavy an object is, but also how easy it is to speed it up or slow it down. You feel the effect of mass when you push a loaded cart or an empty one – you have to push harder to speed the loaded trolley up **and** to slow it down. *Different materials are recognisable by their properties, some of which are used to classify them as being in the solid, liquid or gas state.* Children need the physical experiences of handling different materials in different circumstances. They need to be guided to experience light travelling through transparent and translucent materials; how water is absorbed by some materials and repelled by others; how some materials bend permanently, some are springy and some are brittle. Develop children's language to talk about these experiences and revisit them regularly. Children need to have experiences of the states of matter and be encouraged to discuss their properties. Children need many opportunities to build these experiences and the language needed to talk about them. An example experience might be three plastic bottles – one filled with ice, one filled with water (to the top) and one filled with air. Encourage children to squeeze, shake and feel the mass of the bottles and to talk about the behaviour of the substances inside the bottle.
KS2	*When some substances are combined they form a new substance (or substances) with properties that are different from the original ones.* Children need experiences of chemical changes. Cooking is an obvious example. Toasting bread is a chemical change: burning it is more dramatic. The charred bread is a new substance. Cooking eggs is another good example of a chemical change. You want to draw children's attention to what is happening by asking questions: 'Can you make the toast back into bread? Can you make the cooked egg white runny again? What properties have changed?' Build up a bank of useful experiences and explicitly compare them. You might build on the cooking examples by burning candles; comparing rusty and new nails; putting old coins in vinegar and putting Mentos mints in coke. The experience is important, but not sufficient: encourage children to think and talk about the similarities and differences between all of these phenomena. *Other substances simply mix without changing permanently and can often be separated again.* Children need to experience sieves and filters to separate mixtures. Starting with everyday mixtures, like peas in water, and moving on to other mixtures. Some are harder to separate than others: separating dried lentils and rice is fiddly (and boring). Using magnetism (e.g. marbles and ball bearings) and solubility (salt and grit by dissolving the salt and then filtering) can come later. *At room temperature, some substances are in the solid state, some in the liquid state and some in the gas state. The state of many substances can be changed by heating or cooling them. The amount of matter does not change when a solid melts or a liquid evaporates.* There are several materials that can change state in sensible classroom temperatures. Melting ice is the most obvious. Children should experience ice melting in their hands, and practise using words to describe the sensations. Chocolate too will melt in your hands. Making comparisons is a powerful way to focus attention. Wax can be useful, but more fiddly to handle safely. Pouring liquid candle wax onto a plate and poking it with a pencil tip can work well (if supervised carefully!). Evaporation and condensation are again more tricky to gain physical experiences of. You can watch the last of the water in a pan boil away, turning into steam, but this needs to be done carefully. Condensation on a bathroom mirror or window is a good example of a gas turning into a liquid. The physical sensation of drawing in the condensation and experiencing the water drips is a physical way of experiencing this.

Box 1 An example curriculum for 'All matter in the universe is made of very small particles' – *Continued*

KS3	I have included KS3 because that is when the abstract chemistry concepts are taught. The foundations need to be built ahead of this time. Considering the models secondary science teachers are likely to use in chemistry can help to build some powerful hinterland knowledge for your children. *If a substance could be divided into smaller and smaller pieces it would be found to be made of very, very small particles, smaller than can be seen even with a microscope. These particles are not in a substance; they are the substance. All the particles of a particular substance are the same and different from those of other substances. The particles are not static but move in random directions.* The key point with atoms and molecules is that you can't just keep dividing a substance into smaller and smaller pieces indefinitely – eventually you reach the smallest particle beyond which you can't go. Before children can understand this, they need to experience the process of dividing a substance into smaller and smaller pieces. You can model this with plasticine and a modelling knife. Foreshadowing their KS3 learning could be useful by simply saying that in KS3 they will learn why you can't keep dividing forever (and not just because it gets really fiddly to cut microscopic specks of plasticine). *The speed at which they move is experienced as the temperature of the material. The differences between substances in the solid, liquid or gas state can be explained in terms of the speed and range of the movement of particles and the separation and strength of the attraction between neighbouring particles.* The particle model is very important in high school chemistry. Children need to be able to imagine balls behaving in various ways. They can get physical experience of the behaviour of balls using marbles. Stacking marbles in piles is an excellent model for solids (embed the base layer of marbles in a layer of plasticine). You can model liquids and gases by putting marbles in a transparent bag or plastic bottle. As with all of these hinterland experiences, the experience alone isn't enough. You need to direct attention to the relevant features: describe how the marbles move in a bottle when shaken. Show how you can 'stir' the marbles in a bowl. *A chemical reaction involves a rearrangement of the atoms in the reacting substances to form new substances, while the total amount of matter remains the same. The properties of different materials can be explained in terms of the behaviour of the atoms and groups of atoms of which they are made.* Experience with Lego® is powerful hinterland knowledge for chemical reactions. Secondary science teachers often use Lego to model chemical reactions in KS3 and 4, though less commonly let their students physically model the reactions using Lego. Students who were familiar with Lego when they were younger are more likely to benefit from this model.

Conclusion

A well thought through and systemically delivered chemistry hinterland curriculum will build solid learning foundations for your children. You might not see the immediate benefit in your own lessons, but their comprehension of abstract concepts later on will be richer and more 'muscular'.

You don't need to spend much time on them: little and often is the best policy. Revisit the same experiences year on year – the experience of remembering in different contexts and in different places is key to being flexible with the ideas.

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A recipe for enjoying chemistry with colour

Jess Strain tells why natural dyes are important to the future of a more sustainable fashion industry and how you can bring textiles and science together in your classroom

Figure 1 A naturally dyed kimono, hand dyed with indigo and digitally embroidered with cellulose-based thread

My interest in natural dyes began in 2020. The first COVID-19 lockdown shut down my university studios at the height of my graduate textile collection in March 2020. I had been working with a range of synthetic dyes in my university's dye lab, testing different recipes for weeks to get the perfect shade of purple, blue and green. Then, at the drop of a hat, I had zero access to the labs, dyes and any of the equipment I required to dye my graduate collection. I had been casually researching natural dyes in the months leading up to my graduate collection, but I hadn't had time to sit down and try the process for myself. Suddenly, I had all the time in the world to slow down and learn more about age-old processes like natural dyeing.

Advantages of natural dyes

Natural dyeing can be traced back to China in the year 2600 BC and natural pigments have been found in Egypt in the tomb of King Tutankhamun. As well as natural dyes, you can also cultivate organic cotton crops that yield naturally coloured cotton in green and brown. Coloured fabrics have a rich history and were once used to show status in society. At one point, the colour purple could only be obtained from a mollusc: it is estimated that 8500 molluscs were required to create just one gram of dye extract.

Nowadays, fashion employs synthetic dyes to colour the majority of our clothing. These dyes can contain chemicals that are harmful to both consumers and garment workers. Often leaking into the rivers surrounding garment factories, water can turn 'millennial pink' or 'shocking green' depending on the season. Not only is this practice hazardous to the planet but it is also lethal for the drinking water of communities in garment-manufacturing hotspots such as Bangladesh, China and Cambodia. This is just one shocking example of the stark exploitation of both people and the planet that is so often associated with fast fashion.

The United Nation's Sustainable Development Goals (SDGs) provide a blueprint for sustainability, peace and prosperity for people and the planet. SDG 6 aims to provide clean water and sanitation for all. Natural dyes, pigments and naturally coloured cotton are an incredible alternative to chemical textile dyes. Innovation within areas of biological dyes and commercialising natural dye processes are at the forefront of innovation and provide a glimmer of hope in what appears to be a sea of fast-fashion fixes. Considering how our clothing impacts something as fundamental as drinking water for communities in the Global South can be overwhelming but is essential if we are to begin changing the way we interact with fashion.

Key words: Natural dyes Sustainable Mordant

Figure 2 A wallhanging created from discarded linen and Dartmoor fern and gorse-flower dye

Figure 3 Organic cotton coloured with onion skin dye, and decorated with Italian crepe paper, beads and sequins

My natural dye journey

Upon my return to my family home in Devon from my studies in March 2020, I delved into the pages of Babs Behan's *Botanical inks* book (Behan, 2018), which served as a 'North Star' for many of my experiments over the coming weeks.

