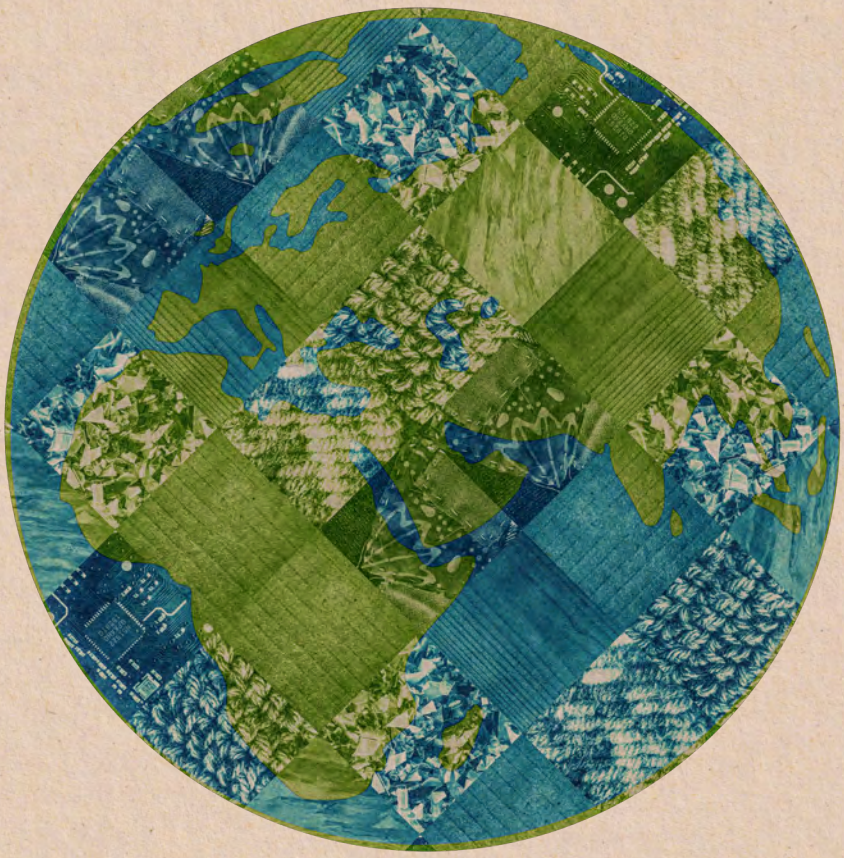
(Eco)vocative Objects

Things that engage with environmental issues



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Foreword

Melissa Glackin

(Eco)vocative Objects asks something of us. Across this chapter collection, we are invited to see the act of making as not only an intellectual and practical endeavour, but also an expression of emotional engagement and ethical responsibility. Like the *Heartwood* books from which it builds, *(Eco)vocative Objects* demonstrates how we as educators can trust in our imagination, foster creativity in learners and together respond to the world around us.

The roots of *(Eco)vocative Objects* lie in the STEM Education MA, and in particular the *STEM: Making and Creating* module, a space shaped by a collective commitment to move beyond the confines of traditional STEM education. Its ambition is not modest: to engage head, heart, and hands together, and in doing so, to work toward an education that is more socially and environmentally just.

Through the rich examples of practice, the authors call for a reimagining of how teaching and learning through STEM making might be approached. *(Eco)vocative Objects* invites us to consider what STEM learning becomes when sensory, relational, and ethical dimensions are foregrounded, and creative outputs are celebrated.

As the introduction makes clear, making as a practice is never neutral. Every act of making carries questions of power, values, and justice: whose hands are involved, whose knowledge counts, what ends are being served? The authors hold those questions with honesty and care, demonstrating with remarkable range that making need not be in service to production and consumption. STEM learning can be reoriented toward practices of care and collaboration; and toward the slow and attentive work of responsibility to all sentient beings.

That reorientation is the quietly radical heart of this volume. *(Eco)vocative Objects* emerges from a community that takes seriously a difficult challenge for STEM education: not only to help us understand the world, but to reshape our relationships with it in more environmentally and socially just ways. That is, to ask not just what we know, but how we live, how we make, and how we are accountable to each other and to the more-than-human world.

This is no small ambition, but it is a necessary one.

Introduction

Alex Hadwen-Bennett,
Heather King

Makerspaces and making inspired pedagogies have increased in popularity in STEM education in recent years, particularly in informal settings. Many suggest that makerspaces have the potential to offer an inclusive approach to increasing youth engagement (Barton et al., 2017). At the same time, critics have highlighted that makerspaces are not automatically equitable and argue that they can reinforce inequitable participation in STEM education (Dawson, 2017). Some criticise the gendered and capitalistic connotations of the term 'maker' itself. Indeed, at a time when we are facing a socio-ecological crisis, we must also query whether the world really needs more 'stuff' to be made (Chachra, 2015).

These debates have been central to our research and teaching on the MA in STEM Education at King's College London for many years. We ask: is environmentally- and socially-just making possible, and if it is what should it entail?

Through our work, we have demonstrated that more socially-just, critically reflective and environmentally responsible approaches to making are not only possible, they have the potential to be transformative for learners and educators alike (Rushton & King, 2020).

