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Primary Science Teaching Trust

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Editorial

● Sarah Earle

Building on the last issue's sustainability theme, we begin with two articles that continue this discussion. In his research review, **Andy Markwick** places environmental consciousness as a foundation for the other pillars of sustainability. He proposes that such emphasis on the environment should be paramount, and that more needs to be done to support the active engagement of children by embedding Education for Sustainability and authentic contexts at the heart of the curriculum.

In the next article, **Jennifer Rudd, Geraldine Lublin, Joanna Kusnierek** and **Marina Saez Lecue** describe exactly that, *Recycling+*, a programme of work to address the real problem of fast fashion. The cross-discipline team capitalises on the opportunities afforded by the new curriculum for Wales to construct a week of cross-curricular learning.

The active role of children is considered through a different lens in the next article, where **Andrew Manches and Euan Mitchell** describe a large-scale international study on Embodied Learning. The way in which we interact with the world, with and through our bodies, is a growing area of interest for science educators (Kersting *et al*, 2021). Their *Move2Learn* project considers the role of gesture, movement and sensory experiences in supporting and expressing young children's science learning.

The following article from **Cherry Canovan, Joanne Pledger and Ruth Spencer** also utilises a full body approach, exploring the way that dance can be used with learners to explore the teaching of the *Earth and space* topic. *Into Our Skies: Space in Schools* again draws together a cross-discipline team, who bring together the science content and the active involvement through dance.

The final article from **Scott Walker and Christina Whittaker** raises questions around how we support the active involvement of children in science. Their longitudinal analysis of nominations for the local *School Physicists of the Year* finds that such a scheme, and associated local initiatives, appear to support increased engagement, but may not address unconscious bias in those doing the nominating.

The last article reminds us that not all interventions may lead to the desired effect, that all studies have limitations and there may be unintended consequences arising from initiatives. Similarly, the first article notes the increasing prevalence of eco-anxiety, as children become more aware of the environmental problems facing the world (Coffey *et al*, 2021). Although, such an emotion can also be a useful driver, motivating action (Kurth & Pihkala, 2022). Perhaps this is where the role of the practitioner is key, to provide a practical outlet or call to action, to feel empowered rather than powerless. It is the careful and sensitive implementation by expert practitioners that will make the difference as to whether such initiatives support the active involvement of children in their learning.

References

Coffey, Y., Bhullara, N., Durkin, J., Shahidul Islam, M. & Usherb, K. (2021) 'Understanding Eco-anxiety: A Systematic Scoping Review of Current Literature and Identified Knowledge Gaps', *Journal of Climate Change and Health*, **3,** 100047. https://www.sciencedirect.com/science/article/pii/S2667278221000444

Kersting, M., Haglund, J. & Steier, R. (2021) 'Growing Body of Knowledge: On Four Different Senses of Embodiment in Science Education', *Science & Education*, (30), 1183–1210. https://link.springer.com/article/10.1007/s11191-021-00232-z

Kurth, C. & Pihkala, P. (2022) 'Eco-anxiety: What it is and why it matters', *Frontiers in Psychology*, (13), 981814. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.981814/full

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Educating for sustainability

● **Andy Markwick**

Abstract

This article reconceptualises sustainability as being built upon a foundation of environmental consciousness and understanding. It explores the current thinking around education for sustainability to offer an alternative curriculum view: a view where sustainability permeates throughout the primary curriculum and is driven by pedagogies that offer children opportunities to grow their confidence, challenge ideas and offer solutions to the local, national and, ultimately, global problems they will face through their lifetime. By increasing children's sustainability capital and their agency towards these challenges, we can reduce eco-anxiety.

Keywords: Sustainability, environmental consciousness, curriculum, pedagogy, eco-anxiety

Introduction

The world faces many complex and non-linear anthropomorphic sustainability challenges, which are now only beginning to be understood, and with a greater recognition that considerable and immediate change in the ways in which we interact with our environments is required (Kioupi & Voulvoulis, 2019). World governments are making high profile decisions to address the severe global issues that we are all facing. UNESCO (2017, 2019) have presented 17 agreed areas of focus termed Sustainability Development Goals (SDGs), summarised in Table 1.

It may also be beneficial to revisit *The Earth Charter* (2000), which was the outcome from the 1992 Earth Summit in Rio de Janeiro. The charter promotes the following themes:

- Respect and care for our communities of life
- Ecological integrity
- Social and economic justice
- Democracy, non-violence and peace.

It would be very hard to argue against any of these requests and, indeed, we might consider using these themes to restructure education.

Without question, children have a vested interest in decisions being made now, as these will undoubtedly influence their lives substantially more than those who have made the decisions, and so it is imperative that children have the agency to join in the debate. For children to be best placed to contribute towards the ongoing debates surrounding global issues such as climate change requires them to have knowledge of key factors affecting the degradation of our environments and depletion of our resources.

Media reports of the potential for global environmental disasters occurring, if governments do not act immediately to change their current trajectories, are fuelling the spread of eco-anxiety amongst our young (Panu, 2020). Children have become acutely aware of issues such as global warming, water shortages, famines, deforestation, the destruction of ocean life and the resultant loss of habitat for *flora* and *fauna*, and they often feel helpless to do anything about it (Hickman, 2020).

Teachers are in a key position to support children's understanding of the many issues that we face both globally and locally, and to develop children's agency for making the confident and well-informed decisions needed to inform their futures.

Table 1. The UN 17 sustainability goals in greater detail.

Sustainability Goal	Aim
1. No poverty	To end poverty in all its forms everywhere
2. Zero hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Good health and well-being	Ensure healthy lives and promote well-being for all at all ages
4. Quality education	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
5. Gender equality	Achieve gender equality and empower all women and girls
6. Clean water and sanitation	Ensure availability and sustainability management of water and sanitation for all
7. Affordable and clean energy	Ensure access to affordable, reliable sustainable and modern energy for all
8. Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Industry, innovation, and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
10. Reduce inequalities	Reduce inequality within and among countries
11. Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
12. Responsible consumption and production	Ensure sustainable consumption and production patterns
13. Climate action	Take urgent action to combat climate change and its impacts
14. Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt the reverse land degradation and halt biodiversity loss
16. Peace, justice, and strong institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Partnerships for the goals	Strengthen the means of implementation and revitalise the global partnership for sustainable development

Recognition that curriculum change in schools is required to equip the next generation with the necessary skills to address the complex environmental, social and economic problems has been taken seriously by the Scottish (Vision 2030+, 2016), Welsh (Wales and the SDGs, 2019) and Irish (DoE, 2018) governments and, although rather late to the table, seen as important by the English government (DfE, 2021).

Environmental consciousness as a foundation of sustainability

An understanding of what is meant by sustainability is complex as evidenced by the wide range of conceptual frameworks and their ensuing interpretations (Purvis *et al*, 2018). One very prevalent description uses three interconnected pillars of Economic, Social and Environmental sustainability (e.g. Basiago, 1999; Molden *et al*, 2012), represented in Figure 1. For a more in-depth discussion of the historical foundations of theoretical conceptions of sustainability, see Purvis *et al* (2018).

The diverse interpretations of sustainability can in some ways be linked to the different emphasis placed upon each of the three pillars. Organisations such as the World Wildlife Fund have argued for greater emphasis being placed upon conservation (WWF, 1991), and Milne (1996) suggests that the priority should be placed upon social and environmental aspects, with economic criteria being subordinate. If the health of our environments is agreed to be of fundamental importance, a very different graphic can be envisaged (Figure 2, Table 2), one that places environmental consciousness and understanding as the foundation of all other aspects of sustainability, with secondary pillars considering social justice, transparent and accountable economics, and democratic leadership.

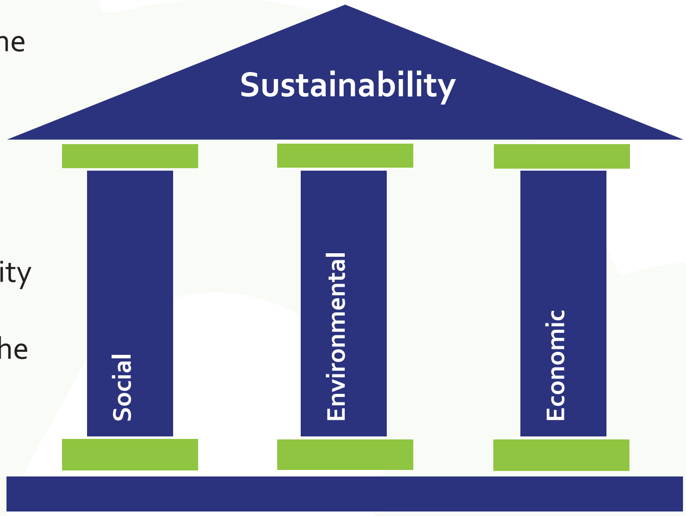


Figure 1. Typical representation of the three sustainability pillars.

It is argued, therefore, that all other factors presented within the sustainability model (see Figure 1) are acutely reliant upon an environment that is healthy and sustained. The critical focus upon eco-systems would help transform current behaviours towards ones that strive to provide protection for our world and its *flora* and *fauna*, and for non-negotiables such as safety and security, equality, democratic justice, and equal opportunity being agreed by humankind. The aim would be a flourishing world for all.

It is argued that the destruction of ecosystems has been almost entirely caused by the wealthiest nations and transnational corporations, yet the resultant consequences have been felt most by the poorest nations (Klein, 2014; ourworldindata.org). Examples of countries that are seriously affected by global warming include Bangladesh, the Maldives, Tuvalu and the Seychelles (Worldatlas.com; UN, 2021). For example, rising sea levels have resulted in unprecedented flooding in Bangladesh, where homes and crops have been destroyed. To better care for our planet, we should not be debating how to balance economic growth, protection of environments, social equality and progress for sustainability (Custance & Hillier, 1998); instead, we must argue for our environments to flourish. For humankind to acknowledge and appreciate that they are an integral part of the Earth's biosphere requires a good knowledge of the complex and fragile interactions between *fauna* and *flora* within ecosystems and this might begin within the school curriculum and with the inclusion of environmental education.

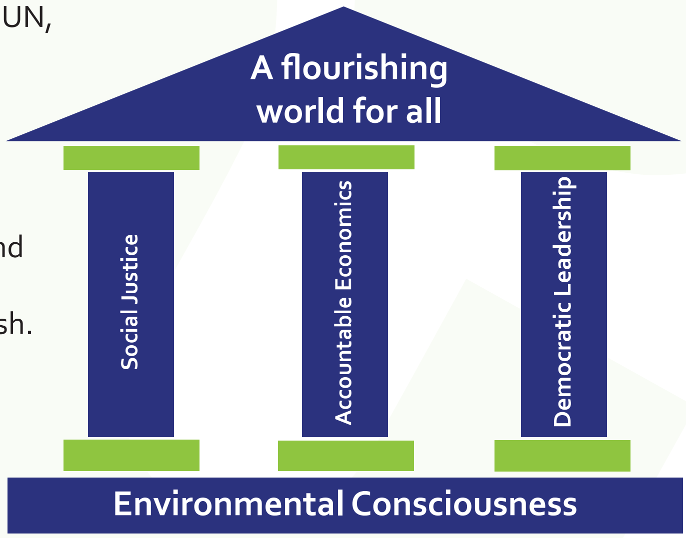


Figure 2. An alternative representation of the pillars for sustainability, and ultimately a flourishing world for all.

Table 2. Explanations for the sections in Figure 2.

<table>
<tr><th>Pillar</th><th>Explanation</th></tr>
<tr><td>Social justice</td><td>We need education to drive social justice, developing an understanding of the need for the equity in opportunities and privileges for everyone. We need a society where the more vulnerable are cared for. One where all humankind can support each other to flourish together (White & Reiss, 2014).</td></tr>
<tr><td>Accountable economics</td><td>Global, national and local transparency of economics is essential. Wealth should be distributed fairly so that people benefit equally. Pursuit of profit must not be made at the expense of protecting and growing our natural environments for all to enjoy.</td></tr>
<tr><td>Democratic leadership</td><td>Leaders need to think and act democratically. They are in 'power' to serve rather than to control. Their intentions should be to make the lives of others better. Democratic leadership is underpinned by a deep understanding and celebration of cultural difference, the importance of social justice and inclusivity.</td></tr>
<tr><td colspan="2">Environmental consciousness
Humankind must understand and appreciate how we are just one part of the complex ecosystems found on Earth. What we do influences the health of the planet. Environmental education will play a pivotal role in engaging the next generation of leaders in supporting the democratic pedagogies required to prepare future generations to act responsibly towards each other and our fragile ecosystems. Children should be able to consider the rights of other living things and become informed about eco-justice.</td></tr>
</table>

Panos and Damico (2021) argue that the power of the media can often distort the evidence about scientific findings to suit their specific agenda. In addition, readers will '*come to texts with their own ideas, values, perspectives and positions which "motivate" each of us to receive and accept information that aligns with our beliefs or confirms pre-existing perspective'* (p.3). Children are also vulnerable to such distortions of evidence and so it is vital that they are provided with evidence-informed, secure knowledge to enable them to understand how they are intrinsically part of the environment and how people's actions, both individually and collectively, can influence the health of an environment and ultimately all living things, including themselves.

Education for sustainability

For children to recognise, and be able to engage effectively with, the complex global challenges that they will undoubtedly face in their lifetime, there is a need to provide them with opportunities to learn how to collaboratively problem-solve, and apply a range of approaches that integrate a multitude of disciplines (Amos & Christodoulou, 2018). Children not only need to see the 'big picture', but to also explore it in detail in order to consider solutions (Scoffham & Rawlinson, 2022). Such Education for Sustainability (EfS) is supported by pedagogies that engage learners in the socio-scientific aspects of understanding global themes through active engagement and problem-solving approaches (Evans *et al*, 2016; Levinson, 2018). Rieckmann (2012) develops these ideas further by suggesting that the complex global challenges are often contradictory, or 'wicked' environmental problems, which require a 'systems approach' where solutions are found by accessing and integrating ideas from many disciplines. In schools, this might be explored by integrating cross-subject approaches to solve problems (e.g. Markwick, 2021; Strachan, 2022; Strachan & Davey, 2022). Increasing children's knowledge of the issues around the global challenges will increase their sustainability capital.

The English National Curriculum does not explicitly mention EfS, but this does not mean that it cannot be effectively explored through subject areas in the curriculum (DfS, 2013). Developing problem-solving opportunities for children through concepts of sustainability can help to develop scientific and mathematical thinking skills, communication and collaboration skills and a deeper appreciation of local, national and global citizenship (Markwick, in prep; Levinson, 2018). As Jensen (2014) suggests, we have a curriculum that is still educating children as if we have no planetary crisis. Scoffham and Rawlinson (2022) consider in some detail the essential reframing of education to meet these immediate challenges and provide several examples of how teaching across the curriculum might be envisaged. One might argue that, although our current curriculum does not have the integrity it needs for the future, there is potential to make incremental changes that move us closer to this goal.

It is also important to recognise that, too often, teaching and learning is dictated by what is assessed (Wright, 2002; Wormald *et al*, 2009). As Stergiovanni and Starratt (2007) suggest, assessment is often looked upon as *'the tail that wags the dog'*, meaning that *'what gets assessed gets taught'* (p.127). If ideas for addressing sustainability are not assessed, then it may be less likely that schools will change their curriculum or pedagogies.