I began with a tried-and-tested natural dye: onion skins. This dye matter is easily accessible; I asked my friends and family to collect their onion skins (only the dry part) from their cooking and I also asked my friends who worked in supermarkets to collect the remnant onion skins. When I didn't have quite enough for my dye bath, I went around the supermarkets gathering the dry onion skins from the bottom of the loose onion crates (it was a source of great enjoyment for my dad to watch me scraping the crates with a bag in hand!).

Next, I walked with my mum and sisters to collect nettles on our daily walk. I took gardening gloves, a pair of shears and a bin bag. We collected almost a full bin bag of nettles (taking care not to cut too much from one plant – it is important to leave enough for the plant to grow back once you have taken what you need). I then set to work chopping the nettles into smaller pieces; the smaller you chop your dye matter, the more colour and tannin can be released, so the more effective your dye bath. On a scorching day in Spring 2020 I was crouched over a washing basket chopping my nettles into small chunks with my mum's gardening gloves and shears. I used these nettles to dye some gorgeous duchess silk that had been gifted to our university by fashion designer Alexander McQueen. I dip-dyed the fabric and let the dye soak up the silk creating a gorgeous gradient.

The possibilities are endless with natural dyes, but some of the tried-and-tested dyes come from avocado skins, onion skins, eucalyptus, nettles, dock roots, madder roots, cochineal (beetles), weld, woad, indigo, dyer's chamomile, walnuts and marigolds.

Exploring Dartmoor colours

During 2021 I took it upon myself to document the colours of Dartmoor National Park plants. At the time I was completing an artist residency and felt it was time to explore the muted but rich colours of my local environment. I decided on two types of fern and gorse flowers. Over the course of a few months, I foraged ferns and gorse flowers from various locations across Dartmoor and documented the colours that I extracted in a book. To many people's surprise, the ferns actually yield a blush peach colour – not green like nettles.

Towards the end of the project, I gathered some discarded linens from a soft furnishings workshop where I worked and dyed these with ferns. The result was two embroidered wall hangings (Figure 2). This level of exploration into an environment I had once regarded as bleak and bland was a huge eye-opener. I realised that if I could create gorgeous tones and a colour palette from Dartmoor ferns, then I could do it anywhere and so could teachers and children in schools! By being provided with opportunities to extract dyes, children are learning about how

Box 1 A simple process for making and using a natural dye

You will need:

- 30 cm x 30 cm silk square per person (I recommend a heavy silk such as duchess, but any silk suitable for batik or silk painting will do)
- 100 g of onion skins for every 100 g of fabric (ask the children to collect the onion skins from their kitchens at home or ask your school's caterers, but note you only want the dry outer skin, not the moist skin)
- a big saucepan, big enough for your fabric to move freely in the pan
- a source of heat like a hob or stove
- a bowl
- a vessel or tub with a similar capacity to the pan
- a sieve
- a wooden or metal spoon or stirrer (not copper as this will affect the pH of the bath)

The prep:

1. Leave your fabric to soak in a bowl of water for at least 6 hours before you are ready to dye your fabric.
2. Fill your pan with room-temperature tap water, enough so that the fabric will be able to move freely.
3. Empty your onion skins into the pan and stir.
4. Simmer for 1 hour, this is now your dye bath.
5. Once an hour has passed, turn off the heat and leave the onion-skin dye bath to steep for 12 hours.
6. Strain the onions from the dye bath into your other vessel/tub and pour the onion-skin-free dye bath back into the pan. Your dye bath is now ready to go.

The dyeing:

1. Take your pre-soaked fabric and lower it into the dye bath, ensuring the fabric can move freely around the pan.
2. Bring the dye bath to a simmer, being careful not to boil as this could damage the silk. Make sure to agitate the silk so that the dye can reach all parts of the fabric. Be aware that the fabric may stick to itself, so be sure to tease it apart for even dye coverage.
3. Turn the heat off after one hour.
4. Allow the fabric to steep in the dye bath for at least 12 hours, occasionally stirring and agitating.
5. Rinse the fabric until the water runs clear.
6. Allow the fabric to dry, preferably air dry out of direct sunshine.

materials are made and mixed, properties, and identification and classification of living plants as well as investigative processes.

Simple natural dyeing tutorial

In order to give your fabric the best chance of absorbing as much natural dye as possible, you can mordant the fabric before you dye it. Mordant comes from the Latin word *modere*, meaning 'to bite'. You are opening up the fibres of the fabric to allow the dye to 'bite' onto the fibres. The mordant you use depends on the type of fabric that you are dyeing: whether it is an animal fibre such as silk or wool or a plant fibre such as cotton or linen. Natural dyes only work on natural fabrics and mordants make the dye more colourfast and rich.

For ease in the classroom I have created a recipe that doesn't involve mordanting, instead opting for an animal fibre, which is far more receptive to natural dyes than are plant fibres. This way you can avoid any potentially harmful substances around children. Details are given in Box 1.

Because this fabric has not been mordanted, the colour won't be as rich or colourfast as it would be otherwise. To preserve the colour as much as possible keep the fabric out of direct sunlight. The beauty of natural dye is that you can overdye any fabric with a new dye and you will get a brand-new colour – fantastic to explore as part of your art lessons!

Jess Strain is an artist and advocate for sustainable practices. She is available for workshops and talks about natural dyes and sustainable design.
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Chemistry in archaeology: an overview and some activities for primary children

Anita Radini and **Kate Sutton** showcase how archaeology can support teaching chemistry, and give examples of open-access resources


Anita (right) delivering a session at Burlington Junior School on archaeology as a career (with Kate on the left)

Archaeology is the discipline that deals with the study of the human past based on the ruins, objects and even the remains of people (for example skeletons and mummies) that humanity leaves behind as it moves forward. It has the great purpose of providing a voice for the very many peoples, groups of peoples (such as the poor) and cultures not represented in ancient and historical texts. While we tend to think about archaeology as a discipline rooted in the 'humanities', science has played an ever-growing part in it, and today we have an entire area of the discipline called archaeological sciences (Britton and Richards, 2020), where chemistry features strongly.

Chemistry and archaeology

Chemistry plays a very important role in archaeology in many ways: not only are the dating and composition of many artefacts and archaeological residues and materials based on chemical analysis, but chemistry is part of the essential tool kit in the curatorial aspects of many archaeological finds appearing in museums (Price and Knudson, 2018).

One of the first aspects of the use of chemistry methods in archaeology concerns the dating of archaeological material and isotopic analysis:

- Isotopes have great value for archaeologists because they can inform, based upon their decay, about the age of a great variety of archaeological materials.
- The distribution of key isotopes such as O, N and C stored in human and animal bones can also inform on diet, while strontium (Sr) isotopes can be used to establish where ancient people were born (see *Weblinks* – Michelle Alexander).
- The same isotopes can also be used to study agricultural regimes in past societies, using archaeo-botanical seeds of burnt cereals often retrieved in archaeological sites.

Another important aspect of chemistry applied to archaeology lies in the fact that archaeologists often do not know what archaeological materials, artefacts and even pigments were made of. This is true for both organic and inorganic archaeological material and residues:

- Knowing the unique composition of artefacts can help archaeologists to understand how they were made, guiding their conservations.
- Knowing the unique composition of artefacts can also help in understanding where they have come from and help in their authentication, a very useful aspect when dealing with stolen artefacts and the illegal trade of archaeological objects.
- Chemistry can also be applied on amorphous archaeological residues, often of organic origin. Ancient lipid analysis for example is revolutionising the way archaeologists study diet (see *Weblinks* – Oliver Craig and the British Museum).
- Chemistry is also helping reveal many aspects of ancient cultural practices and technologies, one of the best-known areas of study being

Key words: Archaeology Chemistry Isotopes

Ancient Egyptian mummification practice.