Our experiences have convinced us that making-inspired pedagogies can play a vital role in shaping forms of STEM education rooted in both social and environmental justice. Such approaches, however, require a shift away from narratives framing making in terms of production. Instead, our approach emphasises the value of repairing, reusing and recycling, situating making as a practice of stewardship rather than consumption. Equally important is recognising and valuing the cultural processes embedded within diverse forms of making.

In the *STEM: Making & Creating module*, we deliberately model pedagogies that challenge the power dynamics that can operate within makerspaces. This includes widening the range of materials and mediums available beyond the typical electronics and digital technologies. By making space for textiles, as well as found or recycled materials, we encourage learners to explore various modes of expression that reflect different cultural traditions and bodies of knowledge. These practices also

challenge narrow assumptions about what counts as STEM and legitimate ways of expressing and engaging with STEM concepts.

Over time, a vibrant community has grown around this module. Staff, alumni, doctoral researchers and friends of the programme have contributed to a lively, intergenerational and continually evolving network of makers, thinkers, and practitioners. It has been particularly rewarding to see alumni take these pedagogical principles into their own classrooms and develop new approaches of their own that foreground both social and environmental justice.

As this community grew, so too did our realisation that the stories, objects, and pedagogical insights emerging held an important message for a wider audience. We wanted to create a space where these stories could be shared, prompting readers to engage with environmental issues in accessible, evocative and emotionally resonant ways.

The inspiration for this volume draws on Sherry Turkle's influential book *Evocative Objects: Things We Think With* (Turkle, 2007), which explores how everyday objects carry meaning, memory, and insight. Building on this tradition, we invited members of our community to contribute essays that tell the story of a particular '(eco)vocative object' that they, or their learners, designed using STEM skills and principles to illustrate or communicate an aspect of the socio-ecological crisis. Each essay illustrates that the value of making is much more than simply creating an artefact; rather, making combines all the ideas, reflections, and emotions that the process of creating and engaging with others evokes.

The chapters in this volume have been brought together to reflect both the diversity of practices that have emerged within our community and the shared commitment to exploring how making can enable more thoughtful, critical, and emotionally resonant engagements with environmental and social justice issues.

The first two chapters, by Tom Corker and Harry Gowlett, are rooted in Design and Technology education and explore how working with recycled and repurposed materials can enable learners to engage critically with questions of sustainability. In different ways, both contributions challenge normative narratives of making, positioning repurposing and recycling as central to developing more responsible relationships with the world around us. Oria Shuman's chapter similarly foregrounds the way in which learners can take steps towards more sustainable practice, in this instance by building their own solar-powered ovens.

The next three chapters explore how making with textiles can create opportunities for learners to explore the intersections of environmental concerns and social justice. Michelle Boyle and Kathryn Peake explain how a textiles-based project can bring people together around shared concerns. In the following chapter, Winda Hidayanti examines the issue of textile waste and its disproportionate impact on communities in the Global South. Michelle Campbell then discusses the role that yarn-based crafts can play in community activism.

Chapters 7 and 8 turn to the role digital making can play in facilitating engagement with environmental issues. In Chapter 7, Carrie Anne Philbin brings together coding, e-textiles, and data literacy to explore how learners might make sense of complex environmental data. The possibilities of digital making are developed further in Riccardo Galbiati's chapter, which demonstrates how the creation of a computer game can enable learners to engage simultaneously with mathematical ideas and ecological relationships, such as the disruption of predator–prey dynamics through pollution.

The role of the expressive arts in engaging with environmental issues is explored in Chapters 9 and 10, with Jonathan Berliner reflecting on the role of songwriting in engaging learners emotionally with environmental issues and Gaz Lawrence considering more broadly how artistic experiences can create forms of engagement that differ from, and complement, those offered by scientific data.

In the final chapter, Mariana Muñoz-Gómez reflects on her engagement with Mapuche weaving, drawing attention to Indigenous knowledge systems that foreground interdependence between human and more-than-human worlds, and which have long been marginalised within dominant Western scientific frameworks.

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01

Plastic fantastic! Giving polymer waste a second life

Tom Corker

Tom is Head of Technology at Felixstowe School which has STEM hub status through Kings College London. Tom completed his MA in STEM education with a keen interest in design thinking and the role of design and technology in STEM education.

"56% of plastic waste is not recycled by waste collection companies. So instead, at Felixstowe School we have developed ways to do it ourselves."

Plastic polymers first became popular in the 1940s and 1950s. Materials such as Nylon and Bakelite soon became household names. Today, materials such as polypropylene (PP), polyvinyl chloride (PVC) and HDPE (high-density polyethylene) are more common, with the UK producing approximately 5 million tonnes of polymers each year. Around half of this is used for packaging whilst one quarter is used for the construction industry.

Currently, only 44% of polymer waste is recycled in the UK each year. Frustratingly, whilst there are just over 1,000 recycling centres in the UK many do not accept polymers for recycling.

Throughout the sourcing of crude oil (the raw material of polymers), during commercial production, and in their disposal, polymers are known to cause environmental damage. The chemical chains are not bio-degradable; their degradation results in the production of toxic microplastics. Yet, the demand for plastic polymers remains strong.

Take time to reflect on the items you have used today. Which of these are made from polymers? The pen you write with, the chair you've sat on, the keys you use to type on your laptop, the zip on your coat, the fascia inside your car; the list goes on...