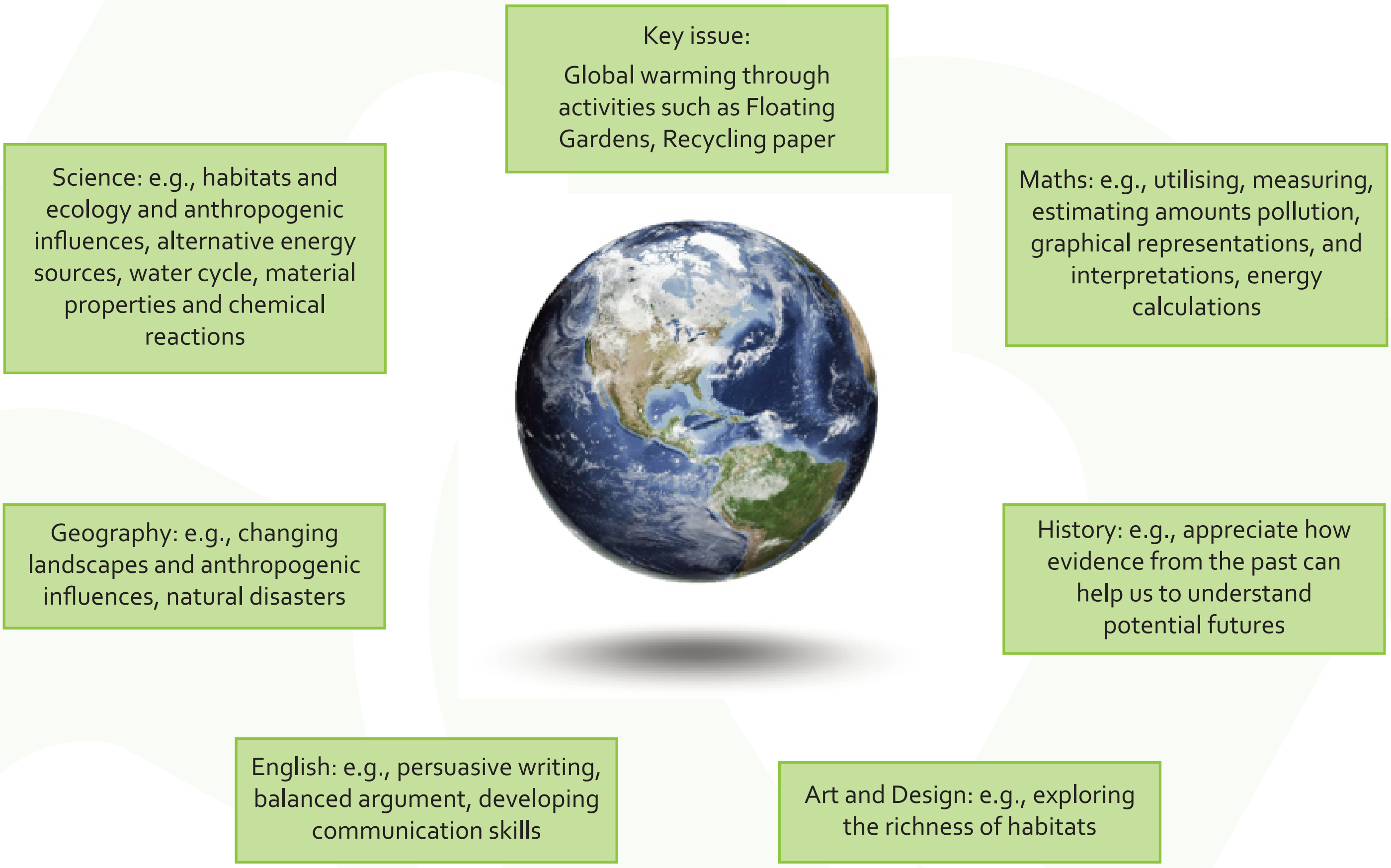
There is a plethora of literature strongly arguing that science and how it interconnects with social and environmental contexts should be learned through enquiry-led pedagogies that develop children's ability to understand complex and interrelated problems, empathise with others and problem-solve from 'real' world evidence (Dole *et al*, 2016; Wiemer, 2013; Minner *et al*, 2010; Panno & Damico, 2021). One starting point would be to apply the Primary Science Capital Teaching Approach (PSCTA), which is founded upon principles of social justice and inclusivity (Nag Chowdhuri *et al*, 2021, 2022). As such, the PSCTA recognises that children need to be introduced to potential local transformations in order to engage them. The importance of a child's immediate influencers, such as family, school and environment, on their personal and social development was recognised by Bronfenbrenner through his Ecological Systems Theory (Bronfenbrenner, 1979). This approach would help to provide children with greater agency, and so reduce eco-anxiety caused by feelings of helplessness towards the global challenges that they are facing (Panu, 2020).

Fullan and Langworthy (2013) argue that pedagogies must encourage deeper learning that includes opportunities to practice critical thinking, creativity and collaboration. To ensure that this is indeed the case, schools could offer a curriculum that engages students with real-world scenarios, or at least pseudo-authentic contexts (modelling real contexts), which provide the opportunities to gain the necessary knowledge and skills to address these types of challenge (Sadler *et al*, 2011; Gallagher & Gallagher, 2013; Amos & Christodoulou, 2018).

Figure 3 illustrates a possible approach, with the learning focus being about the impact of global warming. Children are encouraged to creatively apply knowledge and skills from a range of traditional subject areas. It could be argued that this approach would reduce the depth of learning of these subject areas, yet it can equally be argued that to apply the subject-specific knowledge and skills needed to solve a problem leads children towards a deeper and more nuanced understanding.

Applying enquiry-led pedagogies can be a powerful way to engage children in learning by supporting their curiosity (van Uum *et al*, 2016) and develop children's scientific reasoning through exploratory talk (Mercer *et al*, 2004). This approach can be introduced through problem-based learning (PBL), which has been shown to improve attitudes and motivations towards learning, enhance depth of learning and develop creative thought and abilities to think divergently (Dole *et al*, 2017). When these competencies are applied within a collaborative, enquiry-focused framework, greater autonomy will be achieved and, with this, the potential for developing an innovative mindset in students (Dole *et al*, 2017). It is argued that these ways of learning will provide the next generation with the necessary skills to become the transformative thinkers who we need for ecological, economic and social improvements.

Figure 3. An example of how subject areas might be integrated together to help children consider how a global problem might be solved. (See Scoffham & Rawlinson (2022) and Strachan & Davey (2022).)



Conclusion and recommendations

The acceptance that radical and immediate changes in the way in which we see ourselves as part of our ecosystems has been recognised globally (UNESCO, 2017, 2019; UN, 2015, 2022) and highlights the need for educational transformation to begin today.

Children have the capacity and the right to be involved in issues of sustainability, and teachers can support this through a curriculum intent that focuses on these global challenges. It is imperative that governments support schools by providing learning opportunities that are embedded into the national curriculum. It is also important that assessments have a greater emphasis on questions that specifically focus on ideas around sustainability. Schools may still feel powerless in light of the many challenges that they face, yet they can instigate change within the current national curriculum. What follows are some ideas that schools may want to consider in their journey towards EfS, and a range of resources for EfS are provided at the end of this article.

Teachers will be expected to engage in pedagogies that support children to understand the importance of ecosystems and how humankind influences these, and so it is of importance that governments invest in high-quality professional development now (DfE, 2022).

1. **Adapt your curriculum** to provide children with opportunities to explore and enjoy learning about their natural world. Explore your local environment through the lens of sustainability. Be aspirational in setting targets that promote 'awe and wonder' about our natural world.

2. **Engage children in authentic contexts:** Develop children's agency to contribute effectively towards the changes they want to see. This is a critical aspect in reducing eco-anxiety in children when engaged in education for sustainability (Strachan & Davey, 2022).
3. **Eco-education should be a globally-agreed key focus for children in the early years and primary:** EfS should become a key driver for the primary curriculum.
4. **Teachers will require access to high-quality professional development** to improve subject knowledge and pedagogies. This could be established through existing networks (e.g. Association for Science Education (ASE), Primary Science Teaching Trust (PSTT), Royal Society of Chemistry (RSC), Institute of Physics (IoP), the Royal Society of Biology (RSB) and STEM Learning Ltd.).
5. **STEM in the Community projects** could provide additional support for families to engage in activities centred around sustainability (Markwick *et al*, in prep).
6. **Be aspirational:** aim for a flourishing future for all living things on Earth.

References

Amos, R. & Christodoulou, A. (2018) 'Really working scientifically: strategies for engaging students with socio-scientific inquiry-based learning (SSIBL)', *School Science Review,* **100,** (371), 59–65

Amos, R., Knippels, M.C. & Levinson, R. (2018) 'Socio-scientific inquiry-based learning: possibilities and challenges for teacher education'. In: *Science Teacher education for responsible citizenship: Towards a pedagogy for relevance through socio-scientific issues*, Dillon, J., Evagorou, M. & Nielsen, J.A. (Eds.), Dordrecht: Springer

Basiago, A.D. (1999) 'Economic, social, and environmental sustainability in development theory and urban planning practice', 692 Sustainability Science (2019), 14:681–695 123, *Environmentalist,* (19),145–161

Bronfenbrenner, U. (1979) *The Ecology of Human Development. Experiments by Nature and by Design*. Harvard University Press. Online: https://khoerulanwarbk.files.wordpress.com/2015/08/urie_bronfenbrenner_the_ecology_of_human_developbokos-z1.pdf

Custance, J. & Hillier, H. (1998) 'Statistical Issues in Developing Indicators of Sustainable Development', *Journal of the Royal Statistical Society. Series A (Statistics in Society),* **161,** (3), 281–290

Dole, S., Bloom, L. & Doss, K.K. (2017) 'Engaged Learning: Impact of PBL and PjBL with Elementary and Middle Grade Students', *Interdisciplinary Journal of Problem-Based Learning,* **11,** (2)

DfE (2022) *Sustainability and climate change: a strategy for the education and children's services systems.* London: Crown Copyright. Retrieved from: https://www.gov.uk/government/publications/sustainability-and-climate-change- strategy/ sustainability-and-climate-change-a-strategy-for-the-education-and-childrens-services-systems

DoE (2018) *National Strategy on Education for Sustainable Development in Ireland*

Evans, N., Tomas, L. & Woods, C. (2016) 'Impact of sustainability pedagogies on pre-service teachers' self-efficacy', *Journal of Education for Sustainable Development,* **10,** (2), 1–19

Fullan, M. & Langworthy, M. (2013) *Towards a new end: New pedagogies for deep learning.* Seattle, WA: Collaborative Impact

Gallagher, S. & Gallagher, J. (2013) 'Using problem-based learning to explore unseen academic potential', *Interdisciplinary Journal of Problem-Based Learning,* **7,** (1), 111–131

Hickman, C. (2020) 'We need to (find a way to) talk about…Eco-anxiety', *Journal of Social Work Practice,* (34), 411–424

Klein, N. (2014) *This changes everything: Capitalism vs. the climate.* New York: Simon & Schuster

Kioupi, V. & Voulvoulis, N. (2019) 'Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes', *Sustainability 2019,* (11), 6104

Levinson, R. (2018) 'Introducing socio-scientific inquiry-based learning (SSIBL)', *School Science Review,* **100,** (371), 31–35

Levinson, R., Knippels, M.C., van Dam, F., Kyza, E. *et al* (2017) 'Science and society in education', *Socio-Scientific Inquiry-Based Learning: connecting formal and informal science education with society.* https://www.parrise.eu/wp-content/uploads/2018/03/parrise-en-rgb.pdf

Markwick, A. (2021) *Science Investigations Through Stories: a blended approach with maths and English.* Hatfield: ASE/Millgate House
Mercer, N., Dawes, L., Wegerif, R. & Sams, C. (2004) 'Reasoning as a scientist: Ways of helping children to use language to learn science', *British Educational Research Journal, (*30), 359–377
Milne, M.J. (1996) 'On sustainability; the environment and management accounting', *Manag Account Res*, (7), 135–161
Minner, D.D., Levy, A.J. & Century, J. (2010) 'Inquiry-based science instruction – what is it and does it matter? Results from a research synthesis years 1984 to 2002', *Journal of Research in Science Teaching*, **47,** (4), 474–496
Moldan, B., Janousˇkova´, S. & Ha´k, T. (2012) 'How to understand and measure environmental sustainability: indicators and targets', *Ecol Indic., (*17), 4–13
Nag Chowdhuri, M., King, H. & Archer, L. (2021) *The Primary Science Capital Teaching Approach: Teacher handbook.* London: UCL Institute of Education
Nag Chowdhuri, M., King, H. & Archer, L. (2022) 'The Primary Science Capital Teaching Approach: Building science engagement for social justice', *Journal of Emergent Science*, (23), 34–38
Panos, A. & Damico, J. (2021) 'Less than one percent is not enough: How Leading Literacy Organizations Engaged with Climate Change from 2008 to 2019', *Journal of Language and Literacy Education*, 17, (1), 1–21
Panu, P. (2020) 'Anxiety and the Ecological Crisis: An Analysis of Eco-Anxiety and Climate Anxiety', *Sustainability 2020*, (12), 7836
Practical Action (2018) *Practical Action – Links to the UK Science Curriculum.* Retrieved from: https://practicalaction.org/science-curriculum
Purvis, B., Mao, Y. & Robinson, D. (2019) 'Three pillars of sustainability: in search of conceptual origins', *Sustainability Science (2019)*, (14), 681–695
Reiss, M.J. & White, J.H. (2013) *An Aims-Based Curriculum: The Significance of Human Flourishing for Schools.* London: IOE Press
Rieckmann, M. (2012) 'Future-oriented higher education: Which key competencies should be fostered through university teaching and learning?', *Futures*, **44,** (2), 127–135
Sadler, T.D., Klosterman, M.L. & Topcu, M.S. (2011) 'Learning science content and socio-scientific reasoning through classroom explorations of global climate change'. In: *Socio-scientific Issues in the Classroom*, Sadler, T.D. (Ed.), pps.45–78. Dordrecht: Springer
Schank, C. & Rieckmann, M. 'Socio-economically substantiated education for sustainable development: development of competencies and value orientations between individual responsibility and structural transformation', *J. Educ. Sustain. Dev. 2019*, (13), 67–91
Scoffham, S. & Rawlinson, S. (2022) *Sustainability Education: A Classroom Guide*. London: Bloomsbury
Sergiovanni, T. & Starratt, R. (2007) *Supervision: A Redefinition*. Boston: McGraw-Hill
Strachan, A. (2022) 'Embedding sustainability in primary science education', *Journal of Emergent Science*, (23), 27–32
Strachan, A. & Davey, J. (2022) *Saving The Planet One Science Lesson At A Time.* Hatfield: ASE/Millgate House
UNESCO (2017) *Moving forward the 2030 Agenda for Sustainable Development.* Paris, France: UNESCO. Available online: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
UNESCO (2019) *UN Decade of ESD.* https://en.unesco.org/themes/education-sustainable-development/what-is-esd/undecade-of-esd
United Nations (2015) *Sustainable Development Goals.* https://www.un.org/sustainabledevelopment/sustainable-development-goals/
UN (2022) *The sustainability development goals report.* Available online: https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf
van Uum, M.S.J., Verhoeff, R.P. & Peeters, M. (2016) 'Inquiry-based science education: towards a pedagogical framework for primary school teachers', *International Journal of Science Education*, **38,** (3), 450–469

Welsh government (2019) *Wales and the Sustainability Development Goals.* Available online: https:// www.gov.wales/wales-and-the-sustainable-development-goals
Weimer, M. (2013) *Learner-centered teaching: Five key changes to practice.* N.J.: Jossey-Bass
Wormald, B.W., Schoeman, S. & Somasunderam, A. (2009) 'Assessment Drives Learning: An Unavoidable truth?', *Anatomical Sciences Education.* Michelle Penn Centre for Medical and Healthcare Education, St George's, University of London, London, UK
Wright, W.E. (2002) 'The Effects of High Stakes Testing in an Inner-City Elementary School: The Curriculum, the Teachers, and the English Language Learners', *Current Issues in Education,* **5,** (5), 1–23

Websites used for baseline data

Ourworldindata.org
https://ourworldindata.org/contributed-most-global-co2
United Nations, 2022
https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf

Worldatlas

https://www.worldatlas.com/articles/10-countries-that-could-disappear-with-global-warming.html
https://unfccc.int/news/most-vulnerable-countries-leading-climate-response

Some interesting websites to visit for EfS

Royal Society of Chemistry
https://edu.rsc.org/primary-science/sustainability-contexts-for-primary-science/4014614.article
STEM Learning
https://www.stem.org.uk/resources/elibrary/resource/26879/recycling-and-sustainability
NASA: Evidence for global warming
https://climate.nasa.gov/evidence/
Nature's path
https://www.naturespath.com/en-us/blog/20-activities-kids-learn-sustainability/

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Recycling+: Helping learners understand fast fashion and how clothing choices can help address the climate emergency

. Jennifer A. Rudd • Geraldine Lublin
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Abstract

Every item of clothing we wear contributes to climate change, but how do we raise this with primary school students? This article describes Recycling+, a unit of work on the topic of clothing.

The New Curriculum for Wales provides a unique opportunity to develop new units of work to deliver high quality climate change education. This article describes a collaboration between academics from science, geography and modern languages and classroom teachers at a Welsh primary school to develop a unit of work on clothing choices and the climate emergency. The unit of work encourages students to think about their clothing – where it comes from, how it is looked after and where it goes after disposal. Students learn technical language such as 'biodegradable' and 'sustainable', and are encouraged to be creative by upcycling clothing and engaged in activism, writing letters to politicians about sustainable clothing.

Keywords: STEAM Education, primary curriculum, sustainability, climate change education, fast fashion

Introduction

The climate emergency is a key global challenge faced by all of us, but especially future generations. Effective climate education has the capacity to help young people make choices that can reduce emissions and keep the climate below 2 degrees of warming (Cordero, Centeno & Todd, 2020). Through curricula specifically designed to inform and empower, it is possible to develop learners who are inspired to act on climate change, rather than just passively learn about it.

The Welsh Government has recognised the critical role that education plays in helping pupils learn about real world problems in a New Curriculum, which was launched in Welsh schools in September 2022. One of the aims of the New Curriculum is to develop *'ethical, informed citizens [...] of Wales and the world'* (Welsh Government, 2020, p.24).

This provides a unique opportunity to create units of work that address the climate emergency by making cross-curricular connections between different subject disciplines. Enabling teachers to deliver such learning requires partnerships between educators and academic experts in the fields of climate change, communication and climate change education (Civinini, 2021; National Climate Education Action Plan, 2021). Research-informed teaching resources can enable teachers to meet the needs of the New Curriculum and feel confident to deliver them, whilst also addressing one of the Four Purposes of the New Curriculum, namely supporting learners to become *'ethical, informed citizens of Wales and the world'* (Welsh Government, 2020).