- Chemical analysis of ancient soil can provide important information on ancient agricultural systems and help us understand the scale of food production as well as human impact on the ancient environment.

Archaeological chemistry uses a great variety of tools and equipment, and therefore can be used to illustrate a variety of laboratory equipment. A concise but useful overview of resources is given by Nikita, Bonner and Rehren (2022) in their open-access article, signposting open-access resources in the field of archaeological science from several universities around the world.

Activities for children

The challenge for teachers is adapting the very many uses of chemistry in archaeology to the age of children in their class and to their curriculum. An overview of some key links and resources is given in Box 1.

Conclusion

We hope this brief overview has shown you the role that archaeological science can play in teaching chemistry and inspiring your pupils about careers in archaeological science, chemistry and applied chemistry. Many aspects of the way archaeologists approach the study of the past have chemistry at their foundation. Ranging from measuring how old archaeological finds are, to understanding their composition and provenance, to the effort put into preserving them, chemistry is an integral part of archaeological science.

Box 1 Overview of key links and resources

Archaeological science classroom activities

https://zenodo.org/record/3634997#.Y9jaAXbP23A

Learning symbols of various elements and the chemistry of most common materials around us is one of the first steps in chemistry. The Cyprus Institute proposed activity on archaeology metallurgy with memory cards is free to download; they could be used as they are, or easily adapted to give children a visual and memorable idea of chemical 'nomenclature' or labelling of metals.

Using isotopes to reconstruct diet

https://historicfoodscapes.wordpress.com/2015/06/15/of-bones-beads-and-bracelets-the-festival-of-ideas-at-york

Here Dr Alice Toso uses colour-coded wooden beads, where each colour represents a type of food that could be tracked with Isotopes. Children could put together bracelets representing their diet and look at that of others.

Ice archaeology

https://kidminds.org/the-best-ice-archeology-experiment-for-kids

Another potentially useful experiment to explain the different states of matter and how they affect materials could be obtained by replicating or adapting this 'ice archaeology experiment' by Eva Alexandra, where different objects were frozen and defrosted in ice cubes to show children the different behaviour of various materials.

Experiment with the Vikings

https://edu.rsc.org/download?ac=15104

A further potentially useful activity could be related to the use of soil and its characteristics. An activity of this kind is described in detail in these Viking period based STEM activities from the Royal Society of Chemistry.

Archaeological science colouring book

http://christinawarinner.com/outreach/children/adventures-in-archaeological-science

Chritina Warinnner and her team have developed a colouring book about archaeological science, which includes a mention for chemistry. Such colouring activity helps children to connect to the laboratory and daily routine of the life of an archaeological scientist.

Weblinks

Michelle Alexander, *Understanding ancient diets with stable isotope analysis*: www.youtube.com/watch?v=J-gC7UXUoYk

Oliver Craig, *Organic residue analysis in archaeology: a brief introduction*: www.youtube.com/watch?v=nxNMm78tvrI

British Museum, *World History Lab*: https://worldhistorylab.britishmuseum.org

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Partners in progress: how school placement can benefit both pre- and in-service teachers

John McCullagh and **Andrea Doherty** report on the role pre-service teachers can play in developing the science practice of their placement school

Figure 1 Pupils creating their own 'walking water' in a hands-on science lesson

We have previously reported on the merits of involving student teachers in school-based curriculum development projects (McCullagh and Doherty, 2018; Earle and McCullagh 2020; McCullagh and Doherty 2021). These projects have involved up to 20 primary science specialist student teachers planning and teaching lessons in a small number of local primary schools. The students and teachers worked together to develop and evaluate teaching strategies and resources, which could continue to support in-service teachers long after the project was completed. Our evaluations of this work have consistently shown a great increase in the student teachers' competence and confidence as well as substantial benefits to the host teacher and the science provision of the school. In our latest project, the 'Student Teachers Supporting Primary Science Project', financed by the Royal Society of Chemistry's Outreach Fund, we aimed to explore whether the same impact could be achieved when an entire cohort of undergraduate students worked with a much larger group of schools. Could this potential 'win–win' deployment of student teachers prove effective on a larger scale and thus provide a form of professional development for our teachers?

Project details

The project involved a total of 228 student teachers in the first (106) or second (122) year of their four-year undergraduate degree programme in primary education, and teachers from 209 primary schools from right across

Key words: Partnership Perceptions Support

Figure 2 The project sequence

Northern Ireland. During the 'Planning and Preparation' phase (Figure 2), the students studied the pedagogical theory underpinning enquiry-based science during seminars and workshops on campus.

Over the course of their day visits to their host schools the students began planning hands-on enquiry-based science lessons based on the topic they would be teaching during their placement. They consulted with their science tutors and class teacher and identified the resources that would be required. The funding for the project was used to buy disposable resources (e.g. balloons, sodium bicarbonate, washing-up liquid). As well as teaching at least two enquiry-based science lessons, each student created a teaching resource for their teacher, comprising lesson plans, worksheets and a short instructional video. This resource was left with their host teacher at the end of the project.

The impact of the project was assessed via questionnaires administered to students and teachers. This final phase of the project also included a primary science conference, which featured an exciting science demonstration lecture by the University of Warwick's Schools Outreach Fellow, Nick Barker, and poster and table displays of the students' lessons and resources.

Project outcomes

Impact on student teachers

All the students reported that the project had developed their overall classroom practice of science and made them more confident and positively disposed to teaching science in their future teaching practices. Year 1 students completed a self-audit before and after teaching, based on the General Teaching Council for Northern Ireland's (GTCNI) competence framework. They rated their confidence in aspects of planning, teaching and evaluating. The data showed increases in their confidence in planning, classroom management and evaluating their classroom teaching. The students valued the opportunity to learn about teaching from actually teaching and, for many, directly experiencing the benefits of hands-on enquiry tasks helped them reframe their thinking about science in the primary school (Figure 3):

Prior to teaching the lessons, I didn't think science should be a high priority. However after teaching it and seeing the benefits first hand I feel it is extremely important. (Year 1 student teacher)

I will be teaching more science in future as I saw first-hand how fundamental this is to overall pupil development. (Year 1 student teacher)

Being '*forced out of my comfort zone*', as one student put it, was the useful aspect of the project most frequently cited by year 2 students:

Last year on teaching practice I only taught one lesson in science and that was just completing a worksheet. I'm not confident in science so would probably have avoided it if possible.

Figure 3 Exploring density towers with a student teacher

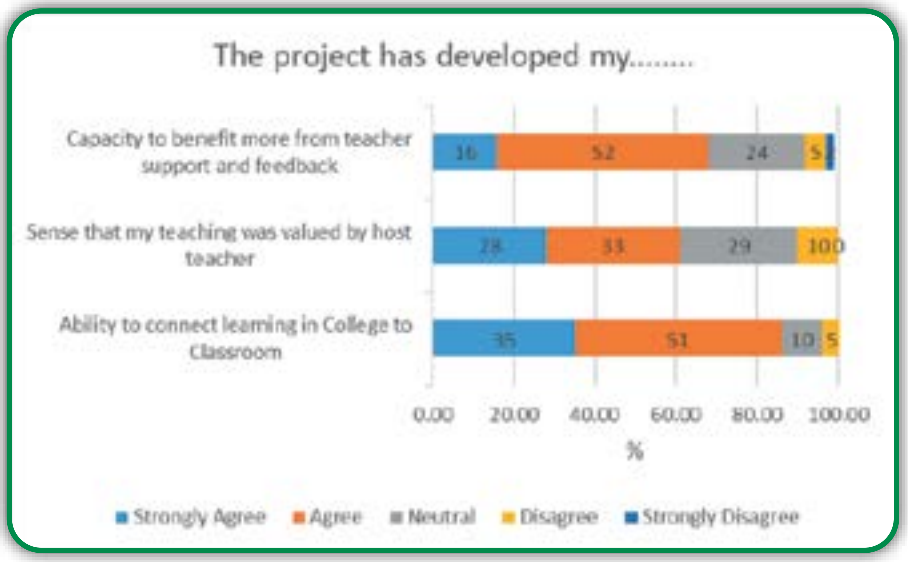

Figure 4 Impact on student teachers' learning experience during placement.