Polymers are used for these products as they are easy to clean, come in an abundance of colour choices, and are strong and durable. They are also easily mass produced. Polymer sheets, granules, pellets and powders can be heated and formed into complex shapes. This process can be carried out quickly and repeatedly; for example, in a factory setting hundreds of parts or products made from polymers can be produced in one day.

It really does seem polymers will remain in use for some time, not least until viable alternatives are identified. It is therefore

Fig. 1

essential that we look at how we limit their negative impact on the environment. How do we use these materials? What do we do with them after use? Can we limit polymer waste? Can we increase recycling?

These questions are particularly pertinent in my own setting of Felixstowe where polymer items are often washed up on the beach. For my community, the issue is raw and hits home.

It was in response to this issue that our exciting project was developed. We sought a simple, low-cost solution to not only improve polymer recycling but also engage students in understanding the connections between the making of plastics and polymer recycling.

First thoughts

Few of us can tell the difference between different sorts of polymers (unless, of course, comparing a flexible polyethylene bag to a durable polypropylene lunch box!). Due to their chemical composition there are hundreds of polymers available but, in fact, there are only a small handful of polymer materials that are used on a regular basis. As a result, the Plastics Industry Association has been able to develop a coding system that can be placed on all polymer products to identify the polymer from which the item is manufactured. This simple system has the potential to rapidly aid the recycling process ensuring materials are quickly identified and not mixed together. The recycling codes shown in Figure 1 are used in the UK as well as many countries in the world. Each number denotes the specific polymer.

The recycling process involves the breaking up of these polymers into smaller parts, heating them and reforming them into new materials. At Felixstowe School we thought we would try this ourselves. Our reasoning was simple: if we genuinely want to provide young people with an understanding of real-world processes — and improve wider recycling rates — we will need to start in school.

Polymer recycling – a making process in a school workshop setting

Key to the recycling process is the need to reform similar materials together and not mix different materials. The polymer material codes ensure that materials are organised appropriately. In a school setting, we made the decision to select one material to prevent contamination. We chose high density polyethylene (HDPE) as this material has excellent reforming properties and is also commonly used in everyday items (Figure 2).

We placed these items in a shredding machine (Figure 3). The large cutting blades in the machine quickly cut the polymer products into small polymer granules (Figure 4).

We then placed these polymer granules into a large heat press (Figure 5) to melt the polymer granules and then press the reformed polymer into consistent sheets. The resulting colourful pattern is due to mixing different HDPE products together (Figure 6).

The newly produced sheets can then be used just as we might use commercially bought material sheets. In our setting, students cut the new HDPE sheet into shapes of their own design to form key rings (Figure 7).

Lessons learnt from making

Our explorations with the heat presses involved many episodes of trial and error! Initially, we tested other polymer materials

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

but found HDPE to be the most effective when forming new sheets. It was also readily accessible.

Next, we soon learnt that forming new sheets using a heat press can be a time-consuming process. The sheets were large and difficult to manipulate. As a result, we decided to use smaller heat presses (Figure 8) which would allow individual students to participate in the process during lessons and achieve quicker results.

When forming new polymer sheets (Figure 9), we soon found that we could not achieve a 'perfect' colour. Whilst some were frustrated that we could not achieve the same consistency as industrial production, a sense of joy and wonder soon prevailed: we learnt to accept our swirling colourful patterns and be proud of our unique results!

When sheets were produced on the large heat press, they would often spill over slightly when pressed into shape. This would cause 'flashing' at the edge (Figure 10). This is a process that is seen in industry, allowing a connection to be made between the real world and a school setting.

We found the hand cutting process with this material to be relatively simple but found laser cutting to be more challenging. The problem appeared to be due to each polymer sheet varying slightly in its composition. To address this issue, we needed to make several cuts with different settings on the laser cutter (Figure 11).

Where waste material was left over from cutting, we found that we could recycle this material again. This reduced waste and aided the recycling process. Lastly, we found that some colours are more commonly used than others on polymer products. For example, white is used regularly but red and blue were much harder to source. Green was a relatively common colour as it is often used on semi-skimmed milk bottle lids.


Fig. 8

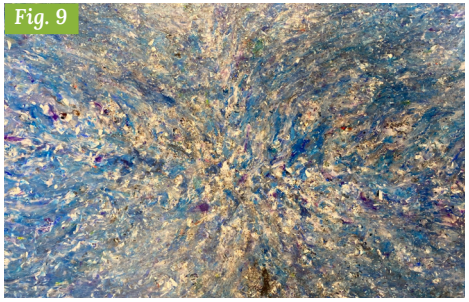
Fig. 9

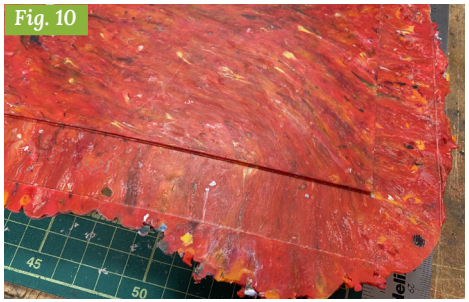
Fig. 10

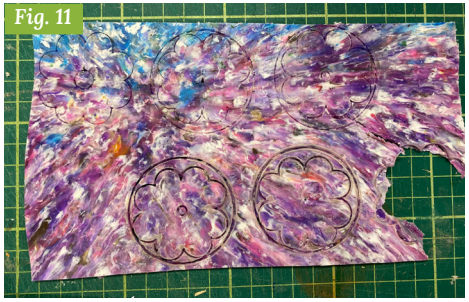
Fig. 11

Environmental and emotional connections for students

Carrying out this process with students was a joyful process. It also brought about some unexpected results.