Given that the climate emergency affects the entire planet, however, the imperative of sustainable behaviour goes beyond Wales, and any resources created in line with the New Curriculum are also applicable in educational settings across the world. Recognising the key role that education has to play, UNESCO has identified 'Teachers & Educators' and 'Youth' as two of the five priority action areas set out in its *Education for Sustainable Development 2030.* This is in keeping with the global needs set out in the United Nations Sustainable Development Goals. Encouraging learners to be mindful of the impact of their actions on the planet is key to achieving sustainable cities and communities (SDG 11), fostering responsible consumption and production (SDG 12), and promoting climate action (SDG 13). By virtue of our chosen topic, the unit of work that we created may also contribute to having a global impact on reducing poverty (SDG 1), promoting decent work and economic growth (SDG 8) and building resilient infrastructure, advancing inclusive and sustainable industrialisation and fostering innovation (SDG 9).

Why create a unit of work around clothing?

Uniforms are mandatory at most primary and secondary schools across the UK, including within Wales. These uniforms come at a financial cost to parents/carers and have planetary costs associated as well, in terms of their carbon and water footprint. Indeed, currently over 5% of the UK's total annual carbon and water footprints result from clothing consumption (Love Your Clothes, n.d.). Although Wales is currently ranked third in the world in domestic recycling, it certainly contributes to the 1.13 million tonnes of unwanted clothing thrown out every year in the UK, 38% of which is neither reused nor recycled (My Recycling Wales, 2018). In addition, many of the clothes that we wear are sourced from fossil fuels, which is a resource that we need to use more sparingly to meet worldwide climate change reduction targets.

Schools can inadvertently add to the problem through designating a 'Christmas jumper day' or through 'World Book Day', leading to parents purchasing additional garments that are worn a limited number of times. In addition, pupils require non-uniform clothes that they can wear outside school, and the use of these clothes is limited to evenings (for some children) and weekends. As children grow rapidly, their high wardrobe turnover is seen as an inevitable development turned social norm, rather than an opportunity to use and re-use clothes by purchasing second-hand, handing on from siblings or cousins, or creating community clothes swap events.

A unit of work around clothing therefore provides an opportunity to start discussions with young learners in a positive way, with a view to placing science in a relevant context and effecting behavioural change. Moreover, since children play an important role in school and family dynamics, such changes in behaviour can hopefully permeate the school culture and the lives of the parents/carers in the longer term. Clothing is a topic that allows pupils to explore their role as citizens of Wales and the world. Through research, observation and discussion, they may understand that small changes in their daily habits, and those of their local communities, can have a positive impact on the environment globally, which goes well beyond just recycling.

How does learning about clothes achieve the goals of the New Curriculum for Wales?

This unit of work developed aims to support primary schools' efforts to embed the local, national and international cross-cutting themes set out in the Curriculum for Wales 2020. In particular, the unit may help schools to create opportunities envisaged in the Curriculum, whereby learners are encouraged to:

- recognise and engage with factors, influences and impacts (including economic, social and environmental impacts) locally, nationally and internationally;
- understand their role as citizens and the structures of government that affect them in each context;
- explore, critically analyse and respond to contemporary issues and challenges affecting their lives and the lives of others through each context;
- understand sustainable development, the challenges that the environment and society face and how they can engage with and make a difference to these issues supporting sustainable citizenship; and
- recognise the links between local, national and international contexts, understanding how they constantly influence each other.

Cross-curricular content and team

The New Curriculum for Wales favours an integrated approach to learning and teaching by working across six Areas of Learning and Experiences (AoLEs):

- Languages, Literacy and Communication
- Mathematics and Numeracy
- Science and Technology

- Humanities
- Health and Wellbeing
- Expressive Arts (Welsh Government, 2020).

The cross-curricular character of the New Curriculum blends well with recent research around STEAM education (Science, Technology, Engineering, Arts and Mathematics). STEAM curricula have been shown to be multidisciplinary, relevant and societally engaged, and bridge the classroom and the wider world (Colucci-Gray *et al*, 2017).

The topic of clothing is, by nature, cross-curricular and therefore lends itself well to the holistic ethos of the New Curriculum. The team developing the unit was itself multidisciplinary, consisting of two primary school teachers (one of whom is the International Languages Lead for a cluster of Welsh primary schools) and academics from Swansea University in the areas of modern languages, geography and climate change education. The modern languages expertise is unusual for a climate change project as, traditionally, climate change education is thought of as being predominantly geography- and science-based. However, modern languages experts, Dr. Lublin and Ms Saez Lecue, drew the team's attention to the Atacama Desert clothes disposal area as a striking example of how global inequalities and the climate crisis were closely interrelated (for example, see Batt, 2022). Through researching where clothes were disposed of around the world, the whole team became acutely aware of both clothes' contribution to the climate emergency and how unequal the distribution of the burden is, as those who have least contributed to the climate emergency tend to be the most vulnerable to its effects. Not only do clothes have a high carbon and water footprint, but their disposal also exacerbates local problems, leading to a build-up of methane (a very potent greenhouse gas) in Accra, Ghana, and worsening desertification in Atacama, Chile (Chancel, 2022).

The team felt that it was important for pupils to come away from the week of learning with an understanding of the words 'sustainable' and 'biodegradable'. There is, however, no clear definition of 'sustainable', nor is 'biodegradable' a straightforward concept. Facilitating understanding of these terms for a target audience aged 4-11 required the team member with a chemistry PhD and a research associate with a Modern Languages Masters to work together to design a number of activities where the nuanced layers of meaning were unravelled.

What is in the unit of work?

We set out to develop a unit of work that focused on a different area of learning and experience (AoLE) each day for a week, ensuring that all six AoLEs are covered.

Tuesday focuses on Science and Technology (S&T), Wednesday on the Humanities, and Friday's Fashion Day focuses on the Expressive Arts (EA). The other AoLEs, Languages, Literacy and Communication (LLC), Maths and Numeracy (M&N) and Health and Wellbeing (H&W) are spread over Monday and Thursday. Different PowerPoint presentations for each of the days provide stimuli and engaging activities so that, throughout the week, pupils are encouraged to engage with their clothes and reflect on how their clothing choices have an impact on Wales and the wider world. Whilst the materials are set out over a week, we understand and expect that teachers will have to adapt the unit to their students and school curriculum. Therefore, some schools may trial it as a whole school week-long topic and others may engage one year group with a few activities. We are interested to see how it will be adapted once a number of schools have trialled the resource.

Figure 1. Overview of the Recycling+ unit of work

Primary School - Short Term Planning
Topic: The Life Cycle of Clothes

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Immersion Day Bring your favourite clothes to school day	Detectives Day Materials: what are my clothes made of? Why?	Here and There Day The journeys that clothes make	Drama Day Perspectives in the world of the fashion industry: what role do we play?	Fashion Day Trends: fast and slow fashion
LLC Exhibit our clothes and express our opinion Spider Diagram: what do I know about my clothes?	S&T Investigation of fabric properties Discuss: Are "sustainable" and "biodegradable" properties? How do we measure this?	Humanities Quiz: Can you guess where X is made? Double sided cards (Clothes on one side, County of origin in the other)	LLC Set up a class discussion about how to make the fashion industry more sustainable (in role, include multitude ideas and perspectives)	EA Discuss how to make your clothes last longer (How to look after my clothes) What is refashion & upcycling?
M&N Data Handling: looking at labels, collect data of origin and composition, and show results in bar charts/pie charts	S&T Rank fabrics' properties from most to least important when choosing what to buy (diamond ranking activity)	Humanities Atacama Desert Clothes Disposal Area (map journey) Comparing the life cycle of two different items: map their journeys from beginning to end	LLC Use these perspectives to inspire a piece of writing: persuasion text or poster	EA Design "The perfect uniform for a happy world". Chn to make decisions on the origin and fabrics used to create an ethical sustainable uniform.
H&W Discuss results and log their opinions on the spider diagram: what have I learnt so far?	S&T What makes a piece of clothing the best buy and why?	Humanities Woollen Mills in Wales (Virtual) Trip to Woollen Mill	H&W Arrange interview with expert What can we do to improve our impact on the planet? Discuss ideas and list benefits linked to their wellbeing	EA Design project: use their own old clothes to make something new

A caveat

There is significant complexity in the creation, use and disposal of items of clothing, including the use of alternative and 'more sustainable' materials, such as the shedding of microfibres. We have not found it possible to communicate that level of complexity to primary-age students and instead tried to focus on a simple and actionable message – to significantly reduce the purchase of brand new clothing to re-use clothing as much as possible.

Immersion Monday

The week starts with all learners bringing or wearing their favourite clothes to school and discussing what they know about them – Where do they come from? Who might have made them? How do the clothes get to a shop? In this way, pupils start the week by thinking differently about an everyday item. For older learners (aged 7+), the discussion can be deepened to include questions around social justice (e.g. labour costs of making the garments and human rights).

Children then learn how to read the labels on their clothes, including washing instructions, origin and fabric composition. They are taught how to log this information numerically using tally charts, bar graphs, or frequency tables (as appropriate for their age and stage).

The day finishes with pupils reflecting on what they have learnt.

Detectives Tuesday

Next is a science and technology-dominated day to ensure that pupils come away with an understanding of the words 'sustainable' and 'biodegradable'. They start gently by thinking about what properties they need from their clothing – e.g. waterproof for rain. Older learners (aged 7+) design a coat for rainy or snowy weather. Younger students (aged 4-6) choose appropriate clothing from a given selection for rainy/snowy/sunny weather.

Pupils then move on to a science investigation, with older groups looking at thermal insulators and younger ones looking at waterproof materials.

To understand what clothing is 'more sustainable' and 'less sustainable', children read a custom-written fiction called *Sam's Clothes*. This follows the story of Sam, who is in class learning about how children's clothing choices can help the planet. Sam has never had new clothes because they are always passed down from siblings or cousins, and Sam has always felt embarrassed about that. The children in the story learn about different materials for making clothes. They learn where wool comes from and how it is turned into knitted items, such as jumpers. They are told that, when composted, clothes break down into soil, meaning that they are biodegradable (see Figure 2, left).

Figure 2. Excerpts from *Sam's Clothes* (story designed using *Twinkl Create)*.

The children in the story then learn about polyester, how it is made from oil and that it is a type of plastic. The children are sad because they know that plastic is bad for the environment. They learn that plastic to make clothes can come from recycled plastic bottles and are thus introduced to the concept of sustainability (see Figure 2, right).

The children in the story then learn about cotton and the amount of water required to grow it. They realise that many of their clothes are not helping the planet. The teacher tells them that they need to look after their clothes, mend them when they are broken, pass them on to siblings, cousins and friends, and buy second-hand or from charity shops when new clothes are needed. Sam finishes the story feeling proud, instead of embarrassed, by the mended, gifted and woollen clothes that he wears on a daily basis.

The story enables complex vocabulary to be introduced to very young learners (aged 4+) without seeming overwhelming. Its use also enables them to get a sense of what the words 'sustainable' and 'biodegradable' mean in the context of their lives, rather than learning them as abstract scientific terms. Simplifications have been made – for example, the dying process of wool can be chemically intensive and affect the biodegradability of the final product – but this discussion could be instigated by older pupils (or their teacher) as a stretch activity.

Pupils finish the day by further exploring ten properties of clothing, such as durability, warmth, or waterproof capability, using double-sided vocabulary cards (Figure 3).

'Biodegradable' and 'sustainable' are also revisited in this activity.

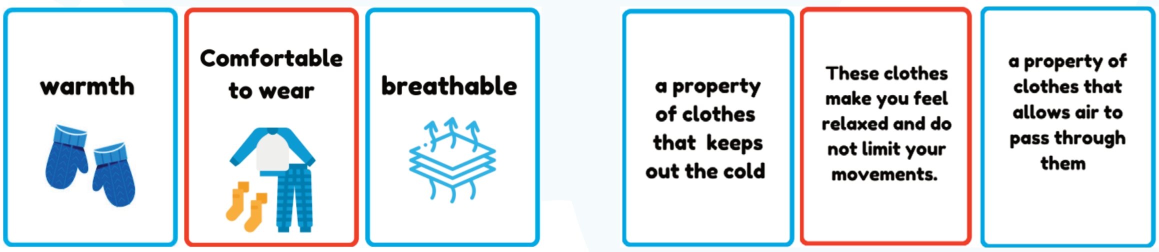


Figure 3. Examples of the double-sided 'Properties of Clothing Cards' (double-sided cards were created using *Canva)*.

Here and there Wednesday

The aim of Wednesday's activities is to use the Humanities to understand where clothes come from. Pupils learn about the geography of the world through being challenged to find countries on a map, but also gain an understanding of how far and by what mode of transport their clothes travel to reach them in Wales.

A game was created using double-sided cards with an item of clothing on one side and the country of origin on the other (Figure 4). Pupils are asked to look at the item of clothing and guess where it comes from. The country of origin on the other side shows the shape of the country, its flag and its name. A discussion is prompted via questions such as: What is the furthest country that we import clothes from? What are they made of? How 'sustainable' are they?

Learners are then asked to watch a video about the clothes disposal area in the Atacama Desert in Chile. They are also taught about the clothes market in Accra, Ghana, and the clothes landfill just outside the city. An opportunity is given to reflect on what they have learnt and how it makes them feel. They are then asked to plot the journey of two items of clothing on a world map – one item made locally that has been used over a long period of time, and an item that was produced in a certain country, used once and then disposed of in another country. Through this activity, pupils understand that many clothes end up in landfill in other countries, where they have a negative impact on the local communities. They will also understand that we can make choices about where to source our clothes in order to decrease that negative impact on communities and, ultimately, the planet.

Figure 4. A selection of the double-sided cards used for the 'Where do my clothes come from?' game (double-sided cards were created using *Canva).*

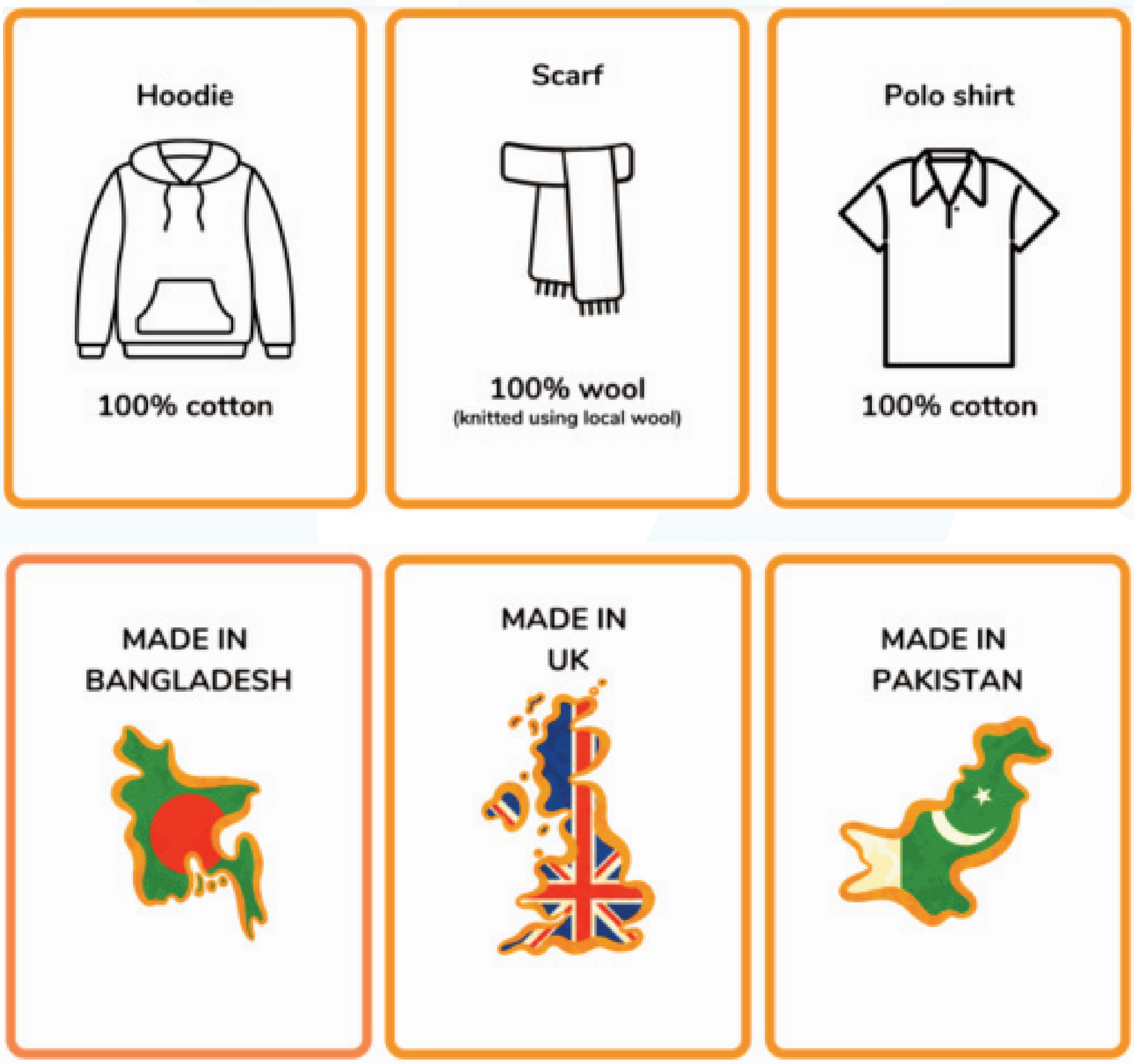


Figure 5. Example letter that learners can adapt and send.