But now that I've taught it, I realise that I can do it and why it is important. (Year 2 student teacher)

In addition to developing their classroom practice, the year 2 students felt that the project had increased their science subject knowledge and their ability to connect science concepts and enquiry skills to the topic they were teaching.

Interestingly, the project seemed to help the students to be more reflective during their placement and better able to relate their classroom experience to aspects of theory and pedagogy that they had studied back in college. The fact that they were bringing ideas and resources to their school made students feel more valued (Figure 4):

It was helpful that we could start planning the placement lessons when we were still in college and get ideas and support from the tutors. It also meant that when I was teaching and then evaluating my lessons I was thinking about what we learned in seminars and if the pupils were getting the different enquiry skills. I prefer this joined up approach.

A number of students reported that they developed a better relationship with their host teacher and that feedback was more useful:

It was like the feedback wasn't always just about me, but was looking at the activities and how they could be developed. I felt I was playing a part in creating something.

Student feedback from the project raises poignant questions for initial teacher education (ITE) regarding its mode of delivery, the student teacher role and the relationship between theory and practice.

Impact on teachers

A baseline survey of the teachers evidenced the low profile of science in primary schools. Approximately three-quarters of the teachers reported teaching no more than 30 minutes of science per week. Encouragingly, almost all believed that there should be more science taught in the primary school. The areas in which teachers felt they could be best supported included access to resources and in-service training (Figure 5).

The project was considered to have been useful by 91% of teachers and 65% felt that they would teach more science in the future. The useful aspects of the project included:

- The opportunity to directly observe that their pupils were highly engaged and really enjoying the science lessons.
- Seeing that science lessons can involve ordinary everyday materials and do not have to require specialist equipment or resources.
- Access to high-quality resources.
- Having taken part and/or observed the science lessons, the teachers felt very more likely and ready to adopt them in their future practice and schemes of work.
- The project provided a wide range of ideas and teaching approaches within the chosen topics.
- The project provided lesson plans and the instructional video to support the teacher and the school in the future.
- Involvement in the project increased the profile of science across the school.

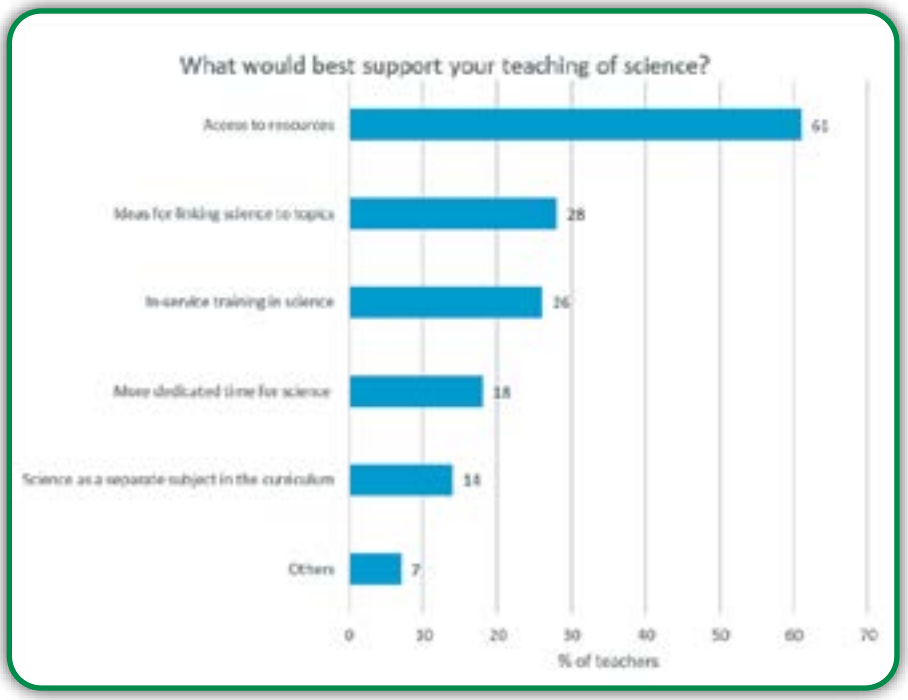

Figure 5 What teachers considered would best support their teaching of science

Table 1 The benefits of meaningful partnership

Stake holder	Benefits
ITE institutions	Allows for closer alignment of ITE curriculum and pedagogy with current classroom practice and needs. Ensures tutors 'keep in touch' with practice.
Schools	Provides access to resources and communication with ITE subject specialists.
Student teacher	Provides time and support to focus on science within a supportive environment, where new practice can be explored.
Teacher	Provides a form of in-service training that is situated within their own classroom and tailored to their needs, over an extended period of time.

As the teachers commented:

Seeing how engaged the children were with the practical experiments and demonstrations has certainly encouraged me to do more science.

It has reminded me of how exciting and important these lessons are, so I will make sure I allocate time for them more often.

It has prompted me and my year group to look into our planning and ensure we are including more science in it.

Conclusion

Although it is almost a decade since we were alerted to the small proportion of time allocated to science within primary schools in Northern Ireland (Johnson, 2013), there appears to be little change in this situation (ETI, 2015; Perry and Irwin, 2015; Burge *et al*., 2020). While funding directed at particular curriculum development projects within small clusters of schools has produced some high-quality resources, wider dissemination and coordinated support to all schools in Northern Ireland seems to have been overlooked.

Perhaps utilising ITE institutions' wide network of partner schools might offer a 'way into' more primary classrooms and a starting point for support and professional growth over the course of the school year. This would however require closer and more meaningful partnerships between schools and ITE institutions, and enable classrooms to become the sites of learning for both student and teacher.

We feel that the project outcomes evidence the benefits to all parties when ITE institutions and schools, teachers and student teachers, work more closely together (Table 1). This would require small, but worthwhile changes in practices within both ITE institutions and schools. On the part of ITE this calls for greater connectivity between the modules taught on campus and the students' placement in school. Student teachers would require considerable support in planning and resourcing their lessons and, in the case of students who may not feel particularly confident in science, a great deal of encouragement. Assessment tasks should be designed to encourage and reward agency and innovation and acknowledge that learning often involves going beyond the comfort zone. Participating schools could consider which aspects of their science provision they might develop when assigning students to particular teachers.

If we want to increase the quality and quantity of primary science taught in our primary schools then teacher educators must work more closely with their partner schools. If we don't innovate and change our approach, how can we expect things to change?

Acknowledgements

We would like to thank the Royal Society of Chemistry Outreach Fund for supporting this project, Ms Ilva Prindule for her diligent management of all the resources, and Dr Nick Barker, Schools Outreach Fellow (University of Warwick) for the inspiring demonstration lecture and his expertise.