In order to maintain the constant supply of HDPE, we had to seek donations from others. Staff began collecting HDPE, placing items in a recycling bin in the staff room specifically for the students to use. The school canteen did the same, keeping hold of all milk bottle lids that they collected during the week. The local church learnt of our initiative, and they too started doing the same. What started as a small venture quickly become a large-scale project supported by the whole community!

Students who perhaps struggled in other lessons gained a real sense of achievement and pride in shredding, forming, cutting and filing to produce their keyring. They were able to see the effects of their hard work within a single lesson.

The smell of reforming the polymers divided opinion. Some students commented, '*I love that smell*' whilst others said, '*it's disgusting!*' Such diverse opinions soon led to discussions about factories in the area, the smells they produce and a realisation of the scale that such places must be operating at. This then led to further discussions regarding pollution and the impact of industries on the environment.

Upon seeing the number of bottles and bottle lids needed for cutting up and reforming into new sheets, students gained first-hand experience of the size of the market for polymers. Students also began questioning how much waste is produced across the town or the country as a whole. In our example, the students were only using HDPE; there are many more polymers out there that can be recycled. Our project is just the tip of the iceberg.

Students began to think more widely about the use and origin of polymers. One student was prompted to lead a debate based on a post he'd read on social media: '*as plastic is made from oil and oil is made from dead dinosaurs, how much actual dinosaur is there in a plastic dinosaur?*'

Students developed a more positive mind-set towards recycling, querying why people would throw polymer waste in the bin.

Students also actively discussed the issue of polymer waste in lessons. Seeing how easy it is to recycle, students developed a more positive mindset regarding recycling, querying why people would throw polymer waste in the bin or, worse still, not place it in a bin at all. Students could see the important role of recycling bins at home and the importance of the local recycling centre to the community.

The heat press process was adopted by several students for their GCSE projects, not least because the Design & Technology GCSE foregrounds sustainability issues. Following the publication of the recent Curriculum Review (Dept of Education, 2025), it is clear sustainability is likely to be an even stronger theme in proposed GCSE changes in the future. Our project will remain a key part of the curriculum for years to come.

Final words

Plastic polymers will continue to be a major part of the modern world. But, to minimise environmental impact, we need to recycle such polymers as much as we can.

The project at Felixstowe School enabled students to carry out the recycling process from start to finish in their own setting. Students experienced real world processes, engaged with debates about real world controversies, and developed solutions that also served to strengthen community cohesion.

This making process led to pride, the development of new skills and a tangible understanding of an important environmental process. With 5 million tonnes of polymer produced each year in the UK and 56% of this waste not recycled, we now have a process to reduce that number and be able to recycle when others won't, don't or can't.

This essay is produced with thanks to Libby Woodley, Carly Clarkson, Lucy Corker and the students at Felixstowe School who ensured the success of this making process.

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02

Designing with waste: An (eco)vocative approach to sustainability in D&T

Harry Gowlett

Harry is a Design and Technology teacher committed to creative, hands-on learning. He developed a keen interest in sustainability during his MA in STEM Education and is now a passionate advocate for critical thinking when making design decisions about materials and their disposal.

"Waste materials can serve as powerful teaching tools, encouraging learners to question notions of value, responsibility, and design choices."

As a Design and Technology (D&T) teacher, I believe that designing and making objects is one of the most valuable educational experiences we can offer young people.

D&T allows learners to be creative, develop problem-solving skills, and gain practical experience that connects directly to the real world.

My approach to teaching D&T has always been guided by the four practices underpinning the subject as identified by Barlex (2011, p.12):

- Making without designing
- Designing without making
- Designing and making
- Exploring the technology and society relationship

Translating these principles into teaching approaches, my practice thus addresses:

- Mainly making
- Mainly designing
- Designing and making
- Design and technology in society

Each strand plays a vital role in shaping a balanced and meaningful D&T curriculum. However, the strand that I have been reflecting on most recently is design and technology in society, particularly how we can teach learners to become more responsible and sustainable citizens through design and making.

In recent years, I have become increasingly concerned about the amount of waste material produced during classroom projects. Although D&T promotes creativity and practical learning, it can also result in large amounts of offcuts and unused materials being discarded. This issue inspired me to create a new set of lessons that encourages learners to think critically about sustainability and resourcefulness, while still

maintaining the hands-on, creative nature of the subject. Crucially, the project also aims to empower learners to question and challenge norms such as waste culture, material overconsumption, and built-in obsolescence, and aligns closely with key themes within the National Curriculum for D&T and GCSE specifications.

Process

The starting point was identifying how much material waste was being produced in the department. It quickly became clear that during typical Key Stage 3 projects, a significant amount of leftover timber, manufactured board, and plastic was being thrown away. I decided to develop a project that would make creative use of these offcuts and allow learners to explore sustainability in a practical, engaging way.

Many students were surprised by how resource-intensive the production of everyday materials can be.