Lower KS2

From

To

Date

Dear ....,

I am a pupil at ....

I have been learning about clothes at school this week. We have learnt about what materials we wear and how we can look after them.

I am really worried that lots of my clothes aren't sustainable. I am also sad that we send our clothes away to countries like Chile and Ghana where they end up in landfill. I wouldn't want to live with a pile of dirty old clothes in my back garden, so why should they?

Please can you make sure that the people who make clothes start caring more about how many clothes they make and where clothes are sent away to? We also need to talk a lot more about repairing our clothes and wearing them for longer, as well as not buying so many clothes.

I think we should all look after our planet. I'm going to do my bit; please can you make sure everyone else does too?

Kind regards,

Drama Thursday

On the Thursday, pupils start by reflecting on what they have learnt about clothes so far. The teacher then provokes discussion about the impact of fast fashion, global chains, popular demand and overproduction of clothing – tailoring it to be age- and vocabulary-appropriate. Technical vocabulary, linked to the fashion industry, is then introduced as a way to bring in different points of view and enhance students' understanding of the roles that each sector plays in the creation and disposal of clothing.

This leads into how the fashion industry can help the Welsh Government's agenda to be Net Zero Carbon by 2050 and culminates with pupils writing a piece of persuasive text. They can choose to write to a politician, their favourite shop, or a celebrity. An example text is given in Figure 5 for use with younger learners, or those who find writing particularly challenging.

Through writing those letters, pupils will understand that even though they are young and not yet able to vote, they can still make their point of view heard. This will empower them to understand that they can act on climate-relevant topics rather than just passively learn about them.

The last activity of the day is to interview an expert or watch a video on slow fashion. Pupils will have the opportunity to learn what they can do to lessen their negative impact on the planet and on others, again reinforcing the message that everyone can *act* as well as learn.

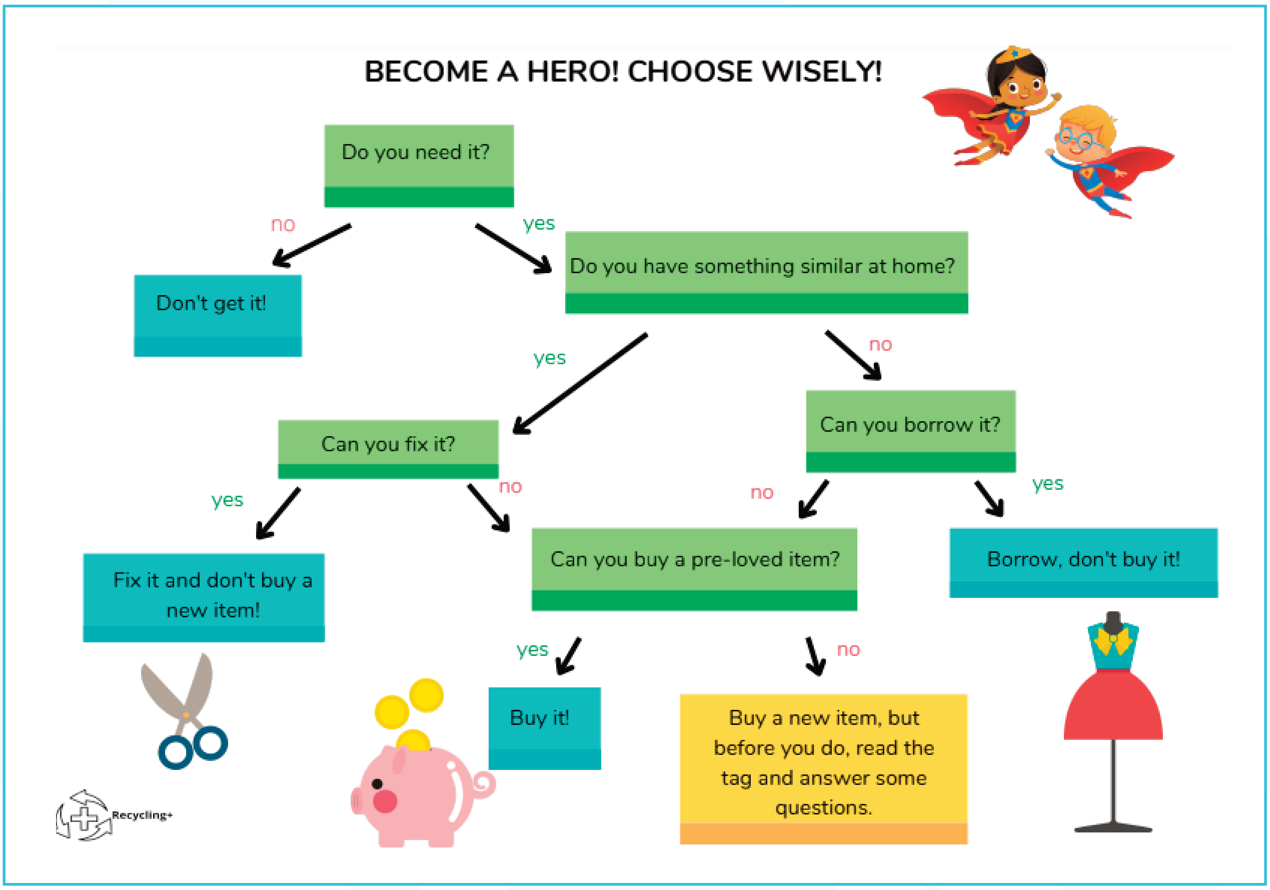
Fashion Friday

Friday's activities are taught through the Expressive Arts AoLE. Pupils start by mind-mapping how to make their clothes last longer. They are then asked to design 'the perfect uniform for a happier world', choosing items with more sustainable properties such as 'from a charity shop', 'made of recycled plastic', etc. They should explain the reasons behind their choices, such as 'My jumper makes the world a cleaner place because it's biodegradable'. They can show the class their designs or set up a gallery in the school corridor to spread the message more widely.

The final activity of the week is for learners to use their own old clothes to make something new, e.g. upcycling an old item, creating finger puppets from odd socks, making aprons or baby bibs from old towels.

As a reminder of the week's activities and the lessons that they have learnt, each pupil is given a printout of a decision tree to put on their wardrobe. It details the decisions that they should make when contemplating the purchase of a new item of clothing (Figure 6).

Figure 6. The decision tree printout given to each student at the end of the unit of work (this has been made using *Canva).*



Conclusion

Working on the Recycling+ project has stretched and inspired the whole team to find the best ways of drawing on our diverse specialist expertise in order to produce classroom-ready materials. Whilst the unit of work has been designed to meet the needs of the New Curriculum for Wales, the emphasis on fun activities, engaging experiential learning and the real-life context means that this resource is adaptable to primary teaching across the UK and beyond. Our experience has been that the deeper understanding of the planetary impact of familiar objects, which are often overlooked or taken for granted, helps children to realise that everyone can make positive choices. Teachers who trialled the unit of work said that this learning led on to further pupil-led actions, such as litter picks around the school. It also resulted in teachers swapping clothes with one another! Feedback also included teachers' concerns about climate change and how they wanted to teach pupils about climate change without scaring them. It was encouraging to hear that this unit of work enabled them to do just that.

Feedback also demonstrated the different interests that the students had. Whilst older students (aged 7-11) particularly enjoyed sorting their clothes into countries of origin, the younger students (aged 4-6) enjoyed testing the properties of clothes materials.

As authors, we hope that sharing the decision tree with the students in the final session helps to reinforce this sense of empowerment and fosters commitment by showing that we are all able to make choices to reduce our carbon footprint. We will continue to work with teachers to consider how the resources are used in schools and whether they need to be further adapted for widespread use.

In the meantime, we are looking forward to hearing from teachers who have used the resources. They are free to download from: https://docs.google.com/forms/d/1u2t_-tuDF5kOvBLwwmj6VAKvaM6P21oIBhiC9yCDIh8/viewform?edit_requested=true

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References

Batt, E. (2022) *Flaws in Fast Fashion: the Atacama Desert Dumping Ground.* UCL Institute for Sustainable Resources. Accessed online 30.11.22. https://www.ucl.ac.uk/bartlett/sustainable/news/2022/apr/flaws-fast-fashion-atacama-desert-dumping-ground

Chancel, L. (2022) 'Global carbon inequality over 1990–2019', *Nature Sustainability*, (5), 931–938

Civinini, C. (2021) 'Climate change and the curriculum: what needs to change?', *Times Educational Supplement*, 6th April 2021. Available at: https://www.tes.com/magazine/teaching-learning/secondary/climate-change-and-curriculum-what-needs-change

Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D. & Trowsdale, J. (2017) *Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21st learning: how can school curricula be broadened towards a more responsive, dynamic, and inclusive form of education?* BERA Research Commission

Cordero, E.C., Centeno, D. & Todd, A.M. (2020) 'The role of climate change education on individual lifetime carbon emissions', *PLoS ONE*, 2020, e0206266

Love Your Clothes (n.d.) https://www.loveyourclothes.org.uk/about/why-love-your-clothes. Accessed July 2022

My Recycling Wales (2018) https://myrecyclingwales.org.uk/materials/textiles Accessed July 2022

National Climate Education Action Plan (n.d.), led by the University of Reading. Available at: https://www.reading.ac.uk/planet/-/media/project/uor-main/uor-campaign/climate-for-change/climate-education-summit/climateeducationsummit-actionplan.pdf?la=en&hash=70A9DA27CDA84F375723D8C91F45B12F

Welsh Government (2020) *Curriculum for Wales Guidance.* Retrieved from: https://hwb.gov.wales/api/storage/afca43eb-5c50-4846- 9c2d-0d56fbffba09/curriculum-for-wales-guidance-120320.pdf

For further resources on teaching sustainable fashion, visit:
https://sustfashwales.org/ks3-education/
https://www.teachingenglish.org.uk/article/fast-fashion
https://www.futurelearn.com/courses/who-made-my-clothes

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Embodied Learning for early and primary science: Key implications from the Move2Learn project

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Abstract

When teachers or children explain science ideas, they often gesture, typically with little awareness of doing so. Over the last twenty years, research has demonstrated the significance of these gestures in revealing the embodied nature of how we think, and the potential to encourage body-based experiences to support learning – Embodied Learning. Drawing upon research in this field, including the international Move2Learn project, which worked with children aged 3-8 in informal science centres, this paper presents three key implications of Embodied Learning for early and primary science: 1) Recognise children's understanding in ways beyond words, especially gestures; 2) Encourage meaningful sensory and movement experiences; and 3) Communicate in ways beyond words, especially gesture. These tentative implications require further research leading to a further key message: the need for research-practice collaboration in this emerging field that draws upon educators' insight from everyday practice.

Keywords: Embodied Learning, Embodied Cognition, gestures, informal science centres

Introduction

The importance of science learning in children's early years is well documented (e.g. Gelman & Brenneman, 2004). However, as children are increasingly introduced to science concepts in school, there is a risk that some struggle to relate these more abstract ideas and language to their everyday experiences in the world. Embodied Learning seeks to address this challenge by proposing approaches to learning that draw on the research field of Embodied Cognition.

Embodied Cognition

Embodied Cognition is a research paradigm in the cognitive sciences that claims that our bodies and our bodies' interaction with the world are inseparably linked to our cognitive processes, challenging the mind-body distinction (Wilson, 2002; Barsalou, 2010). Although this can feel obvious to practitioners who recognise the importance of experience, Embodied Cognition is quite a radical challenge to dominant theories of cognition, which can influence how we consider knowledge, assessment and educational goals.

Traditional theories have tended to separate mind from body: cognitive development is presented as graduation away from concrete to more abstract ways of thinking. A bit like a robot, our *sensory* (e.g. visual, touch, hearing) and *movement* experiences ('*sensorimotoric*') are perceived as important as, but ultimately distinct from, cognitive processing (thinking) that happens in our brain. In contrast, Embodied Cognition argues that cognition is a dynamic activity involving our brain, body and the world around us. We not only interact with the environment to 'offload' cognitive tasks (e.g. writing notes, raising fingers to count) but, even when we think '*in our heads*', we are activating internalised body-based (sensorimotoric) experiences – cognition is embodied.

Gestures – a window into our embodied cognition

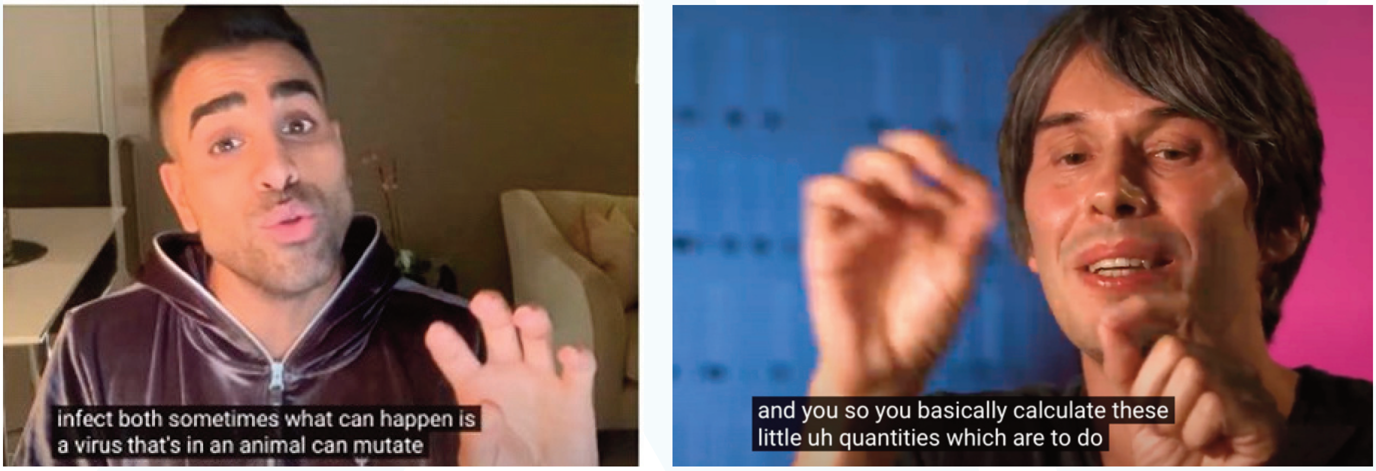
Whilst evidence for Embodied Cognition comes from various sources (e.g. brain studies), in the last two decades a more accessible source of evidence has emerged: gestures (see Goldin-Meadow, 2005).

Gestures refer to spontaneous hand movements typically co-produced with speech when explaining or problem-solving. Many factors influence if and how we gesture – from cultural norms to content of speech. We are often unaware of our gestures and gesture even when the listener cannot see us (e.g. on the phone). Teachers naturally gesture, changing their gestures depending on factors such as learner understanding (Alibali & Nathan, 2012).

Some gestures emphasise words ('beat' gestures). Others connect our speech to the environment by pointing ('deictic' gestures). But the most revealing gestures are representational, where our hands trace, interact with, or even stand for an imagined object. Because gestures are simulated or representational actions (Hostetter & Alibali, 2008; Novack & Goldin-Meadow, 2017), they support the claim that thinking is embodied.

Various works have examined how gestures reveal the embodied nature of concepts. Manches and Ainsworth (2022), for example, revealed some gestures in online videos explaining COVID-19. The Figure 1a[1]) speaker created a gesture of rotating a grasping hand to talk about the way in which viruses mutate. In this work, the authors show the potential to examine gestures in the many online videos of science explanations. For example, in Figure 1b[2], Brian Cox explains Quantum Mechanics – for a radio audience. Here he represents time, movement and quantum quantities by tracing lines with pinching gestures.

Figure 1. Gestures explaining a) COVID-19, b) Quantum Mechanics.



Embodied Learning

With increasing evidence that thinking is embodied, researchers (e.g. Shapiro & Stolz, 2019) have begun to explore ways to support learning by enhancing children's sensorimotoric experiences – Embodied Learning. It is claimed that Embodied Learning can make learning more *meaningful* by helping children connect more abstract forms of communication (e.g. science words or diagrams) with personal experiences (Nathan, 2021). Embodied technologies, concrete materials and gestures will be explored further below.

Embodied technologies

There have been various approaches to Embodied Learning. Much work has explored the potential of *Embodied Learning technologies* to link actions or gestures to digital representations. For example, in Figure 2a, children explore ratio by moving their hands at different relative distances from the tabletop and observing the resulting digital representation (Howison, Trninic, Reinholz & Abrahamson, 2011). In Figure 2b, children explore the movement of moons around planets through whole body actions mapped onto the floor (Lindgren, Tscholl & Moshell, 2013).