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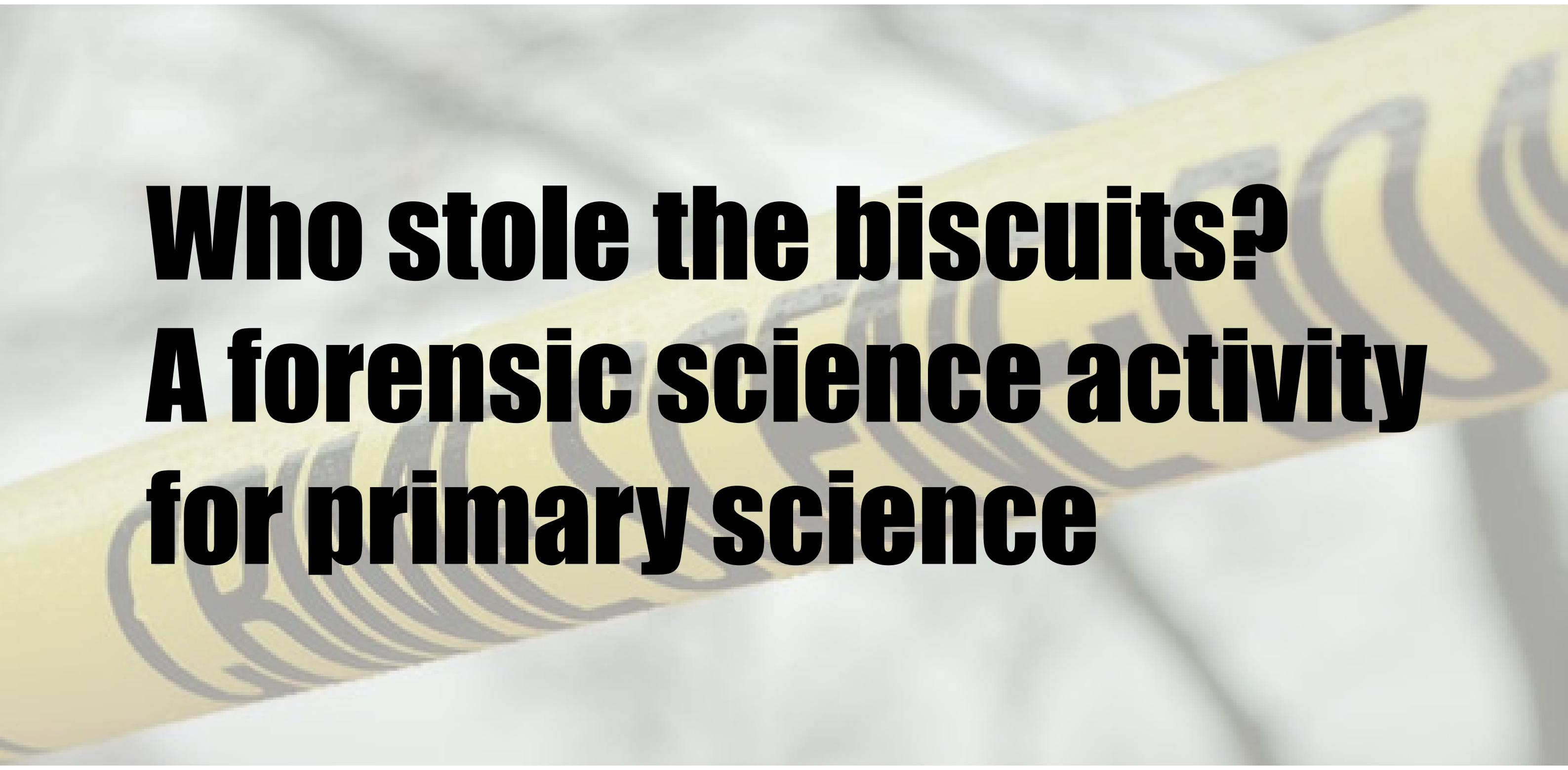

Who stole the biscuits? A forensic science activity for primary science

Ian Turner and **Lewis Morgan** present a series of lesson ideas that capture the excitement of a forensic investigation in a fun and light-hearted scenario

Forensic science is an applied science that utilises the scientific method to answer questions in the context of the law. At its core, forensic science is a very transdisciplinary subject that incorporates the principles of biology, chemistry and physics within crime scene, forensic and criminology disciplinary contexts. Forensic science's strong focus on the development of investigation skills make it a very attractive subject when designing science experiments. However, its sensitive subject matter has traditionally been seen as a barrier to successful integration of the subject into the primary school science curriculum. The consequences of serious crimes and the biological nature of many of the most common forms of evidence (e.g. blood and seminal fluid) are often not deemed appropriate to this age range. Here, however, we present a series of lesson ideas that capture the excitement of a forensic investigation and develop children's investigation skills, using a fun and light-hearted scenario.

The case of the stolen biscuits

The case begins with children watching a short video of a teacher opening their biscuit tin to find it empty. The camera then pans round to show the 'guilty looking' faces of other staff, the suspects in the case. The video is shown to children in the class before they undertake the crime scene investigation and is a great way of creating context for the children to gain some investment in their learning. At this point, the children should be asked about the likely culprit; this allows a short discussion on how they could work out who is guilty. Links can be drawn here to making scientific predictions and this element of working scientifically can be taught and emphasised.

Before travelling to the crime scene to collect evidence, the role of real 'crime scene investigators' can be introduced so that real-life context and connections can be developed further.

The scene is set up in a school hall or large open space (Figure 1). Children can wear gloves, white suits and shoe covers to really enhance their experience. It is important to link the protective clothing to preserving the evidence at this point. Box 1 lists some suggested things to think about for your crime scene.

After the evidence has been collected and observational drawings have been made, the children start a series of lessons exploring the different elements outlined in Box 2. The success of the exercises is informed by scientific questioning and observation skills. A good way to introduce this to children is through the so-called Kipling Six: What, Why, When, How, Where and Who. These are

Key words: Forensic science Investigation Working scientifically

a series of questions that can be asked periodically to check understanding, that is, *What happened? Why did it happen? When do we think it happened? How do we thing it happened? Where do we think it happened?* and *Who do we think is responsible?*

Scientific principles

Each piece of evidence is based on an established branch of forensic science. Each could be incorporated into a discussion with children.

Fingerprints are the tiny patterns on the tips of every finger. They are made of ridges and form three basic patterns called loops, whorls and arches. When a finger touches a surface the sebaceous secretions leave a fingermark. They can be detected, collected and identified using chemical treatments, which vary depending on the surface. Once identified by an expert the fingermarks are called fingerprints

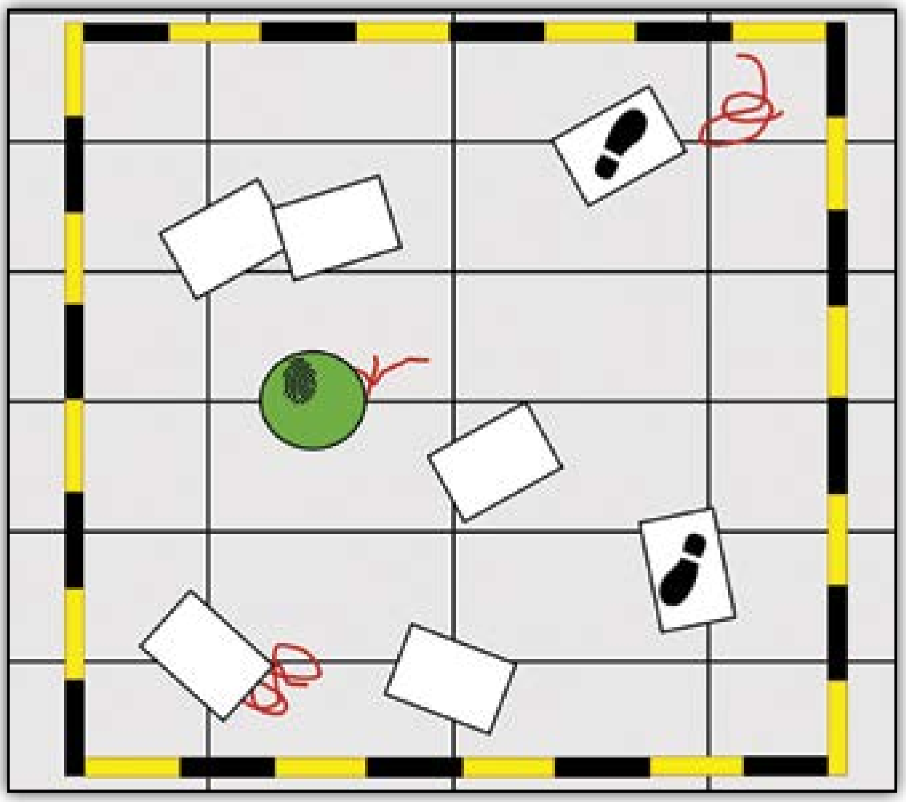

Figure 1 Layout of the 'crime scene' showing the set-up of the various evidential items: fingermarks, fibres and footprints

Box 1 Ideas for your crime scene

Fingermarks

- The biscuit tin should be wiped clean with a dry clean cloth. Then the perpetrator should wipe their finger across their forehead and place 2–3 fingermarks on the tin. The forehead contains high volumes of sebaceous and sweat glands, the secretions from which should leave clear marks. They should be visible by rotating the tin in the light.
- When the fingermarks have been located, they can be collected by the pupils by dusting and lifting.
- Dusting the fingermark adds contrast and helps create an authentic experience. A make-up or mascara brush, with loose hair, works perfectly here. Touch the brush gently in any coloured powder, and then waft the brush (rotated side-to-side) just above (not touching) the fingermark. Small particles of powder should then transfer and stick.
- Cut a piece of wide sellotape and place it firmly over the mark. Then lift the tape and place it on a pupil collection sheet.
- If unable to use make-up brushes, the fingermarks can be lifted directly and placed on the collection sheets. The contrast may not be high, but this can be corrected by using a dark-coloured contrast material.