The result was a project inspired by similar activities used in other schools but adapted to suit our learners and context. The concept was simple: students would design and make a robot-inspired object using only waste materials. However, unlike traditional projects, there were no fixed outcomes or prescribed examples. Learners were encouraged to take creative risks, make their own design decisions, and produce something unique. This open-ended approach was intended to reduce fear of failure and encourage experimentation, reinforcing the idea that mistakes are a

Fig. 1

natural and valuable part of the design process and adopting a learning-through-making approach (Martin, 2015).

At the start of the project, learners were presented with a selection of waste materials, mainly softwood and manufactured board offcuts. Before designing, we explored the environmental impact of these materials by discussing where they come from, how much energy is used to produce them, and what happens in the disposal process. This linked directly to the design and technology in society strand and helped learners understand the importance of reusing and repurposing materials. Many students were surprised by how resource-intensive these everyday materials are, and this understanding provided a strong foundation for the project. These discussions also opened up opportunities to explore wider global issues such as timber imports, deforestation, and illegal logging, helping learners to situate their design work within a broader environmental context (Figure 1).

Next came the tinkering stage, where learners experimented with the materials to understand their properties and potential. They explored different joining methods,

Fig. 2

Fig. 3

practised measuring and cutting, and considered how to combine materials effectively. This stage encouraged independent learning and allowed students to discover ideas through hands-on exploration rather than simply following instructions. Through this process, learners also began to engage with underlying STEM concepts, including the properties of materials and the importance of making and recording accurate measurements (Figures 2 & 3).

As ideas developed, learners began planning the form and function of their object creations. Some decided to create purely decorative pieces, while others added functionality — for example, turning their design into a phone stand, small light, or desk organiser. This flexibility encouraged creativity and meant that every student could work at their own level. Learners were also prompted to consider wider aspects, such as if they were making a phone stand, how their design would support the phone safely and securely, prompting discussions around forces, stability, and balance.

During the making phase, learners applied their practical skills and were supported to take ownership of their work. Because they were using waste materials, the fear of making mistakes was greatly reduced. This freedom to experiment helped build confidence, resilience, and problem-solving skills. Learners began to see that errors were part of the design process, not a failure. Some learners chose to incorporate additional components, such as dowels, screws, or rivets, to enhance their designs (Figure 4). These small additions often improved functionality or visual appeal. Throughout the process, my role was to guide and support, offering technical advice and encouragement while allowing learners to make their own creative choices. This approach aligns with learning-through-making pedagogies, where understanding is developed through active experimentation and reflection (Petrich *et al.*, 2013).

Outcomes and Observations

The final products were incredibly diverse. No two projects looked the same, and each reflected the individuality and creativity of the learner. Some students focused on precision and high-quality finishes, while others took a more experimental approach. This variety demonstrated how well the project catered for different abilities and approaches.

Fig. 4

The open-ended nature of the task also meant that differentiation occurred naturally. More able learners extended themselves by tackling complex designs, while others focused on mastering core making skills. Engagement levels were high throughout the project, with many learners showing genuine enthusiasm and pride in their work.

We also incorporated opportunities for learners to use computer-aided design (CAD), either to plan their initial ideas or to make modifications after building their prototypes. This addition helped bridge traditional making skills with modern digital technologies, reflecting the multidisciplinary nature of D&T (Figure 5).

At the end of the project, learners evaluated their work. They reflected on their material choices, the challenges they faced, and the sustainability of their designs. Many expressed pride in having created something useful or meaningful from what would otherwise have been waste. It was heartening to see how their understanding of environmental responsibility developed through a hands-on learning experience.

Evaluation and Reflection

Introducing this scheme of learning has had a positive impact both on students and on the department. Practically, the amount of waste material being sent to landfill has reduced significantly. Offcuts that would previously have been thrown away are now stored and reused in future projects. This small change has made a noticeable difference to our workshop environment and has promoted a culture of resourcefulness among both staff and students.

Pedagogically, the project supports current educational priorities such as sustainability, creativity, and learner independence. It encourages students to think critically about materials and understand the environmental and ethical implications of design decisions. By promoting creativity and self-directed learning, it also develops transferable skills such as communication, problem solving, and resilience.

From a teaching perspective, this project has reinforced my belief in the importance of learning through making.

There have been some challenges, particularly around managing and organising the waste materials. Sorting and preparing offcuts requires planning and storage space, which can be difficult in a busy department. Some learners also struggled initially with the open-ended nature of the task. Without a fixed brief or example to follow, a few found it challenging to develop ideas independently. However, with guidance most adapted quickly and appreciated the creative freedom.

From a teaching perspective, this project has reinforced my belief in the importance of learning through making. Too much structure can sometimes limit creativity, whereas allowing learners to experiment and take risks fosters deeper understanding and engagement. The project reminded me that the process of designing and making is often more valuable than the final outcome.

The project also supports the wider goals of Design and Technology education, particularly in promoting awareness of sustainability and responsible design. It encourages learners to think beyond the classroom and recognise how design choices can impact the environment and society. This aligns with National Curriculum aims and the increasing emphasis on developing environmentally conscious citizens. By acknowledging how design decisions at industrial and global levels shape

Fig. 5

environmental outcomes, learners can begin to see their own potential agency as future designers capable of challenging unsustainable norms such as over-consumption and planned obsolescence.

Looking ahead, I would like to build on this project by exploring ideas further, supporting learners to consider how products can be designed for repair, reuse, and longevity. Ultimately, this experience has shown that even small changes to our teaching practice can have a big impact. By rethinking how we use materials and helping learners to do the same, we can make D&T more sustainable without sacrificing creativity or enjoyment.