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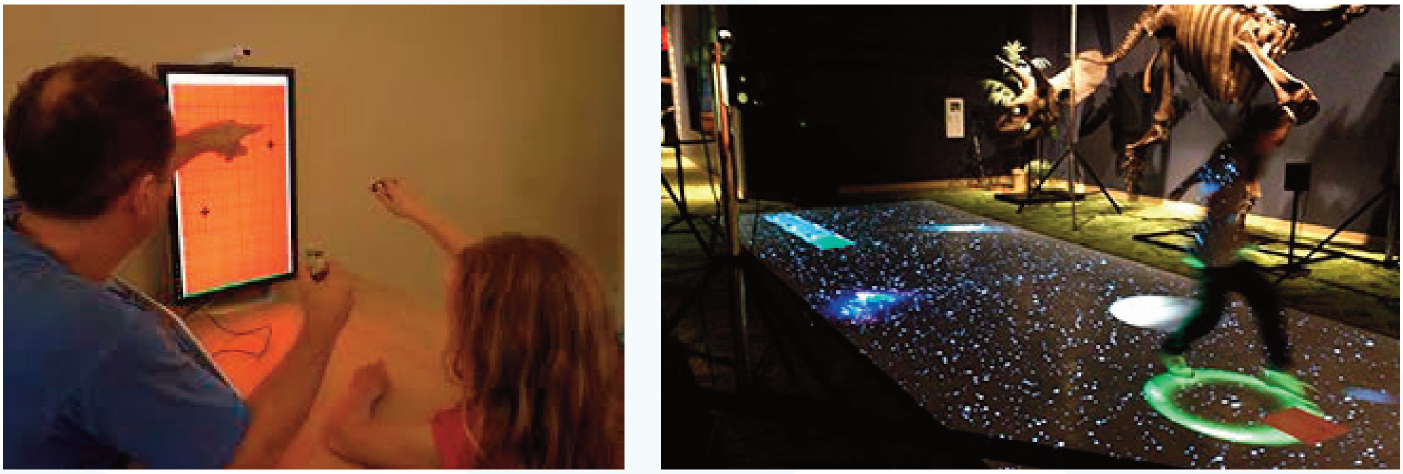
[1] https://www.youtube.com/watch?v=oMHacLHchl0

[2] https://www.youtube.com/watch?v=fcfQkxwz4Oo_

Figure 2. a) Mathematical Imagery Trainer, b) Meteor modelling.



Concrete materials

Other work has adopted an Embodied Learning lens to examine interaction with everyday concrete materials. Manches and Dragomir (2016), for example, investigated how physical materials may help children think and explain number relationships (e.g. why 1+7 makes the same as 2+6). Gesture analysis revealed how both adults and children communicate number concepts using metaphors of numbers being like collections of objects (e.g. grasping and swapping imaginary groups of objects – Figure 3a), or like points along a line (pointing to the far right of the body – Figure 3b). An implication of this research[3] is to consider how using materials (e.g. number line, blocks) and language (e.g. 'count up', 'split') can support metaphors across increasingly complex concepts, and challenge approaches that seek to graduate children away from concrete resources. The importance of sensorimotoric experience has also been demonstrated in early science. Thomas, Price, Nygren and Glauert (2021), for example, showed how young children's hands-on interaction at water tables shaped the type of gestures that they used to communicate their subsequent science explanations.

Figure 3. Gestures when talking about number concepts as a) collections of objects, b) points along a line.

Gestures

Other Embodied Learning research has focused more directly on how *gestures* can support learning. Some work has examined how teachers' gestures can support children's comprehension by revealing information beyond speech alone (Hostetter, 2011). Other research has shown how children's gestures offer teachers an additional means to assess and build upon understanding. Church and Goldin-Meadow (1986), for example, showed how young children were able to communicate understanding of conservation through gesture before they could do so verbally. Some studies have shown how encouraging children's gestures can make learning last (Cook, Mitchell & Goldin-Meadow, 2008).

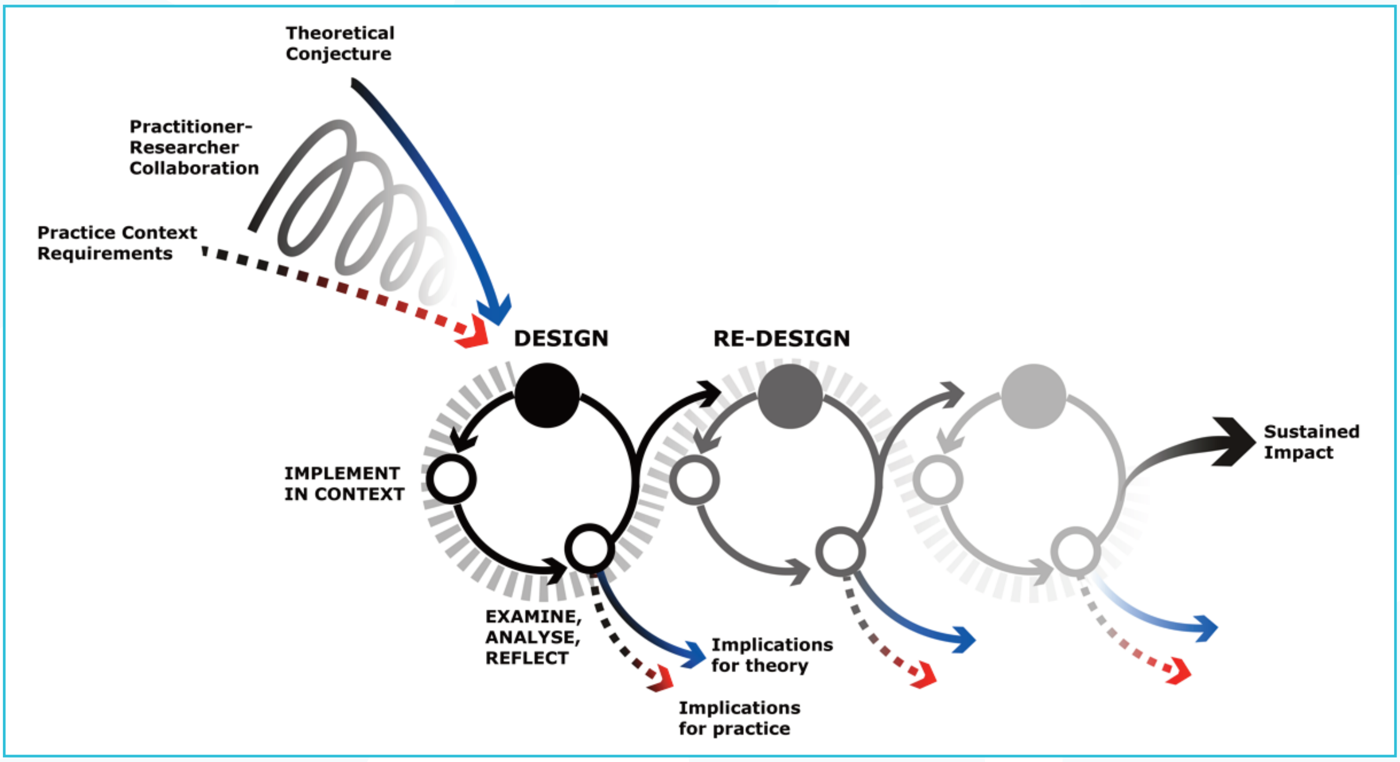
[3] See https://vimeo.com/160639180 for an animated summary of this research.

Move2Learn

Despite the educational implications of Embodied Learning research, studies are often carried out in quite controlled settings and the broader implications for practice are unclear. The Move2Learn research project sought to address these challenges.

Move2Learn (2017-2020)[4] was an international collaborative project (three academic partners; six science centres from UK/US), to explore Embodied Learning in early years science (aged 3-8). The context was informal science centres, where there is demand for knowledge to inform hands-on exhibits and capture the educational value of interactive experiences and design of digital experiences. The project adopted a design-based methodology (Figure 4), that derived implications for theory and practice through several iterations of examining, evaluating and informing designs (which may be physical and/or pedagogical). The UK partnership was led by the first author, who was previously an Infant/Special Education teacher.

Figure 4. Design-based methodological approach of Move2Learn.



Move2Learn involved multiple studies with over 500 children across a range of exhibits at different sites, from fully immersive digital interactive exhibits to more familiar water tables, and variations of participants: children on their own, with peers, with a practitioner (science facilitator/ teacher), or parent. However, the structure for studies was similar: first, children were encouraged to play with an exhibit, and then they were 'interviewed' away from the exhibit and asked to communicate their experience and understanding of relevant concepts. Many sessions were video-recorded to analyse in detail how children and adults interacted and communicated: their speech, actions, gestures, body position, facial expression, or eye gaze. In particular, the research examined how children's actions with the exhibit helped structure their subsequent speech and gestures in interviews.

Move2Learn4Teachers

In response to interest, a follow-on project (Move2Learn4Teachers, 2021-2022) was funded to develop messages and resources from Move2Learn for primary teachers. This was achieved through a series of

[4] See https://www.youtube.com/watch?v=PLYw69l_q5g. for 3-min animated summary of Move2Learn project.

three workshops, with 10 teachers from across the UK, delivered online due to the pandemic. As well as the original science centre practitioner leads, the project collaborated closely with the primary and Early Years lead of SSERC, a leading STEM education organisation and co-author of this paper. From this work, three implications for practice were co-developed and described below:

*1. **Recognise** children's understanding in ways beyond words, especially gestures*

Educators already recognise the diverse ways in which children communicate their understanding (although such diversity is often challenged by formal assessments). However, both traditional paradigms of cognition and practice privilege more abstract forms of communication, notably speech and writing (Flewitt, 2005). By arguing that knowledge is intrinsically linked to internalised experience, Embodied Learning emphasises the importance of recognising more body-based modes of communication, notably gestures, which offer a unique window into children's science understanding (e.g. Thomas *et al*, 2021). Attending more to children's gestures may particularly benefit children who struggle to communicate their thinking through words.

In Move2Learn, children tended not to gesture whilst interacting with exhibits, unless pointing to direct others' attention. In contrast, many (>50%) gestured in interviews, although it was unclear what influenced the likelihood of gesturing (beyond rapport with interviewer). Whilst younger children's gestures were typically not succinct or easy to interpret, they often preceded speech and appeared to help prompt verbal explanation. It was also clear from videos how adults attended to children's gestures and often used them as a springboard for continuing dialogue with children. In some instances (see Figure 5, for example), children would watch and emulate each other's gestures when explaining in pairs/groups.

Figure 5. Children emulating other children's gestures.

The variation in the way that children gestured similar ideas was insightful. Some children re-enacted their actions from a first point of view (e.g. simulating moving blocks on a balance board); others' gestures were more representational of underlying scientific processes, for example how balance was affected by distance from the pivot. Such '3rd person' gestures arguably reflect more developed thinking, representing scientific processes in more abstract ways that can generalise to other balancing contexts.

It is worth noting that, in Move2Learn, children were asked to *explain*, which generally implies speaking – gestures were coincidental. In Move2Learn4Teachers, we developed a game to encourage practitioners and children to focus on gestures by having to explain concept words just through gestures – STEM Charades[5]. This game raises the interesting possibility that we might sometimes help children to express ideas by explicitly *showing* (i.e. gesturing) their thinking.

*2. **Encourage** meaningful sensory and movement experiences*

Children's and adults' gestures demonstrate the importance of experiences in shaping conceptual development. Some concepts have a clearer mapping to experiences: for example, the feel of friction on different surfaces or the force pulling you out from the centre of a roundabout. For other concepts, experiences can act as metaphors (Núñez, 2000): for example, concepts of time drawing on experience of moving forwards and backwards, the flow of water for electricity, running around colliding with others for how gas molecules behave, or balloons to think about the expanding universe. Many science concepts, such as 'energy' (Lancor, 2015), draw upon multiple metaphors.

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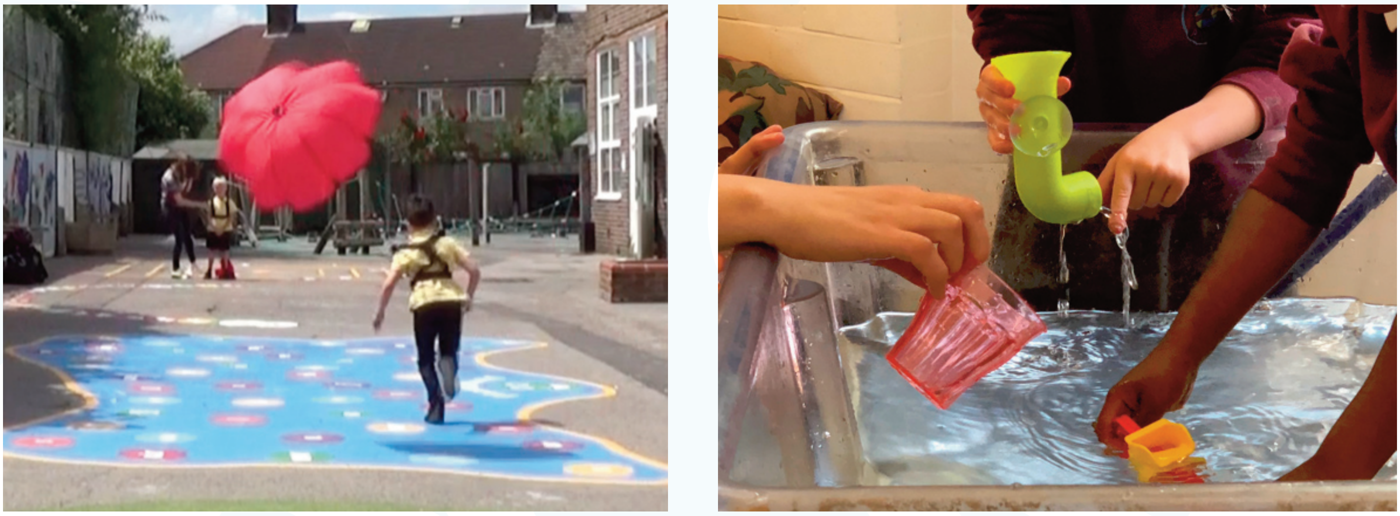
5 STEM Charades video https://youtu.be/J39Ezk1J79E

Many experiences, such as those exemplified above, are gained from everyday interaction in the world (although this does raise questions about whether children have equal access to such 'everyday' experiences). But some experiences can be encouraged in education – through activities (e.g. nature walks) or designs (e.g. educational materials, exhibits). Everyday technologies offer immersive experiences, although they also raise questions about whether forms of interface (e.g. mouse, touchscreen) can sometimes limit sensorimotor interaction.

In Move2Learn, we observed the range and frequency of sensorimotoric experiences that children encountered through engagement with exhibits and activities, from designs encouraging movement (e.g. attachable kites to explore resistance – Figure 6a) to more tactile experiences, (e.g. feeling flowing water or submerging objects – Figure 6b).

Figure 6. Experiences offering meaningful sensorimotoric experiences: a) attachable kites, b) water table.



The importance of active engagement is well documented in education; the more specific contribution of Embodied Learning is to draw attention to the relationship between sensory and movement experience and conceptual thinking – how these experiences help generate cognitive resources for children. The question of which experiences are meaningful for specific ideas is challenging and ongoing. Whilst gesture studies can help reveal the role of some visual and movement experiences, revealing the cognitive significance of other sensory experiences, such as auditory or tactile (e.g. the sound of the wind, the feel of tree bark). remains challenging.

3. Communicate in ways beyond words, especially gestures

Educators employ diverse ways of communicating ideas with children, both through resources around them (e.g. manipulatives, diagrams) and how they communicate directly (e.g. speech, gesture, facial expression). Whilst there has been increased recognition of the importance of multimodal communication in science learning (Kress, Charalampos, Jewitt & Ogborn, 2006), Embodied Learning emphasises the cognitive significance of more body-based communication, notably, the potential to represent sensorimotoric experience through gesture.

Through detailed video observation, Move2Learn revealed the nuanced ways that adults communicate with children in science learning contexts, both when children interact with exhibits and afterwards in interviews. For example, in Figure 7, a science facilitator is supporting children's interaction with a balance board. The practitioner spoke little, but scaffolded children's interaction throughout the session, particularly by drawing children's attention to important features of the exhibit using gesture (pointing), eye gaze or body position (e.g. crouching down to encourage children to notice under the board – Figure 7a). Body position was also important in signalling intention to intervene or encourage children's independence simply through stepping/leaning forward and backwards. Facial expressions were often exaggerated to guide interaction, from intentionally puzzled (to encourage reflection), to happily surprised expressions (to help children recognise significance of actions).

Perhaps the most significant form of multimodal interaction from an embodiment perspective was the practitioner's use of representational gestures. For example, in Figure 7b, the practitioner tilted their forearm to represent the board balancing around a mid-pivot point. This gesture was significant because it offered children an abstracted representation of the complex naturalistic interaction context; it is also the gesture used later by children to describe their experiences.

Figure 7. Practitioner scaffolding through gesture: a) body position and eye gaze, b) representational gesture.

As well as gesturing, adults interacted with exhibits, often to draw children's attention to science relationships or help solve the exhibit task. In one study, we compared similarities and differences between practitioners (science facilitators and visiting teachers) and parents in how they scaffolded children's interaction. The findings revealed how practitioners tended to gesture more, whilst parents tended to act more – possibly because gestures have less impact on children's independent interaction and help provide a pedagogical bridge between children's actions and science language (e.g. 'balance', 'pivot').