Fibres

- Ten to twelve fibres, the majority of which match the perpetrators, should be spread around the crime scene. A note should be made of their location for assistance later on. It may be beneficial to place the fibres under or near something fixed (e.g. trapped under the lid of the biscuit tin to prevent them blowing away).
- The fibre can be collected by the pupils using plastic tweezers and they can be examined for colour using the eye or microscopes or hand lenses if available.
- A mixture of fibre colours that match several suspects can add some complexity to the pupils' investigations

Footwear marks

- Several sheets of paper (from the recycle bin!) are spread out on the floor in a random fashion.
- The perpetrator should place their shoe in a tray of soil and press down firmly. Then they should walk in normal fashion across the various sheets. This will leave a series of footmarks of descending evidence value.
- As well looking at the tread pattern children may wish to measure the footprint and speculate on the size of the individual that produced it. A shoe with multiple tread patterns adds complexity.

and can be used as a form of identification. Fingerprints are unique, even among identical twins.

Fibres are very common in everyday life, making up our clothes, upholstery, carpets and many other objects. They are a form of trace evidence that is often transferred at a crime scene. They can be classified as natural, from plants (e.g. cotton) and animals (e.g. wool), or manmade (e.g. polyester). Visually they are examined by microscopes, including high-powered scanning electronic microscopes. Aspects of fibres such as dyes used to colour them can be further analysed by a range of analytical chemistry techniques.

Footwear evidence is the marks left by shoes, boots and trainers at a crime scene. Initially using pattern recognition and databases, the focus will be on identifying the make and model. Individual wear patterns can help match a mark to a specific shoe; it may also reveal information about the gait and weight of the wearer.

Everyday materials

Statutory requirements

Pupils should be taught to:

- distinguish between an object and the material from which it is made
- identify and name a variety of everyday materials, including wood, plastic, glass, metal, water, and rock
- describe the simple physical properties of a variety of everyday materials
- compare and group together a variety of everyday materials on the basis of their simple physical properties.

Uses of everyday materials

Statutory requirements

Pupils should be taught to:

- identify and compare the suitability of a variety of everyday materials, including wood, metal, plastic, glass, brick, rock, paper and cardboard for particular uses
- find out how the shapes of solid objects made from some materials can be changed by squashing, bending, twisting and stretching.

Figure 2 Suggested links to the curriculum

Box 2 Series of lessons related to 'Who stole the biscuits?'

Teaching session	Activity	Science objectives	Cross-curricular links and ideas
Session 1: The crime			
● Watch the stimulus video created by the teacher. ● Take the children to the crime scene. See Figure 1 for the setup of the hall. White suits, shoe covers, etc., can be added here to enhance the experience of a crime scene. ● Children carry out close observations using scientific equipment, such as magnifying glasses, as they search for clues for who stole the biscuits.	● Children can use various cameras, tablets, etc., to take photographs of the pieces of evidence. ● Children can create a map of the evidence that was collected. ● Children choose one piece of evidence and carry out careful observation of this and then sketch and label their piece of evidence. ● From this, children can begin to make predictions and ask further questions that they want to find answers to.	**Working scientifically:** ● Asking simple questions and recognising that they can be answered in different ways. ● Observing closely, using simple equipment.	**Art:** Close observational drawing provides an opportunity to learn pencil control and the various sketching techniques. **Writing:** Could the children write a story using their ideas about how the biscuits were stolen? **Geography:** The crime scene presents a great opportunity for children to begin thinking about creating a map of where they found the evidence. **Computing:** Children could take photos of the evidence and collect these using various pieces of software.

Box 2 Series of lessons related to 'Who stole the biscuits?' – *Continued*

Teaching session	Activity	Science objectives	Cross-curricular links and ideas
Session 2: Fingerprints everywhere!			
● Show the children that you have managed to collect the biscuit tin. Can the children spot there are fingerprints all over the tin? ● Introduce the science of fingerprints: – What are they? – Why are they unique? – How are they used? ● The police are stuck! They need a good way of matching the fingerprints on the tin to the person they arrest for stealing the biscuits.	● Can you help find the best material to be the most effective at lifting fingerprints? ● Children create a piece of fingerprint artwork using a variety of materials: chalk, pencil, paint, water paint. ● When the artwork is complete, children can then discuss the properties of the materials to decide which is best. They may observe that a material is 'too sticky', 'too runny,' etc.	● Describe simple physical properties of a variety of everyday materials. ● Compare and group together a variety of everyday materials on the basis of their simple physical properties. **Working scientifically:** ● observing closely, using simple equipment.	
Session 3: Fibres			
● Introduce the various tiny fibres that were collected from the crime scene. *Ensure the fibres have come from different materials and are of different colours.* ● Allow the children to unpick fibres and take apart large pieces of material to see how they are made. ● Allow children to explore the fibres with microscopes and hand lenses. ● Talk to the children about where clothes come from and what they are made from. ● You can then introduce different materials for different purposes and move on to the wider world of brick, glass, wood, etc.	● We have collected various fibres and small pieces of material from the crime scene. ● Have a variety of fibres and materials on each table. ● Children observe these closely and feel them carefully. ● Children describe their physical properties and build a bank of physical properties for each. ● Can they then match the fibres and materials to their original source? This could be a physical source, i.e. the original jumper the fibres came from or the block of wood the piece of wood came from, or, depending on the ability of the group and availability, it could be pictures of the original material with describing words to match. ● Once resources have been matched, children could then try to draw scientific conclusions from what they found.	● Distinguish between an object and the material from which it is made. ● Identify and name a variety of everyday materials, including wood, plastic, glass, metal, water and rock. ● Describe the simple physical properties of a variety of everyday materials. ● Compare and group together a variety of everyday materials on the basis of their simple physical properties. **Working scientifically:** ● Identifying and classifying. ● Using their observations and ideas to suggest answers to questions.	**Sustainability and the environment:** This could be a really good chance to introduce the concept of sustainable materials for clothing and also where our clothes are made, etc.

Box 2 Series of lessons related to 'Who stole the biscuits?' – *Continued*

Teaching session	**Activity**	**Science objectives**	**Cross-curricular links and ideas**
Session 4: Footprints			
● Introduce footprints and the photos you collected from the crime scene. ● Using large pieces of paper and different types of shoes, allow the children to experiment making footprints and comparing them. ● Get the children to match footprints to certain shoes from different groups just by looking at the bottom of the shoes. ● Groups could measure (using non-standard units) the soles of the shoes and measure the footprints to compare.	● The biscuit thief needed to get away quickly so they wouldn't get caught. ● Set up a simple test to see which shoe is the most grippy so that the thief wouldn't slip over. You could use ramps and a variety of shoes to see which one slides down the ramp or simply pull the shoes along the carpet to experience the friction of each.	**Working scientifically:** ● Observing closely, using simple equipment. ● Performing simple tests. ● Identifying and classifying.	**Maths:** This is a great chance to get the children measuring length and width of the footprint or shoe. Non-standard units can be used such as Lego bricks or cubes.
Session 5: The culprit			
● Discuss with the children the information they have found on the fingerprints, the colour/type of fibres and the shoes worn by the thief. ● Work with the children to use the evidence they have collected to find out who is the most likely culprit. ● Finish with a CCTV-style video of the culprit sneaking in and stealing the biscuits to see if they were correct.	● Have a master sheet per table with the culprit's fingerprint, footprint and photo of what they were wearing. ● Children have a copy of the footprint, fingerprint and fibre found at the scene. ● Can the children match the evidence they have to the culprits? ● Children can then write about who they believe stole the biscuits and why they believe this links back to evidence they have found.		● Now the case has been solved the children could create a newspaper story about the crime or write their own crime-solving story.