Final words

In this essay, I have shared how a simple shift in approach — using waste materials creatively — can transform both learning experiences and classroom practice. Through the project, learners have developed not only practical making skills but also a deeper awareness of sustainability and their own role in reducing waste. As a teacher, I have seen first-hand how empowering students to make their own design decisions leads to greater engagement, confidence, and independence. The project has also had tangible environmental benefits by significantly reducing the amount of waste produced in the department.

Design and Technology has a unique role in preparing young people for the future. It allows them to combine creativity with responsibility and to understand how their ideas can make a positive difference. By embedding sustainability into our teaching, we are helping to shape a generation of designers and makers who value innovation, resourcefulness, and care for the environment.

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03

Can solar cooking save Planet Earth?

Oria Shuman

Oria is Head of Chemistry in a North London School. During her MA in STEM Education, she developed an interest in the potential of embodied engagement with STEM – a focus she continues to promote through her publications, and in her innovative leadership of the after school science club.

"Students in our after-school science club explored the potential of renewable energy. Their task? To cook a snack made of biscuits, chocolate and marshmallows!"

The act of cooking has been fundamental to human survival and expansion. Traditional practices of cooking require wood for fuel; more modern practices require oil or gas. Despite the substantial technological advancements, under-resourced communities may still heavily rely on traditional cookstoves to heat their food. This can be time consuming, potentially dangerous, energy inefficient and, due to the use of fuels and the production of combustion gases, detrimental to the environment.

Solar-powered cookery holds promise for a safe and an eco-friendly substitute to traditional cooking methods. For example, a study by Verma *et al.*, (2024) reveals that the use of solar ovens in schools in India can reduce their energy consumptions by up to 56 %. In addition, solar ovens can significantly reduce carbon dioxide emissions and health complications (Padonou *et al.*, 2022).

Solar ovens work in a similar way to a greenhouse. The Sun emits electromagnetic radiation. When this radiation strikes matter (in this case uncooked food), it causes the particles in the matter to vibrate and move, thereby producing heat energy. The heat is then trapped inside the oven, causing the food to cook.

Using making in our science club to address contemporary concerns

In the extra-curricular science club at my school, we often engage in making activities. We follow Martin's definition (2015) in that we see making as a set of hands-on activities that focus on design and inquiry to produce or improve a meaningful product from a personal or social perspective. In this way, we see making as a fundamentally iterative process that drives innovation and critical thinking and addresses contemporary social and environmental concerns.

During one of our weekly science club sessions, students aged 11–14 years old explored the potential of renewable energy sources by building their own solar ovens. Their task? To construct an oven which would cook s'mores — a popular American confectionary snack consisting of biscuits, chocolate and marshmallows.

The resources and method are as follows:

Materials

- Pizza box
- Bamboo skewers
- Duct tape/Sellotape
- Aluminium foil
- Clingfilm
- Scissors
- Black card
- Food
- Light source (sunlight/lamps)

Method

1. Cover the bottom of a pizza box with black card
2. Cover the inside lid and sides of the pizza box with aluminium foil
3. Put the food to be cooked into the oven
4. Use two bamboo skewers to hold the lid of the pizza box at an angle
5. Secure clingfilm across the open space using tape
6. Place the oven in direct sunlight (or use desk lamps if cloudy!)

Fig. 1a

A run-through by teacher and technicians

To check that the activity would work as we intended, two science technicians and I conducted a trial run to assess the resources available to us and troubleshoot as needed. Since the pizza boxes were due to arrive later in the day, we had to improvise and use a box that normally contains packs of A4 paper (Figure 1a). This was not ideal as the lid was not attached to the main box unlike a pizza box. In addition, the box was too deep and although light travels at a constant speed and would therefore take the same amount of time to reach the food, its intensity decreases with depth.

We therefore decided to use a different type of box that normally contains cardboard folders as it was shallower (Figure 1b). This box, together with the lid from the paper box, was used to make the solar oven. One of the flaps of the box was attached to the lid using tape.

We taped black material to the bottom of the box as black absorbs almost all wavelengths of light, converting them to heat. The inside lid was lined with aluminium foil to reflect the radiation back onto the black material, thereby heating it faster.

We then added our s'mores to the oven and covered it with clingfilm. The clingfilm prevents the heat energy from escaping by


Fig. 1b

convection (movement of heat energy through a fluid). At first, we poked two holes in the clingfilm and inserted two bamboo skewers that were taped to the lid of the box to maintain its open position. But this was suboptimal as the holes were quite big causing some of the heat to escape (Figure 2) .

We repeated our efforts with new clingfilm and gently placed the bamboo skewers on top. Since it was cloudy and cold in the morning, we could not go outside to test our solar oven. Instead, we decided to use desk lamps. Initially, we used lamps with energy saving lightbulbs.

However, these lamps are designed to maximise efficiency of light production by reducing the production of heat. Hence, the chocolate on the biscuit did not melt even after half an hour.

We then decided to search for some very old incandescent lamps. Fortunately, we had a few stored in the prep room cupboard. It is worth noting that at least three of these lamps were needed to melt the chocolate on the digestive biscuit within a short timeframe. But even with three lamps, the marshmallows and additional chocolate on top did not melt!