In another part of the study, children were interviewed with parents who were told to support children as they might naturally. Here, parents used multiple representational gestures to support their children's recollection of interaction. Gestures often simulated children's actions with the exhibit (e.g. grabbing blocks – Figure 8a). Some gestures were more abstract, such as the balance gestures described previously (Figure 8b). Interestingly, the parent used the same gesture in the interview to link the balance exhibit to a recent seesaw experience. This example shows both how more abstract representational gesture can help connect multiple experiences and the way in which gestures help adults to extend dialogue from shared interaction experiences with children.

Figure 8. Parent scaffolding through gestures: a) simulating children's actions, b) representing concepts.

Conclusion

Embodied Learning is a relatively recent and growing research area promising exciting implications for education. Move2Learn contributes to this field by examining embodied interaction in a practice context, both how children (and adults) interact and subsequently how they communicate experiences and understanding.

Studies from Move2Learn are limited in many ways, not least the relatively unusual interview context after exhibits. Whilst Move2Learn4Teachers showed teachers' interest in and positive experiences of exploring embodied approaches in their classroom, more work is required to develop and evaluate research and practice in this context. The research also raised many new questions for future investigation, such as the relationship between gesture and sign language, or the extent to which practitioners should present gestures for concepts before or after encouraging children to create and reflect upon their own.

Move2Learn has highlighted the necessity of research-practice partnerships; hence the intention for this paper to help build interest in this field by presenting three broad messages, which are presented and summarised in Table 1.

Table 1. Summary of Embodied Learning key implications for practice.

Key implication	Practice notes
Recognise children's understanding in ways beyond words, especially gestures	Encourage children to express their knowledge in diverse ways
	Encourage gesture, perhaps asking children to 'show' you what they mean
	Continue dialogue by building upon meaning that children communicate through gesture
	Encourage children to reflect and discuss each other's meaning through gesture
Encourage meaningful sensory and movement experiences	Encourage where possible opportunities to gain sensory and movement experiences that are meaningful for science ideas from the everyday environment (e.g. nature trips/tables)
	Use/design materials/activities that provide sensory and movement experiences that are meaningful for science ideas
	Consider how materials may encourage different embodied metaphors for science concepts
Communicate in ways beyond words, especially gestures	Use multimodal communication as children interact to draw children's attention to meaningful actions (and results of these actions)
	Use gestures as children interact to help represent the scientific meaning in their actions
	Use gestures to help children draw upon previous experiences and to represent these experiences more abstractly
	Use gestures to help emphasise key words (beat gestures) and draw children's attention to key information (deictic/pointing gestures)

For the research and resources described here, the Move2Learn collaboration was awarded a Social Impact Award[6]; we are now working together to support science educators (formal and informal learning) through the development of an accredited online course on Embodied Learning for Early Years and primary educators. The shared goal is to realise the potential for Embodied Learning to make science meaningful for all children, notably for those who lack confidence or ability in communicating understanding verbally.

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Disclaimer

Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of NSF, the Wellcome Trust, or ESRC.

References

Alibali, M.W. & Nathan, M.J. (2012) 'Embodiment in mathematics teaching and learning: Evidence from learners' and teachers' gestures', *Journal of the Learning Sciences*, **21,** (2), 247–286

Barsalou, L.W. (2010) 'Grounded cognition: Past, present, and future', *Topics in Cognitive Science*, **2,** (4), 716–724

Church, R.B. & Goldin-Meadow, S. (1986) 'The mismatch between gesture and speech as an index of transitional knowledge', *Cognition*, **23,** (1), 43–71

Cook, S.W., Mitchell, Z. & Goldin-Meadow, S. (2008) 'Gesturing makes learning last', *Cognition*, **106,** (2), 1047–1058

Flewitt, R. (2005) 'Is every child's voice heard? Researching the different ways 3-year-old children communicate and make meaning at home and in a pre-school playgroup', *Early Years*, **25,** (3), 207–222

Gelman, R. & Brenneman, K. (2004) 'Science learning pathways for young children', *Early Childhood Research Quarterly*, **19,** (1), 150–158

Goldin-Meadow, S. (2005) *Hearing gesture: How our hands help us think*. Cambridge, MA: Harvard University Press

Hostetter, A.B. & Alibali, M.W. (2008) 'Visible embodiment: Gestures as simulated action', *Psychonomic Bulletin & Review*, **15,** (3), 495–514

Hostetter, A.B. (2011) 'When do gestures communicate? A meta-analysis', *Psychological Bulletin*, **137,** (2), 297

Howison, M., Trninic, D., Reinholz, D. & Abrahamson, D. (2011) 'The Mathematical Imagery Trainer: from embodied interaction to conceptual learning'. In: *Proceedings of the SIGCHI conference on human factors in computing systems* (pps. 1989–1998)

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[6] https://edinburgh-innovations.ed.ac.uk/news/stem-education-collaboration-wins-scottish-knowledge-exchange-award

Kress, G., Charalampos, T., Jewitt, C. & Ogborn, J. (2006) *Multimodal teaching and learning: The rhetorics of the science classroom*. London: Bloomsbury Publishing
Lancor, R. (2015) 'An analysis of metaphors used by students to describe energy in an interdisciplinary general science course', *International Journal of Science Education*, **37,** (5-6), 876–902
Lindgren, R., Tscholl, M. & Moshell, J.M. (2013) 'Meteor: Developing physics concepts through body-based interaction with a mixed reality simulation'. In: *Physics Education Research Conference-PERC* (Vol. 13, pps. 217–220)
Manches, A. & Ainsworth, S. (2022) 'Learning About Viruses: Representing Covid-19'. In: *Frontiers in Education* (p. 517). Lausanne: Frontiers
Manches, A. & Dragomir, M. (2016) *The Effect of Concrete Materials on Children's Subsequent Numerical Explanations: Metaphorical Priming.* Singapore: International Society of the Learning Sciences
Nathan, M.J. (2021) *Foundations of embodied learning: A paradigm for education*. Abingdon: Routledge
Novack, M.A. & Goldin-Meadow, S. (2017) 'Gesture as representational action: A paper about function', *Psychonomic Bulletin & Review*, **24,** (3), 652–665
Núñez, R.E. (2000) 'Conceptual metaphor and the embodied mind: What makes mathematics possible?'. In: *Metaphor and Analogy in the Sciences* (pps. 125–145). Dordrecht: Springer
Roth, W.M. (2001) 'Gestures: Their role in teaching and learning', *Review of Educational Research*, **71,** (3), 365–392
Shapiro, L. & Stolz, S.A. (2019) 'Embodied cognition and its significance for education', *Theory and Research in Education*, **17,** (1), 19–39
Thomas, R., Price, S., Nygren, M. & Glauert, E. (2021) 'How Sensorimotor Interaction Shapes and Supports Young Children's Gestural Communication around Science', *International Journal of Science Education*, **43,** (8) 1292–1313. 10.1080/09500693.2021.1909771
Wilson, M. (2002) 'Six views of embodied cognition', *Psychonomic Bulletin & Review*, **9,** (4), 625–636

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Space in schools: Teaching physics through dance

● Cherry Canovan ● Joanne Pledger ● Ruth Spencer

Abstract

'Into Our Skies: Space in Schools' is a cross-curricular approach to teaching science through dance developed as a response to the COVID-19 pandemic and home schooling. The 6-week scheme of work used movement and dance as a tool through which pupils aged 9-11 could explore concepts of Earth and space, alongside a set of practical classroom activities. Surveys conducted with teachers who used the scheme of work concluded that the science learning achieved in the dance aspect of the programme was equal to the more traditional classroom activities. Meanwhile, 80% of teachers reported an increase in curiosity in the pupils in the dance session, and the same proportion saw an increase in participation among pupils who would normally not engage in science lessons. At an age when attitudes to science are becoming fixed, this cross-curricular approach could be vital in increasing the achievement of pupils and maintaining their interest in science.

Keywords: Widening participation, STEAM, cross-curricular, primary, space

Introduction

The *Into Our Skies: Space in Schools* project is a 6-week scheme of work, which fully covers the English National Curriculum *Earth and Space* topic for ages 9-11. The scheme uses movement and dance to engage pupils with the curiosity and excitement of science through interactive educational dance videos, and embeds the learning through classroom investigations.

This resource was developed, in collaboration with dance artist Lucy Starkey and composer/sound engineer Lee Affen, during the COVID-19 pandemic. One motivation was research by Canovan and Fallon (2021a, 2021b), which revealed that primary teachers found it difficult to provide science lessons during the first lockdown, with a large proportion struggling to adapt the curriculum for online learning.

Research shows that young people's science aspirations could be fixed by the end of primary school (Archer *et al*, 2020). The large-scale ASPIRES study, which tracked a group of young people from ages 10-14, found that from the age of 10 only around 15% of young people aspire to be a scientist (Archer *et al*, 2013). The authors note that *'Longitudinal tracking indicates that the majority of young people's aspirations are quite consistent from the age of 10 to 14, remaining within the same broad categories (science; STEM-related; non-STEM)'* (p.1).

In today's world, where science is responsible for some of the most advanced and critical technology, it is vital that we inspire and encourage young children to explore the subject of science. The *Raising Aspirations in Physics* report (Institute of Physics, 2014) found that *'children from disadvantaged families are less likely to take physics'* and recognised that pupils from certain backgrounds may not have role models to identify with. For young people from low-participation backgrounds, their only exposure to science may be through the school setting. For many, COVID removed or downgraded this provision, at a critical time for children's interest in the subject, meaning that the window of opportunity during which to engage them may have been lost. Canovan and Fallon, who studied primary science during this period, state that the move to home learning created conditions with the potential to lead to *'a widening of* *differences in science learning amongst primary-aged pupils, with those from more deprived backgrounds, already at a disadvantage in normal educational conditions, put at an even greater disadvantage'* (Canovan & Fallon, 2021b). The authors' follow-up study (Canovan & Fallon, 2021a) found that a lack of science catch-up activities in primary schools *'risks science learning loss being forgotten'.*

The *Into Our Skies* project sought to move away from traditional teaching methods and approach the teaching of science from a more physical and creative perspective, whilst meeting National Curriculum guidelines for *Earth & space.* The project aimed to spark curiosity about science among young participants, an objective that has been identified by Ofsted as desirable for science learning (Ofsted, 2013) and which is held by psychologists to enhance learning (Gruber *et al,* 2019).

A similar cross-curricular approach was explored in a 2017 drama-based study by Oxford Brookes University and the Primary Science Teaching Trust (McGregor *et al,* 2017), which used drama in primary science to support children's understanding of concepts by *'enacting scientific processes'.* Teachers reported that it made *'science real'* and more effectively included children who traditionally felt excluded from science. Another study, McGregor (2012), reported that drama made science appear less elitist and more fun, with 70% of children surveyed saying that it improved their understanding of difficult ideas. Indeed, an 'outstanding lesson' from a 2011 Ofsted report was one where children acted out the life cycle of a butterfly using movement.

Graham and Brouillette (2016) found that students in high-poverty schools exposed to even minimal STEAM (Science, Technology, Engineering, Arts and Mathematics) lessons showed greater improvement in standard assessment tests than those exposed to STEM-only teaching. Meanwhile Burnard *et al* (2018) concluded that including the Arts gave children *'a more positive view of engagement with STEM subjects'.*

So why dance? The positive benefits of dance participation on physical and mental wellbeing post-pandemic are known (Roncaglia, 2021) and, at a time when young people are facing the *'perfect storm of an obesity crisis and a mental health epidemic'* (One Dance UK, 2020), dance, with its ability to nurture physicality and creativity in a non-competitive environment, is a *'vital and incredibly effective tool' (ibid.)* in addressing the needs of young people.

There is a small amount of literature directly related to the teaching of science through dance. The 'Dance of Science' project (Valls *et al,* 2019) provided professional development to science teachers to integrate science and creative dance. They found a shift in the teachers towards a more constructivist approach (autonomy, interest, experimentation), and teacher-reported benefits included pupils being able not only to retain information better, but also remember it in more depth.

Meanwhile, a Forbes review article by Amsen (2019) on several projects combining dance and science showed that the practical nature of learning through dance encouraged deeper questioning of scientific ideas in all children. However, the author concludes by noting that it was unclear whether participating students had successfully learned scientific concepts.

In more general terms, there is also a body of evidence showing that incorporating physical movement can enhance learning. A large scale study review of 850 articles by Strong *et al* (2005) found strong evidence to support the conclusion that *'physical activity has a positive influence on memory, concentration and classroom behaviour'.* Meanwhile, a further review by Madan and Singhal (2012) finds that *'motor actions can enhance memory for specific information'* and concludes that *'our minds and our bodies are more connected than previously thought'.*

With the above in mind, the aim of the *Into Our Skies* project was to use dance to engage pupils who would not otherwise think of space science as 'for them', via the creation of a fun learning environment. The questions that this paper seeks to answer are threefold:

1. Do primary teachers see a programme that includes dance as a useful addition to the school space science curriculum?
2. Is there any evidence of improved factual learning via the incorporation of a dance element?
3. Can such a programme spark curiosity and/or improve participation among those who are normally not engaged with science?

Method

The resource

The *Into Our Skies* scheme of work is based around a 6-week teaching term and, in response to COVID-19, was designed to be delivered either in school or as home learning. The scheme was designed as an 'off-the-shelf' resource with teachers free to use some/all of it as required. The scheme of work included:

- 3 interactive educational dance videos using movement to explore key science concepts;
- 3 bespoke soundtracks;
- 6 hands-on classroom investigations using only household items that could easily be carried out at home. These included a complete PowerPoint for the teacher/parent and support notes with a starter activity, pupil activity and extension activity; and
- Support notes for the dance videos to help teachers/parents develop pupils' movement and give explanation of the science that is demonstrated at each point.

The schools

Designed with pre-publication knowledge of the work of Canovan and Fallon (2021), our scheme of work was publicised on social media sites and through existing teacher networks and has been available to download since August 2020[1]. By December 2020, we had 187 registrations, 148 from schools, plus home educators, trainee teachers and others from across the UK (see Figure 1).

Participating schools had intakes ranging from the highly affluent to the very deprived, as measured by percentage receiving pupil premium, an extra payment made by the government to schools to support disadvantaged learners. Distribution by pupil premium mirrored the national picture fairly well, indicating that we had engaged a representative cross-section of schools in the programme.

The evaluation

To evaluate our scheme of work and the role of dance in teaching a STEM subject, we contacted the teachers who had registered for the scheme and who had agreed to complete an evaluation. Our survey contained a range of multiple-choice options, along with free-text questions to gain more information. We received a total of 44 responses from teachers, 30% of the total pool. Of the schools that replied, the majority (42/44) were located in England, hence any results speak to the English education system rather than elsewhere in the UK; this in part could be due to the fact that the scheme of work was created based on the English National Curriculum. As respondents were self-selecting, it is possible that they were more positive (or negative) about the programme than the cohort as a whole. Following this survey, we conducted a second, more in-depth round of surveys with a small pool of three participants.

Results

In general, *Into Our Skies* was well received by teachers. Of the 44 participants who completed our initial survey, 91% rated the materials as 'good' or 'very good', with none selecting a negative response (although it is acknowledged that those with negative views would have been less likely to have completed the survey). Meanwhile all respondents said that they would recommend some or all of the scheme of work to another teacher.

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[1] Teachers are still able to register and download the scheme of work from: https://www.uclan.ac.uk/about-us/schools-and-colleges/into-our-skies

Many teachers commented positively on the quality of the resources, which were 'clear' and 'easy to use', and the innovative approach of teaching space science through dance was also commended. In free text responses, more than half of participants commented favourably on this aspect of the scheme, saying that it was an effective delivery method.

Figure 1. Google map showing pins at the postcode of the registered participants.

Creativity and novel approach

Looking more deeply at the responses of teachers to the materials, a number of themes emerge within these positive views. Firstly, there were many comments to the effect that the sessions led to a positive effect among pupils, with teachers describing them as 'fun' and 'engaging'. The interactivity of the dance elements was key to this; it was *'a far more interesting way to deliver this unit,'* said one participant. Another group commented on the creativity of the approach of mixing dance and space science, calling it 'unique' and 'novel'. Primary school teachers are expected to have a wide skill set, and not every teacher will be confident in both science and dance; responses indicated that the programme supported these aspects, in terms of both science curriculum knowledge and the performance elements. Comments included:

> *'Dance itself is hard to plan and teach, so the package combining both was an unusual and creative approach.'*

> *'I'd never thought of that before. It challenged me as a teacher to think outside my comfort zone.'*

Impact on factual learning

An important question to consider is whether the inclusion of dance led to teacher-reported improved learning among pupils. To address this and other questions, we asked teachers to consider the relative impacts of two parts of the *Into Our Skies* programme, the interactive dance sessions and the more traditional space-based classroom activity pack, when compared to a 'normal' science lesson. The activity pack acts as a control representing any unfamiliar science lesson, and we are investigating whether the dance sessions had reported impacts over and above that.

Although numbers of responses are too small to allow us to draw any firm conclusions, the results are certainly suggestive. In general, both the dance sessions and activity packs were felt to be more effective across all measures than an ordinary lesson, including the amount of science learning achieved. However, we were looking to see whether a bigger boost to learning was experienced following the dance sessions than that following the classroom activities; at first glance, this proved not to be the case, with 71% of teachers saying that the dance led to more learning than a normal lesson, compared to 73% when the comparison was with the classroom activity pack (see Table 1).