Conclusion

This sequence of lessons could form the basis of a really good discussion point with your children about 'weight of evidence' and the formulation of conclusions. It could be a good opportunity to discuss with the children that science is not always totally conclusive.

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Hidden gems – a different way of teaching life cycles

Nicola Gliddon, an outdoor education and nature connection teacher, shares how dock leaves can reveal a whole new world

Figure 1 Imparting a sense of guardianship over nature to children may be one of the most valuable impacts we can make as educators. © Belmont Estate

Life cycles – over and over again

One of the United Nations Sustainable Development Goals is 'Life on Land' (SDG 15) and this can be explored practically through real hands-on experiences that connect children with the land upon which we all depend. Imparting a sense of guardianship over nature to children may be one of the most valuable impacts we can make as educators.

After being a class teacher for over a decade, I found that working outside all day on a rewilding site makes you view teaching differently. Ideas of how to teach certain aspects of the curriculum are challenged and nature presents endless new opportunities. Our job as educators is to look for them!

Ask most primary school teachers how to teach life cycles and you will likely hear reference to frogs, caterpillars and chickens, along with mental images of butterflies fluttering around a netted container in a stuffy classroom and the endless search for the key to the school pond padlock. There is awe and wonder in having tadpoles in the classroom and 'growing' butterflies to release onto the school field but there are of course endless examples all around us of other life cycles that children can observe, identify and learn from. The ubiquitous, but often overlooked, familiar dock leaf plant can provide us with a wonderful new way to observe the stages of a life cycle.

Which plant would you reach for if stung by a stinging nettle?

Dock leaves are synonymous with our British landscape and their link with stinging nettles is probably what makes them familiar to most of us. But did you know that there is a rather fetching insect that lives out its whole life cycle on a single dock plant? The green dock beetle, *Gastrophysa viridula*, is a beautiful iridescent insect that resembles a tiny jewel. Green with sheens of gold, red and blue, they live almost exclusively on dock and often all stages of the life cycle can be found at once, on one plant, from March to October.

What a delight to not wait months for sad-looking caterpillars to pupate in their pot of brown food paste before being released as somewhat harried butterflies into the hands of eager children on a barren playground! The children can observe, all at once, a life cycle right before their eyes!

What's up Dock?

If you aren't confident with your identification skills, here are some quick tips on finding a patch of dock plants. The correct name for the plant we are looking for is broad-leaved dock – scientific name *Rumex obtusifolius.*

Look on the edges of fields, hedges or woodland, and especially near any water. Docks like light and moisture and, as they can grow up to 1 metre high, they are best found where the grass isn't mown every two weeks.

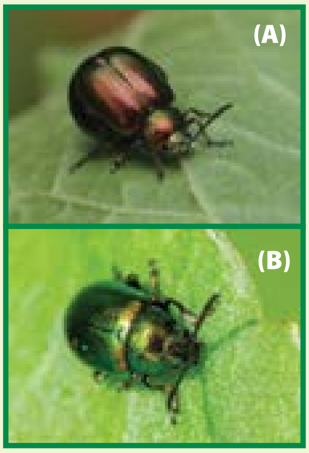
Docks have large, leathery leaves with no furry underside (comfrey is furry and in my experience is often mistaken for dock by adults). The leaves are green, often with red splodges over the leaf surface and

Key words: Life cycles Outdoor learning Rewilding

Box 1 Life cycle stages of the green dock beetle, *Gastrophysa viridula*

- **Eggs:** Bright yellow/orange clusters of between 20 – 50 eggs at a time on the underside of leaves.

- **Larvae:** They go through different stages before pupating underground into their adult form. The easiest ones to spot are the dark brown/black larvae on the underside of the leaves as they munch away.



- **Adults:** A beautiful iridescent green, they 'play dead' when handled and will roll like a pea into the centre of your hand or drop to the ground. The females often have very swollen abdomens full of eggs (A) so the males tend to look smaller (B).

© Shutterstock

Figure 2 Broad-leaved dock, *Rumex obtusifolius.* © Pixabay

Figure 3 Flower spikes of broad-leaved dock in autumn. © Shutterstock

sometimes visibly red veins (Figure 2). Flower spikes begin as lime green with red edging but turn to a rusty red in autumn (Figure 3).

Green dock beetles – the life cycle

Finding the beetles is super easy when you have found a patch of dock. Look out for leaves that have been reduced to skeletons as a clear clue. The stages to look out for are shown in Box 1. As always, encourage children to handle wildlife with respect and care and return observed insects to the plant on which they were found.

Not just a pretty face

This tiny emerald beetle is an eco-system engineer. As they feast on dock leaves, reducing them to mere skeletons of veins and stem, they prevent dock from becoming too dominant in one area. Nature is healthiest when in balance so natural processes like this can be vital to an ecosystem.

Rewilding projects, like the one at Belmont Estate, are as much about restoring balance to smaller natural processes as introducing beavers and wolves. As time passes, we may notice different species taking over until the ecosystem balance is restored. By discovering the delights of dock beetles, you can open up a wider conversation about the need for balance within ecosystems and adaptation of species to their environment.

Nicola Gliddon works at Belmont Estate in Somerset, which provides free nature-based education for children and young people.
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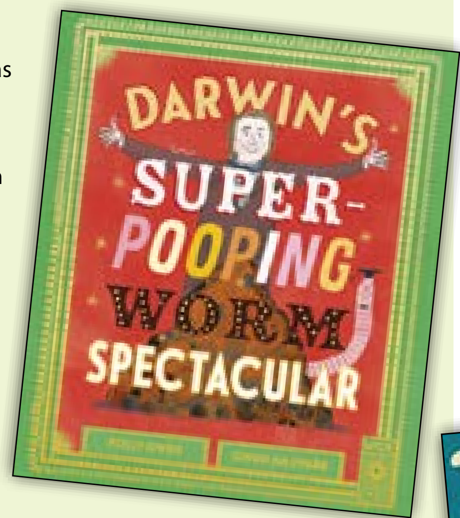
Darwin's super-pooping worm spectacular

Polly Owen and Gwen Millward
London: Wide Eyed Editions, 2023
32 pp. £12.99
ISBN 978 0 7112 7595 9

Full of surprising and fascinating facts of interest to any 7- to 11-year-old



This book was a real surprise to me; even as an adult, I learnt new and fascinating facts. Many of us instantly associate Darwin with *The origin of species* but he was also passionate about worms; this book tells how his love for the worm enabled him to realise how the humble worm is the most important animal on our planet. Don't believe this? Well, read this book!

This is a non-fiction book with cartoon illustrations incorporating an ongoing narrator in the form of a worm. It gives examples of the various investigations that Darwin undertook with worms, testing their light, smell and sound sensitivity. An aspect that was truly amazing and that all children will love is – yes – you've guessed it – poo! Did you know *'Worms add an inch of poo to the soil every five years'*?

I thoroughly enjoyed reading this book as did the children in my class. It has short, snappy, easily read sections of information. Ideally, it should be read from front to back but I noticed a number of my class picking it up and just flicking through it, reading odd pages of information, which often hooked them – they would take it off the display to read it more fully.