According to the solar oven manual from Imperial College Outreach (Solar Oven Activity, n.d), it should take a few hours for all the food components to melt using desk

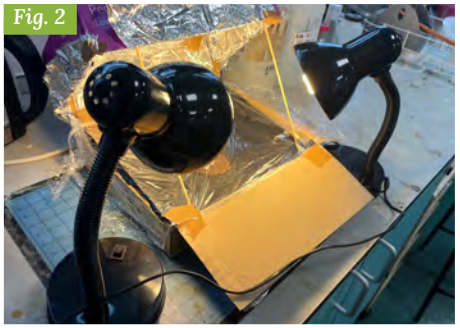
Fig. 2

lamps and thirty minutes in direct sunlight on a sunny day. But since we were obliged to be inside (due to the rainy weather), and the science club is only scheduled for an hour, things weren't looking promising...

The students' turn

Ten students aged 11-14 years old attended the science club on the day. Myself, a teacher trainee, and three sixth form students (aged 16-18 years old) were present to help the students make their solar ovens. Although many of the students had a good understanding of climate change and arguments for renewable energy sources, none believed that they personally could act by testing and improving solutions to energy-use dilemmas:

"Wow really! No way! How can we make an oven in school?"

- Year 8 student

"Can we take it home and use it?"

- Year 7 student

"This is so cool!"

- Sixth form student

Such responses reinforce the value of our making approach, and the potential such activities can have for forging stronger science identities and encouraging students to pursue careers that address environmental challenges. All students were highly eager to embrace this challenge. The thought of cooking s'mores also held a strong appeal! Students were given simple instructions and the protype made earlier was demonstrated. However, they were also informed that this prototype was not a perfect model and thus they were advised to engage in open-ended exploration to experiment to find their own solution.

Although students were making their solar ovens individually, there were times where help from the sixth formers was required, such as when taping various parts of the box or when covering with clingfilm. This was a great way to emphasise the importance of teamwork and collaboration in making and in science experiments.

Making activities that focus on real life environmental concerns can empower students to apply their STEM knowledge and take action.

Due to the relatively short timescale for the club, students were only provided with limited resources. However, we recognise that it would have been more beneficial for students to have researched a range of different materials before determining which would be most suitable, sustainable, and the least harmful. For instance, if we consider pizza boxes and aluminium foil, both are renewable and recyclable. However, pizza boxes made from recycled cardboard can release harmful chemicals and so could contaminate the food. Weighing up options such as this is part of the design challenge.

Cooking time!

Given that it was still cloudy and windy outside, students had to use desk lamps. We offered lamps with LED and incandescent bulbs and, with the aim of building critical thinking, invited students to select the lamp they thought would work best. Students confidently concluded that the incandescent lamps would be most effective:

"I think I'm going to use this lamp, it feels hotter."

– Year 8 student

Students chose to place two to five incandescent lamps around their oven during the cooking process.

"I have to make sure the light hits my marshmallow. I like my marshmallows nice and burnt. I hope it burns!"

– Year 7 student

It took about five to ten minutes for the chocolate on the digestive biscuit to melt (Figure 3). Although it was not apparent that the chocolate was melting from afar, the students' fingers were soon covered in chocolate upon touching their biscuits. It was great to see such satisfaction:

"The chocolate on my biscuit has melted. Yummy!"

– Year 7 student

"Look what we did in science club today!"

– Year 7 student (talking to his brother who was waiting outside)

Beyond this activity

The effectiveness of solar ovens is contingent on the weather. Due to the unpredictable weather in some parts of the world, it can be difficult to estimate the exact cooking time. Thus, one must consider the type of meal that can be cooked and the size/quantity of the food as larger portion sizes require longer cooking times. Moreover, a slow-cooking