This finding might superficially suggest that learning was not incrementally boosted by incorporating a dance element. However, when we delve deeper, the picture becomes more supportive of the role of dance in learning. For a number of measures, including improved participation, curiosity, and length of focus, the dance sessions were felt to be substantially more beneficial than the classroom activities. These findings are summarised below in Table 1:

Table 1. Relative impact of dance and 'traditional' sessions.

	% stating the programme was more impactful than a 'normal' lesson	
	Dance sessions	**Classroom activities**
Level of participation	74%	55%
Length of pupils' focus	68%	57%
Curiosity of pupils	80%	62%
Science learning achieved	71%	73%

As mentioned in the literature review, sparking curiosity in science is an Ofsted priority, and psychology literature suggests that curiosity enhances learning (Gruber *et al*, 2019; Ofsted, 2013). Similarly, actually taking part in an activity and maintaining concentration on it is a necessary condition for learning. It is reasonable, then, to suggest that, while the volume of science content available to be learned is not greater in the dance sessions, the conditions are present in these aspects of the programme to promote lasting learning that is likely to be retained by greater numbers of pupils. This is consistent with findings highlighted in the literature review in reference to the connection between movement and learning.

This impression is supported by qualitative responses from both our main survey and smaller in-depth survey. The combination of science and dance made the associated knowledge *'memorable and more real'*, said one respondent, while another commented that *'the children retained information a little more'.* This is likely associated with increased interest and engagement with a practical session, but some teachers also noted that it allowed space science, which can be rather an abstract concept when presented in the classroom, to be viewed from another perspective. The workshops provided *'different angles to teach space'*, said one, while another commented that the dance/science interface supported *'the complex ideas of movement in space'.* Examples of the practical ways in which this expressed itself were given by some teachers:

'After completing the dance lessons, the children were dancing round the classroom to remember the order of the planets.'

'The children went home and wanted to find out about the stars and visible planets.'

Our in-depth qualitative survey gave an opportunity to explore these thoughts further. One told us that the sessions gave her pupils *'good ideas about the movement of the planets,'* noting that it's *'always hard to do this practically'.* Another reinforced the point, saying that *'space is notoriously difficult to make practical other than showing orbits'.* These results suggest that the combination of dance and space science is an effective and engaging way of imparting complex ideas and may lead to increased learning.

Harder to reach groups

We were also interested to investigate whether a programme such as *Into Our Skies* might have additional benefits for pupils who may be harder to reach, particularly those who are generally uninterested in science. In order to do this, we asked teachers to think about the engagement of pupils who were generally interested in science, and then pupils who were not generally interested. Most agreed that both aspects of the programme – the dance session and the activity pack – were described to be more impactful than a normal lesson. However, this view was more strongly expressed for the group who were normally uninterested in science, as can be seen in Table 2:

Table 2. Relative impact on pupils with different levels of interest in science.

	% stating the programme was more impactful than a 'normal' lesson	
	Dance sessions	**Classroom activities**
Engagement of pupils generally interested in science	63%	63%
Engagement of pupils generally not interested in science	80%	67%

Relatedly, there is also some suggestion that the dance session may support science among pupils who are low prior attainers. Whilst we did not ask about this explicitly, some of the responses raised the possibility; for example, participants in our in-depth qualitative survey suggested that lower attainers or those who had difficulty with written exercises had particularly benefited:

'[It] makes it easier for those that find writing hard.'

'It was more hands-on and enjoyable for those who struggle to access written learning.'

The key to this may be in the comment of another teacher that the activity was *'low stakes and accessible to all'.* It is relatively common for primary-age pupils to perceive science as 'too hard', with the Wellcome Trust finding that around a third held this attitude (Leonardi, 2019). Accessing science via dance may, therefore, be a way in which those who find the subject intimidating can approach it from a fresh angle, which feels more manageable. This is an area which merits further study.

Wider applicability

Although the *Into Our Skies* scheme focused on the interface between dance and space science, we were interested in whether this pedagogical approach might be applicable to other areas. Teachers who had used the resources were largely positive about this idea, with suggestions for further programmes covering a wide range of the science curriculum, particularly forces. Interestingly, others posited that the methodology could work for history, geography and other subjects.

Discussion and implications

It is clear from the above results that our teacher respondents valued the dance-based scheme of work for space science lessons, and it provided a well-resourced way for them to 'break from the norm' in their pedagogy. This result aligns with the findings of the existing minimal literature surrounding dance and science teaching.

However, the more important impacts were on how they described learning and participation and here, also, there is evidence of success. Teachers reported that the dance element led to an improvement in vital preconditions for learning, including curiosity, length of participation and length of focus; they gave examples of enhanced retention of facts and sustained post-session desire for topic information.

There is also evidence that incorporating dance could improve the involvement of pupils who are not normally interested in science, with 80% of teachers reporting increased engagement among this group. As noted in the literature, this is particularly important for the 9-11 age group, which is where pupil science identity begins to be fixed. Some teachers also suggested that the use of dance was beneficial for the participation of less able students.

Taken as a whole, our study suggests that dance-based sessions are a valuable addition to science pedagogy for this age group, with the potential to boost learning and engagement among pupils, including those who are harder to reach. A next step could be to gather direct data on impacts on pupil attainment, as the current findings rest on the views of teachers. It would also be valuable to investigate what type of CPD could encourage teachers to deliver such cross-curriculum STEAM content. In addition, conducting similar research with a larger group of pupils could enable the differential impacts on groups such as those from less affluent backgrounds or ethnic minorities to be investigated.

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References

Amsen, E. (2019) 'Can Children Learn Science Through Dance?' *Forbes.* Published online

Archer, L., Moote, J., Macleod, E., Francis, B. & DeWitt, J. (2020) *ASPIRES 2: Young people's science and career aspirations, age 10–19.* https://discovery.ucl.ac.uk/id/eprint/10092041/

Archer Ker, L., DeWitt, J., Osborne, J.F., Dillon, J.S., Wong, B. & Willis, B. (2013) *ASPIRES Report: Young people's science and career aspirations, age 10 –14*. King's College London. https://kclpure.kcl.ac.uk/portal/files/64130521/ASPIRES_Report_2013.pdf

Burnard, P. *et al* (2018) 'The art of co-creating Arts-based possibility spaces for fostering STE(A)M practices in primary education'. In: *Arts-based methods in education around the world*, Chemi, T. & Du, X. (Eds.). Gistrup: River Publication. Accessed 19.10.22. https://www.repository.cam.ac.uk/bitstream/handle/1810/274063/Rivers_Publication_STEAM_chapter_9788793609372C11.pdf

Canovan, C. & Fallon, N. (2021a) '"It isn't a priority." Will primary science learning loss be forgotten?', *Journal of Emergent Science*, (21), 46–53. https://www.ase.org.uk/resources/journal-of-emergent-science/issue-21/original-research-it-just-isnt-priority-will-primary

Canovan, C. & Fallon, N. (2021b) 'Widening the divide: The impact of school closures on primary science learning', *SN Social Sciences*, **1,** (5), 117. https://doi.org/10.1007/s43545-021-00122-9

Graham, N.J. & Brouillette, L. (2016) 'Using Arts Integration to Make Science Learning Memorable in the Upper Elementary Grades: A Quasi-Experimental Study', *Journal for Learning through the Arts*, **12**, (1). https://doi.org/10.21977/D912133442

Gruber, M.J., Ranganath, C. & Valji, A. (2019) 'Curiosity and Learning: A Neuroscientific Perspective'. In: *The Cambridge Handbook of Motivation and Learning (1st ed.),* Renninger, K. & Hidi, S. (Eds.). Cambridge: Cambridge University Press. Accessed 5/10/22. https://doi.org/10.1017/9781316823279

Institute of Physics (2014) *Raising Aspirations in Physics: A review of research into barriers to STEM participation for students from disadvantaged backgrounds.* https://www.iop.org/sites/default/files/2021-03/raising-aspirations-in-physics.pdf

Leonardi, S. (2019) *What pupils think of science in primary schools*. Wellcome Trust. https://wellcome.org/sites/default/files/what-pupils-think-of-science-in-primary-schools.pdf

McGregor, D., Wilson, H., Bird, J. & Frodsham, S. (2017) *Creativity in Primary Science: Illustrations from the classroom.* Primary Science Teaching Trust. Published online. https://pstt.org.uk/application/files/8914/8949/8323/Creativity_in_Primary_Science_PSTT_OBU.pdf

McGregor, D. (2012) 'Dramatising science learning: Findings from a pilot study to re-invigorate elementary science pedagogy for five-to seven-year olds', *International Journal of Science Education*, **34**, (8), 1145–1165. https://doi.org/10.1080/09500693.2012.660751

Ofsted (2013) *Maintaining Curiosity: A survey into science education in schools, November 2013.* https://www.gov.uk/government/publications/maintaining-curiosity-a-survey-into-science-education-in-schools

Ofsted (2011) *Successful Science: Strengths and weaknesses of school science teaching, January 2011.* https://www.gov.uk/government/publications/successful-science-strengthes-and-weaknesses-of-school-science-teaching

Onedanceuk.org (2020) *Everything we loved about dance was taken away: The place of dance in UK education*. Accessed 29.9.22. https//:www.onedanceuk.org/wp-content/uploads/2018/10/Everything-We-Loved-About-Dance-Was-Taken-2.pdf

Roncaglia, I. (2021) 'The Role of the Performing Arts in Improving and Maintaining our well-being during and post-covid pandemic', *Psychological Thought*, **14,** (1), 1–8. https://doi.org/10.37708/psyct.v14i1.606

Valls, R., Black, C. & Lee, M. (2019) 'Five years of integrating science and dance: a qualitative inquiry of constructivist elementary school teachers', *Research in Dance Education*, **20**, (2), 113–129. https://doi.org/10.1080/14647893.2018.1550477

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What can teacher nominations for a science prize reveal about perceptions of primary science over time?

● Scott Walker ● Christina Whittaker

Abstract

This article is an analysis of data from teacher nominations of their chosen student scientist of the year. With seven years of the School Physicist of the Year (SPOTY) data to draw upon, several trends and patterns emerge that allow critical reflection on local science interventions during that time. Findings include an increasing profile for primary science, but also a lack of young female student nominations in the primary education phase. The authors consider evidence of any shift in primary teacher perceptions of what science is, who science is for, and how primary science is valued across the city of Stoke-on-Trent.

Keywords: Science capital, community, unconscious bias, crossing boundaries, science identity

What is SPOTY?

The School Physicist of the Year (SPOTY) is an annual awards event, now in its seventh year (hosted by Keele University) and supported by The Ogden Trust and, more recently, Science Across the City (SATC). SPOTY is designed to celebrate the outstanding effort and achievements of science (physics) students currently in Year 6 (ages 10-11) or Year 10 (ages 14-15) at schools within a given radius of Keele University. The Ogden Trust has previously provided funding for similar SPOTY events across the country; however, this paper considers data from the Stoke-on-Trent events only.

How is SPOTY organised?

All eligible schools are notified by letter of a timeframe within which to nominate a student for the SPOTY award. Social media forums are utilised to raise awareness of SPOTY. The guidance to schools invites the teacher to select one student who they feel deserves to be recognised for their efforts and achievements in science. The guidance states that this does not necessarily need to be the highest achieving student academically, and encourages that the focus is on significant improvement or demonstrated enjoyment and great interest in the subject. The letter and associated guidance have remained consistent over time and the letters for secondary phase and primary phase only differ by the use of Year 6 or Year 10 in the target group. The nomination form requires contact details along with a 'long paragraph' response for the teacher to add in an explanation of their choice. All nominated students are successful and are invited to receive the award at the formal certificate evening.

Why does SPOTY exist?

It is well documented that the number of young people studying A-level physics (ages 16-18) has been stagnant for decades (Ofqual, 2021). This has contributed in part to the so-called STEM skills shortage (UKCES, 2015), as low numbers of A-level physics students lead to low numbers of physics undergraduate students, ultimately meaning that tens of thousands of crucial STEM jobs remain unfulfilled. This pipeline of physics graduates provided the initial stimulus for setting up the SPOTY awards, but the programme should now be considered in the broader context of supporting interest in science.

In Stoke, SPOTY was included as part of an outreach programme focused on raising and maintaining the award winners' science capital (the sum of all the science-related knowledge, attitudes, experiences and resources that an individual builds up through their life – see the Science Capital videolink below for an accessible introduction). It is proposed that SPOTY students will not only continue to enjoy the subject but, moreover, begin identifying as scientists/physicists who are therefore more likely to pursue further study and (ultimately) a STEM career. The ASPIRES Research (Archer *et al,* 2013) found that *'A student is least likely to express science aspirations if they are female, white, have low/very low levels of cultural capital, are in the bottom set and do not have any family members who use science in their jobs'* (p.3). For girls and those from some minority ethnic backgrounds, the visibility of physics role models to whom they can relate (both in the science national curriculum and broader media) is often low. SPOTY not only provides an external 'validation' of a student's effort and achievement in the subject but, through the scientist guests invited to the awards ceremony, brings them face-to-face with real, relatable and local role models.

What is SATC?

Science Across The City (SATC) was established from a DfE Opportunity Area grant in 2019, with the purpose of closing the attainment gap between students in Stoke-on-Trent and their peers nationally. The vision was to enable more school-to-school collaborative reflective learning, to engage more teachers with quality STEM CPD, to enable more school access to STEM resources and STEM pupil offers, and to empower teacher subject leaders with depth in their specialism. SATC has supported teacher professional learning, with over 85% of city schools engaged in at least one of following formal CPD interventions: Thinking Doing Talking Science (EEF, 2022), TAPS (TAPS, 2022) and PSQM (EEF, 2020).

Why does SATC exist?

Science in primary schools is known and reported as being too often overlooked in favour of English and mathematics. Amanda Spielman, in her commentary on the Annual Report (2020), states that Ofsted saw both the quantity and quality of science teaching reduced (Ofsted, 2020). Science across the City focused city-wide strategic attention to the forgotten core subject by engaging at Headteacher and city governance forums alongside the English and mathematics improvement teams.

Investing in teacher professional development has potential long-term sustainable gains, as it is not only the current pupil cohort that benefits, but also ongoing future cohorts too. SATC adopted the DfE values for effective CPD, ensuring expertise, collaboration, sustainability over time and senior leader commitment (DfE, 2016). Improving teacher quality through school-based teacher learning communities is argued as essential to a culture of continuous development by Dylan Wiliams (Wiliams, 2010). SATC, as its model of change, established a community of science leaders who share and support beyond their own schools. This community, known as the SATC science influencers (SATC, 2020), supports rapid transfer of messages and signposting between peers.

Method

Data existed that had been collected each year from 2016 to 2022 for the purpose of managing the success of the SPOTY awards events. Anonymised data were stored securely, with permission, enabling the authors to explore trends over time. Data each year included: the number of nominations received, the nomination written by the teacher, and the gender of the student nominated.

Given the investment in primary science in Stoke-on-Trent during 2019-2022, the authors looked for patterns over time, to consider whether there were any discernible changes to the participant engagement in SPOTY.

Three themes are considered in the findings below:

- Over time, was interest in the SPOTY awards for primary science in schools increasing?
- What features do teachers describe in their nomination of a 'good scientist'?
- Over time, have there been changes in the proportion of girls and boys nominated?

Findings

Table 1. Number of SPOTY nominations annually.

SPOTY year	Date	No. of teacher nominations	Average word count per teacher nomination	No. of boys: girls nominated by their teacher	
				Boys	Girls
1st	July 2016	8	63	5	3
2nd	July 2017	23	79	20	3
3rd	July 2018	25	51	19	6
4th	July 2019	27	62	15	12
5th	July 2020	36	64	26	10
6th	July 2021	54	63	35	19
7th	July 2022	42	60	30	12

1. *The increasing profile of primary science*

The very first Keele SPOTY awards, held in 2016, saw just 8 nominations (see Table 1). This grew slowly over the next four years and, in 2020, there were 36 SPOTY award winners. Through collaboration with SATC in 2021, there was a significant increase in the number of nominations, up to 54 (Figure 1), suggesting that the SATC localised community of science influencers may be helping to raise the profile of the Awards. This year, 2022, saw the first dip in nominations, with a total of 42 students recognised. This reduction in numbers is likely attributed to 'COVID-exhaustion', with the summer of 2022 being an incredibly challenging year for many students, teachers and wider school communities. SATC is seeking further funding to host a 2023 SPOTY event, which may provide an opportunity to explore if this was a COVID dip and if the numbers can climb again beyond the previous best total.