This book could be used as a general-interest book for any 7- to 11-year-old child, not just those studying evolution in year 6. It links to soils and their creation, usually taught to ages 7–9. It has a fact section, at the back of the book, along with suggestions as to how we can promote earthworm survival and even a link to the Earthworm Society. Most interestingly, there is even a worm species named after Darwin: *Geophagus Darwini.*

Jane Banham

STEM Lead, Friskney All Saints Primary School

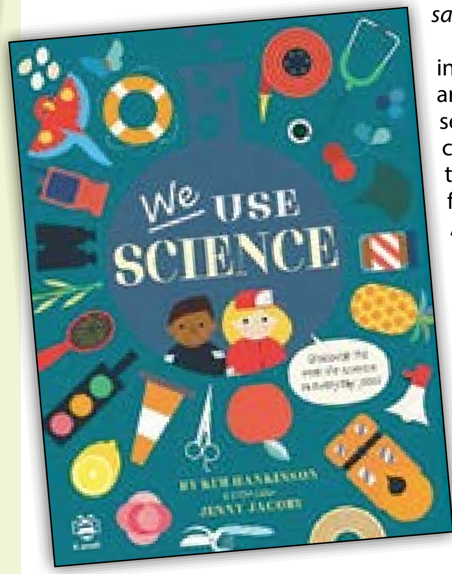
We use science

Kim Hankinson, with STEM Editor Jenny Jacoby
London: b small publishing, 2022
32 pp. £7.99
ISBN 978 1 913918 22 4

Explains the real-life science in everyday jobs, suitable for ages 6–12

We use science is a colourful and interesting information book that teaches children about many different occupations. Each double-page spread features an amazing job: from smoothie maker to lifeguard! It explains what that person does and how they make use of everyday science – possibly without even realising it. There are delightfully labelled illustrations along the bottom half of the page that show the equipment the worker will need; for example, a delivery driver will have boxes, a vehicle and a GPS device.

Some of the professions are obviously science-based, such as doctor and zookeeper, while some are ones you might not have considered, such as a traffic officer and dog groomer. The book explains the technical knowledge that would be needed for these occupations, going into detail about how a fire-fighter extinguishes a blaze by removing one of the elements of the fire triangle: oxygen, fuel and heat. On page 27, the book explains how a dog groomer uses shampoo to get the dirt out of the dog's fur. It teaches us that soap is needed to get the dog clean because the tails of the soap molecules are attracted to the dirt and end up surrounding it, *'creating lots of little dirt droplets'* that *'carry the dirt away from the skin, into the water'.*



The general information about STEM professions could be read to children of age 6–7 as they would enjoy looking at the illustrations of the equipment; whereas, the more detailed scientific explanations and diagrams that show how aspects of each job work will be more appropriate for the older end of the age range, that is 11- to 12-year-olds. This book would be useful in classrooms and fits well into the science curriculum. It encourages children to think about which professions make use of the science they learn in school.

Catherine Ward-Lynch

Y1 teacher, Bowlee Park Community School, Manchester

Nature Heroes: Ava loves rescuing animals

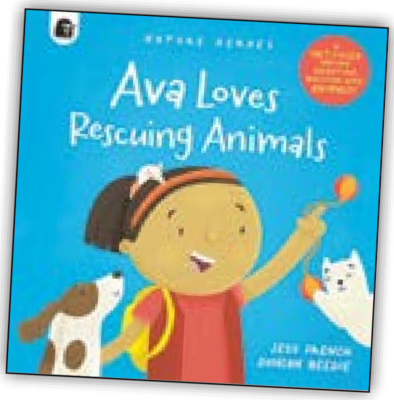
Jess French and Duncan Beedie
London: Happy Yak, 2023
48 pp. £7.99
ISBN 978 0 7112 6771 8

An excellent addition to any primary school book corner for 7+ children or to support teaching 5–11s

This is one of a series of books that focus on different aspects of the environment through the eyes of children. They encourage children to go outside and begin to explore their natural surroundings. Other books in the series include *Billy loves birds, Bella loves bugs* and *Pedro loves saving the planet*.

The text is clear, informative and written in an engaging way, with a selection of illustrations that complement and enhance the narrative. The book is a fantastic mix of fiction, as Ava spends the day with her grandparents, interwoven with non-fiction, as they study life cycles, habitats etc.

The book is aimed at children aged 4–7 but children in my class of 9- to 11-year-olds enjoyed reading it, especially the double-page spread about ecosystems. I have already passed it on to my colleague, who teaches 7- to 9-year-olds, to support them when looking at the characteristics of vertebrate groupings!



The main character is Ava, who longs to be a vet, and spends much of her time at her grandparents' animal rescue centre. The book follows her experiences while she is there. As Ava starts each of her visits to the rescue centre she comes across an animal and the book focuses on different aspects of its life. For example, when Ava visits the pond, her grandmother discusses the characteristics of amphibians and the frog life cycle with the use of diagrams and fun facts.

The text use footprints and poo – always a winner with children – to work out which wild animals have been in the fields, for example deer and foxes. As Ava continues her day at the rescue centre, she learns about food chains, omnivores and habitats.

This book would be an excellent addition to any primary school book corner and has opportunities to be used with a wide range of age groups. It can be read as a lesson input, or accessed by children reading for pleasure.

Jane Banham

STEM Lead, Friskney All Saints Primary School

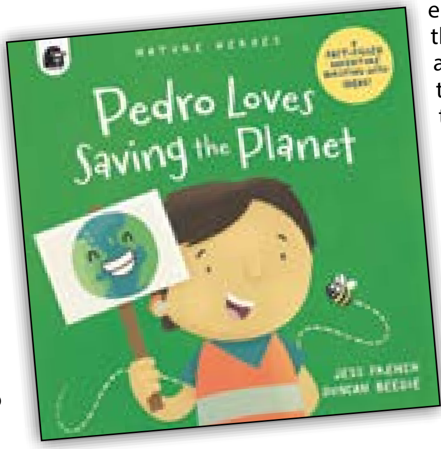
Nature Heroes: Pedro loves saving the planet

Jess French and Duncan Beedie
London: Happy Yak, 2023
48 pp. £7.99
ISBN 978 0 7112 6775 6

A fantastic mix of fiction and non-fiction to support teaching 5–11s or for 7+ children to read themselves

This is one from a series of books that focus on different aspects of the environment through the eyes of children. They encourage children to go outside and begin to explore their natural surroundings. Other books in the series include: *Billy loves birds, Bella loves bugs* and *Ava loves rescuing animals*.

The text is clear, informative and is written in an engaging way, with a selection of illustrations that complement and enhance the text. The book is a fantastic mix of fiction, as Pedro spends the day with his friends in the eco-cabin, interweaved with non-fiction as they study, for example, renewable and non-renewable sources.



The book is aimed at children aged 4–7 but children in my colleague's class aged 7–9 enjoyed reading it. They especially loved the brilliant bug page, which focused on all the really important jobs they do, such as decomposition and pollination.

The main character is Pedro, who belongs to his school's eco-club and spends much of his time in the school's forest cabin discovering how to plant seeds, recycling and even why electric cars might help protect the planet. The book covers, in a simple but informative way, things that children can do to improve the environment, such as walking or biking to school, turning off the taps when cleaning their teeth and turning off lights when they leave a room. The seven Rs, *rethink, refuse, reduce, reuse, repurpose, recycle* and *rot it down*, are discussed with child-friendly examples.

This book is a winner for me as a subject leader, especially as it has opportunities to be used with a wide variety of age groups. At the same time, it can be read as part of lesson input, as well as accessed by children for reading for pleasure.

Jane Banham

STEM Lead, Friskney All Saints Primary School

Mary Anning – A Fossil Hunter's Story

"This project enabled pupils to look at science from a much broader perspective. It challenged their existing ideas and prompted them to raise questions and have very meaningful class discussions"

Our award-winning film, SEA DRAGON, sets the scene for the whole project, introduces trail-blazing paleontologist Mary Anning, and reflects the themes and main ideas being addressed through the learning activities.

This interactive resource features a series of nine core and six enrichment activities which give insights into Mary's life, explore the science of fossils and reflect on the influence of historical, cultural and religious thinking in changing ideas.

The activities are designed to be used flexibly, mainly in science lessons but in some cases are equally appropriate in history, religious education and English. Each activity includes key questions, curriculum links and vocabulary, what children do and learn, classroom resources plus background information for teachers.

Access the resources and award-winning film at:
ase.org.uk/mary-anning

BIG QUESTIONS in CLASSROOMS

The Association for Science Education

TEMPLETON WORLD CHARITY FOUNDATION