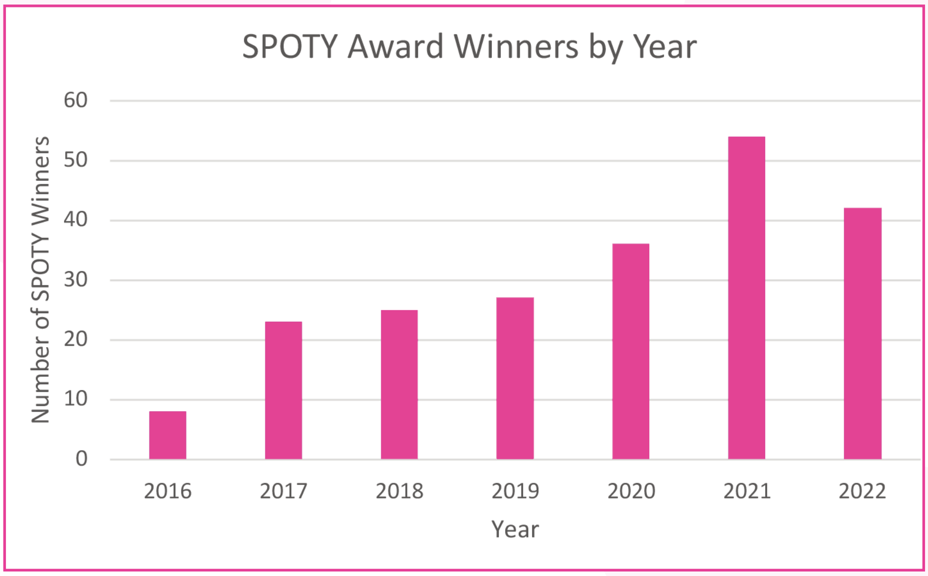

Figure 1. The number of SPOTY nominations made annually since launching in 2016.

2. *Teacher perception of what it means to be a 'good scientist'*

In 2018, the average number of words written by a teacher for a SPOTY nomination was ~51. This rose to ~62 in 2019, where it has remained approximately stable since (Table 1). This year, the average was 60. As can be seen in the SPOTY nominations from teachers (see Table 2), there is overwhelming reference to the nature of scientific method, with many teachers noting question-asking, problem-solving and authentic curiosity. Scientific behaviours are celebrated, and these traits are associated with the identity of being a scientist, and essential in the study of science at all levels. Of particular interest is the recognition that children engage in science outside the classroom and there is clearly an appetite for reading about and engaging in science beyond the formal curriculum.

Table 2. Sample narratives from the teacher SPOTY nominations.

SPOTY Award Winners 2022: Examples of teacher nominations

Child A stands out as being passionate about science. A takes part in science club, on many occasions she completed questions at home to ask visiting scientists. A expressed in parents evening with mum that she aspires to be a scientist in the future as she loves to experiment. She especially enjoys working practically and loves to question and predict during science experiments. Curious about the world around her. She loves to problem-solve and communicates with clear enthusiasm about her findings.

Child B is an amazing scientist, always asking questions, pondering on ideas and thinking about what might happen if... He often arrives at school asking about things he has researched, especially about space. I even gave him some books by Dr. Brian Cox, which he said he had really enjoyed reading. In science lessons B studies hard and comes up with amazing ideas that are always followed by more questions! He is, in my opinion, a scientist of the future.

Child C demonstrates a huge amount of enthusiasm for science. He has taken on the role of a Science Ambassador with dedication. He is always keen to find out information regarding the science topics that he is learning about and asks about his role as Science Ambassador regularly. Our school can always rely on him to discuss science with visitors to our school. He is a true scientist in every respect.

Child D began the year with little confidence in science. After staff have implemented the Thinking, Doing, Talking Science approach through activities such as bright ideas time and odd one out, D has flourished in science lessons. She has explained that she now feels that she can have a go in science without worrying that she might be wrong. D has even worked hard at home to produce a fantastic poster celebrating the work of primatologist Jane Goodall. D loved having the opportunity to share this with different classes around our school and this work then started a whole school celebration of the role of women in science.

Child E has a keen interest in science and will often watch *YouTube* videos at home to learn more about the current topic. He is so passionate about the subject that he has initiated a science club to run on Friday afternoons. At his request, he has sat with the teacher to choose a variety of science experiments to conduct, and a list of resources needed. E is eager to take the lead in the club, with support from his teacher. In his own words, he 'wishes he could just do science for every lesson'

3. *Unconscious bias a barrier for young female scientists*

With seven years of data to draw upon, several trends and patterns have clearly emerged. Alarmingly, the data show an unequal numbers of female students being recognised in comparison with their male counterparts (Figures 2 and 3). For example, in Year 6, only 6 out of 30 (20%) SPOTY nominations this year went to female students. This is entirely consistent with the Year 6 long-term average of just ~21%, with the largest percentage of ~35% seen in 2019. However, there is a stark and striking difference when comparing these data with those of the Year 10 equivalent. Interestingly, if you are a female student, you are twice as likely to be nominated by your teacher in Year 10 as you are in Year 6, with the 7-year Year 10 SPOTY female nomination average being ~41%. The 2022 figure was exactly 50%, thus young female Year 10 scientists were equally as likely to receive the award as their male colleagues.

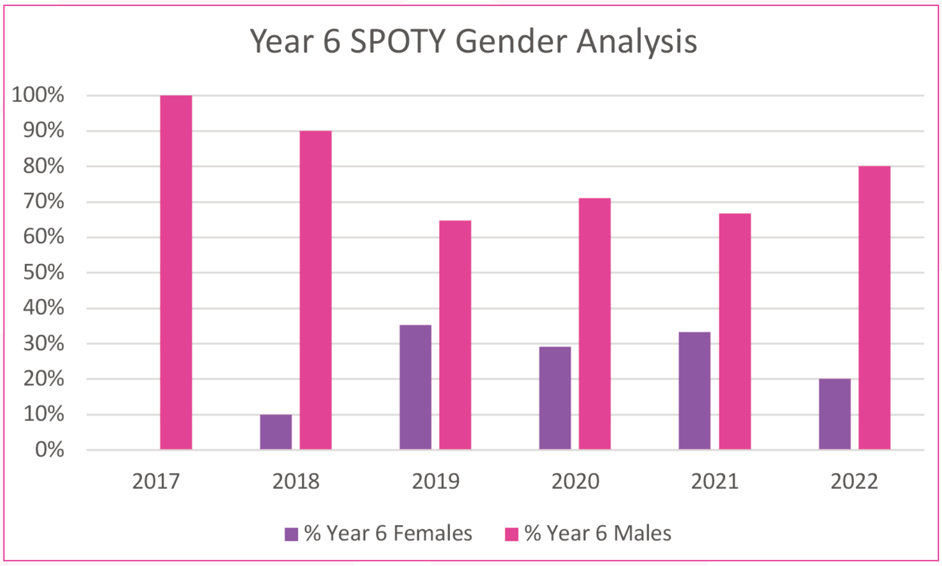

Figure 2. A comparison of percentage male to female SPOTY nominations (Year 6) recorded annually since launching the award in 2016.

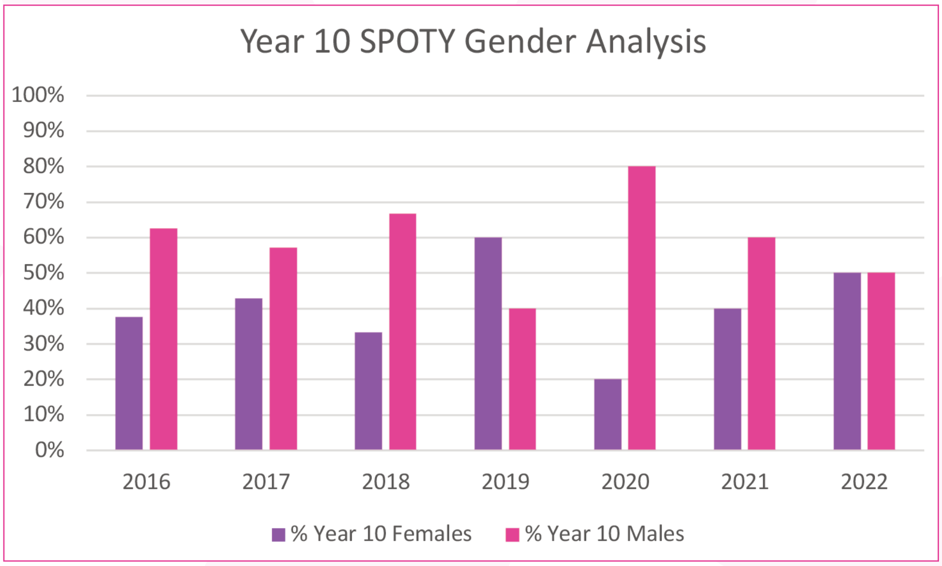

Figure 3. A comparison of percentage male to female SPOTY nominations (Year 10) recorded annually since launching the award in 2016.

Conclusions

Was the profile of the SPOTY awards and primary science increased?

The change over time trend of increased nominations provides evidence for the increasing profile of primary science in Stoke-on-Trent. The authors propose that localised, personalised and trusted messengers matter. They have found that organisations working together can simplify and align key messages to and for teachers:

'It isn't about everybody doing everything but knowing who is doing what best!' (Headteacher, SATC advisory group).

'So many e-mails – we used to ignore most of them but knowing that the messenger knows my needs makes a huge difference to my workload and focus' (Subject leader and science influencer, Stoke-on-Trent).

The authors believe that organisations with a good STEM offer might consider increasing their reach through a community of lead teachers as the respected knowledgeable others. Involving teachers as integral to supporting and influencing other teachers is empathetic, realistic and well-informed.

Did the quality of teacher explanation of a 'good scientist' change?

In response to the line of enquiry, it was noted that quantity of explanation increased over time and the teacher narrative examples included a broad view of science that aligned with SATC values. SPOTY is additional to and supporting of a wider SATC evidence base that investment in sustained professional development improves teacher understanding of the discipline of science (DFE, 2022). The evidence informs an interesting hypothesis, but is not sufficient for discussion of causation, thus further research is needed.

Is unconscious bias for STEM participation a diminishing concern?

The gender findings were unexpected. The SPOTY data analysis poses important questions around (un)conscious biases of primary (science) teachers with respect to who is perceived to be the 'scientists' in their classrooms. Is it possible that 'non-science specialists', as is the case for many primary science practitioners, are themselves directly subject to long-standing, deeply engrained conceptions of who (white, bearded, middle-class, men) and what (white coats, safety goggle-wearing, lab-based) science is? This is particularly notable given that 69.5% of teachers are female, which rises to 82.4% in primary schools (DfE, 2020), where you might expect there to be a positive bias towards female teachers nominating female students.

There is insufficient data to identify whether there is a connection between a teacher holding a degree in a science discipline (the raising of their own science capital through the process) and their likelihood to nominate a female student.

The authors propose that these data provide an alarm-raising call for action, yet more intervention to raise the science capital of under-represented groups in science/physics (such as women) should not be undertaken in isolation from broader awareness-raising and development work with teachers, and the wider school community, so that this capital can be readily recognised, supported and promoted.

Discussion

One of the aims of SPOTY was to increase the science capital of the young person receiving the award. As such, it has always been made clear to the nominating teachers that the SPOTY nominee should *not* necessarily be the highest attaining science student, as there is an assumption that this person may already have higher levels of science capital compared to their cohort. However, by essentially providing no nomination criteria, and leaving this entirely up to the interpretation of the nominating teacher, this may provide an opportunity for unconscious bias[es] to influence their nominations. That said, the authors are mindful that, by providing prescriptive nomination criteria, there is an increasing likelihood that students who achieve higher grades, engage in lessons more actively (or have the confidence to do so) and/or have perceived or actual elevated levels of good behaviour within the classroom, are by proxy likely to be those with higher science capital and therefore the award would reinforce the current STEM meritocracy, as opposed to challenging this, with the many social benefits that such a challenge brings (Reay, 2020).

In 2021, SATC invested in many schools participating in CPD on the theme of unconscious bias. The authors anticipated a shift towards more female nominations. However, given that the data show that the gender bias in Year 6 nominations is as stark as it has ever been, there are inferences here that this training has raised awareness of unconscious bias, but has done little to effect change in behaviour (Fitzgerald, 2019).

What next?

With further iterations of SPOTY, the authors would be keen to complete more extensive scrutiny beyond the limitations of the dataset available. In planning further exploration, the following lenses might be of interest: Does the gender of the nominating teacher affect nomination choice? Does the science specialism affect nomination choice? Does the age demographic affect nomination choice? Does teacher science capital affect nomination choice?

References

Archer, L., Osborne, J., DeWitt, J., Dillon, J., Wong, B. & Willis, B. (2013) *ASPIRES: Young people's science and career aspirations, age 10–14.* London: King's College London

DfE (2016) https://www.gov.uk/government/publications/standard-for-teachers-professional-development

DfE (2020) https://explore-education-statistics.service.gov.uk/find-statistics/education-and-training-statistics-for-the-uk/2020

DfE (2022) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1079113/Opportunity_areas_insight_guide_-_school_improvement.pdf

EEF (2020) https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/primary-science-quality-mark

EEF (2022) https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/thinking-doing-talking-science-effectiveness-trial-2

FitzGerald, C. *et al* (2019) 'Interventions designed to reduce implicit prejudices and implicit stereotypes in real world contexts: a systematic review', *BMC Psychol*, **7**, (29). https://doi.org/10.1186/s40359-019-0299-7

Ofqual (2021) https://www.gov.uk/government/statistics/provisional-entries-for-gcse-as-and-a-level-summer-2021-exam-series/provisional-entries-for-gcse-as-and-a-level-summer-2021-exam-series#as-and-a-level-entries

Ofsted (2020) https://www.gov.uk/government/speeches/amanda-spielman-launches-ofsteds-annual-report-201920

Reay, D. (2020) 'The Perils and Penalties of Meritocracy: Sanctioning Inequalities and Legitimating Prejudice', *The Political Quarterly*, (91), 405–412. https://doi.org/10.1111/1467-923X.12829

SATC (2020) https://www.scienceacrossthecity.co.uk/wp-content/uploads/2020/01/Science-Influencers-The-Concept.pdf

Science Capital introduction video: https://www.youtube.com/watch?v=A0t70bwPD6Y

TAPS (2020) https://taps.pstt.org.uk/

UKCES (2015) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/444048/High_level_STEM_skills_requirements_in_the_UK_labour_market_FINAL.pdf

Wiliams, D. (2010) https://www.dylanwiliam.org/Dylan_Wiliams_website/Papers.html

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Christina Whittaker, Co-lead for Science Across the City.

Contributing to JES

About the journal

The *Journal of Emergent Science (JES)* is an 'open access' biannual e-journal designed to bridge the gap between research and practice, complementing the ASE's professional journal, Primary Science. JES was founded in 2011 by Jane Johnston and Sue Dale Tunnicliffe of the Emergent Science Network. The journal has since been transferred to ASE and is now supported by the Primary Science Teaching Trust (PSTT). JES focuses on research and the implications of research for practice and provision of science (including health, technology and engineering) for young children from birth to 11 years of age. JES welcomes contributions from its audience of early years practitioners, primary school teachers, teacher educators and researchers.

Contributing to the journal

Authors are invited to select the article type that suits the findings they would like to share:

- **Original research**: both small-scale practitioner research and larger projects welcome (maximum of 3000 words, excluding references).
- **Research review**:summary of a larger project or a review of current research in the field (maximum of 2500 words, excluding references).
- **Research guidance**: utilising relevant examples to provide support for practitioner research (maximum of 2500 words, excluding references).
- **Practitioner perspective:** considering application of research from the viewpoint of the practitioner (maximum of 2500 words, excluding references).
- Book and resource reviews on science and research for the birth to 11-year age range are also welcome.

Guidelines on written style

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

- Include a clear title, a 150-word **abstract** that summarises the article and up to five keywords.
- Use subheadings to break up the text e.g. Introduction, Method, Results, Conclusions.
- Tables and figures are useful for readers. For images, high resolution jpegs should be sent separately and the author is responsible for permissions.
- Use UK spelling and single 'quotes' for quotations.
- Avoid acronyms and technical jargon wherever possible and no footnotes.
- There should be a section which considers the **implications** of the research for practice, provision and/or policy.
- Include information about yourself (e.g. job title, email) at the end of the article.
- Contributors should bear in mind that the readership is both national UK and international, so please use children's ages (not just school grades or years) and explain the context of the research.
- For in-text references, use (Author, Date) e.g. (Johnston, 2012). If there are three or more authors, the first surname and '*et al*' can be used.
- Include a reference list (examples below), set out in alphabetical order.

Referencing examples:

Book

Russell, T. & McGuigan, L. (2016) *Exploring science with young children.* London: Sage.

Chapter in book

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

Journal article

Reiss, M. & Tunnicliffe, S.D. (2002) 'An international study of young people's drawings of what is inside themselves', *Journal of Biological Education*, **36,** (2), 58–64

Submission and Review

Articles submitted to *JES* should not be under consideration by any other journal, or have been published elsewhere, although previously published research may be submitted having been rewritten to facilitate access by professionals in the early years and with clear implications of the research on policy, practice and provision.

JES is a biannual online publication. Copy deadlines are usually: October for the January issue and March for the June issue.

Please send all submissions to: janehanrott@ase.org.uk in electronic form. Books for review should be addressed to Pauline O'Connor, ASE, College Lane, Hatfield, Herts., AL10 9AA.

Submitted articles are reviewed by the Editor, Editorial Board and/or guest reviewers. The peer review process generally requires three months. *JES* is keen to support publication of articles from practitioners, so do get in touch if you would like further assistance.

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