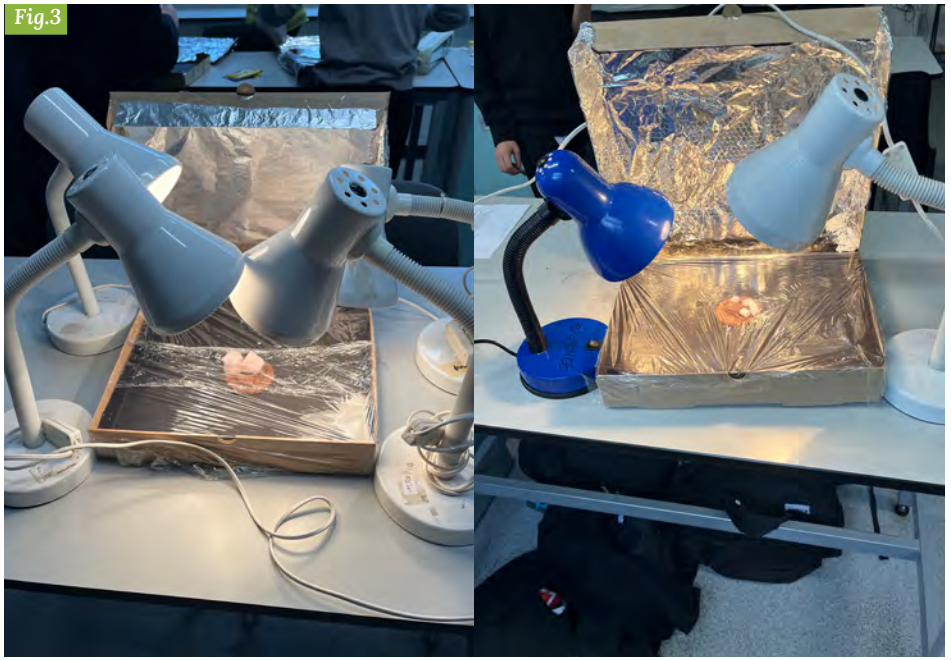
Fig.3

time increases the risk of the food being contaminated. Nevertheless, this activity was clearly successful in fostering curiosity in students with regards to making more environmentally friendly innovations. Although students were readily aware that solar ovens would be most useful in hot countries where sunlight is always present, they had clearly been inspired by the opportunity to explore environmentally friendly innovations. Some were keen to continue exploring the technology:

"This could be useful in the summer when we do barbecues in our garden."

– Year 9 student

The hands-on nature of our science club favours learning by doing over learning by listening and watching. We were also keen to promote the *process* of making the solar oven rather than the final product. This is because the making process supports skills in teamwork, critical thinking, and problem solving. Perhaps most significantly, making not only encourages creativity and exploration in students, it also allows them to put their knowledge into practice and to connect to real-world applications.
Making the solar oven was also inspiring for staff and sixth form helpers. The sixth formers were able to enhance their leadership skills, whilst staff acknowledged the value of the activity for explaining the nature of solar radiation and heat transfer and for teaching about technological inventions that can come from scientific understanding.

"I can really see this being embedded in our curriculum as it brings life to lessons."

– Staff member

Final words

Making activities that focus on real life environmental concerns can empower students to apply their STEM knowledge and take action rather than being bystanders. Making and cooking with a solar oven — even in the winter — offers the opportunity for students to consider materials and their affordances, experiment with constructions, determine efficacies and gain a sense of satisfaction. Whilst our s'mores were certainly tasty, I would say that the students enjoyed their hands-on learning about cooking with renewable energy so much more.

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04

Creating something tote-ally fabulous

Michelle Boyle & Kathryn Peake

Michelle is a Physics teacher in a London state school, a graduate of the MA in STEM Education, and a long-term volunteer with Girlguiding UK. She is also an avid maker.

Kathryn is a mathematics educator and formerly a member of the Girlguiding movement. A former graduate of the MA, she is now a tutor on the *STEM: Making and Creating* module.

"In re-purposing old textiles, a group of young people engaged with their personal values of helping others, and created something useful, long-lasting and wonderful."

Textile production — whether from natural or synthetic fibres — generates pollutants and waste at every stage of its lifecycle. The fashion and clothing industry fuelled by, or maybe encouraging, the demand for 'fast fashion' is responsible for over 10% of the total global carbon dioxide emissions annually. Equally sobering, approximately 20% of industrial water pollution is linked to textile processing and dyeing.

Re-cycling has emerged as a critical strategy for mitigating the environmental impacts of the textile industry, but whilst local authorities have systems for kerbside recycling for many materials, textile collection relies on drop-off points in shopping areas or at recycling centres. This inconvenience limits effective re-cycling and increasingly, large volumes of textiles are simply thrown away. As Winda Hidayanti explains in her essay that follows this, unwanted textiles are also sent to the Global South, where they wreck the local garment trade, or else end up as landfill.

Re-using, re-purposing or up-cycling textiles is therefore essential. Fortunately, re-using has become more common, thanks to charity shops, 'Vinted', and the like. Repairing (to extend the life of a product) or re-purposing (transforming textiles into new products without breaking down the fibres) are also becoming more widespread.

In this essay, we share Michelle's story of working with a group of young Girlguiding Rangers to develop new making skills to re-purpose textiles and make a stand for environmental and social justice.

The tote-ally fabulous project

Having recently completed modules in both *Environmental Education*, and *STEM: Making and Creating* as part of

my MA in STEM Education, I was keen to apply my new knowledge in my day-job as a physics teacher. It is not always easy given curriculum requirements! However, in my role as a volunteer leader with Girlguiding UK, I saw an opportunity to apply my new ways of thinking with my Rangers.

Open to any girl aged between 14 and 18, our Ranger group typically welcomes between 12 and 20 young people per week. We aim to balance our programme with a variety of different activities promoted by Girlguiding UK and are keen to ensure that our activities give back to the local community.

We wanted to develop project that would have a substantial social impact, but a low environmental impact. Previously we had made makeup wipes from fabric scraps and old towels, created beeswax wraps (a very messy undertaking), and made drawstring bags for donated toiletries for the community centre where we meet. We now felt ready to take on something bigger! We were aware of the brilliant work of our local Foodbank and wanted to help. We met with the staff and they suggested that we create Christmas-themed bags for their clients to use over the festive period. Thus, the idea of a recycled tote bag was born.

Applying the making and creating ethos

Martin (2015, p2) describes making 'as a class of activities focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a "product" of some sort that can be used, interacted with, or demonstrated'. Our tote bag project fulfils many of these criteria: our plan was to use recycled materials and follow a pattern to create an aesthetically pleasing and re-usable tote bag for customers of the Foodbank.

During the *STEM: Making and Creating* module, we were encouraged to think about the role of embodied cognition within the process of making. This is the idea that human cognition is grounded in our sensory-motor processes (King *et al.*, 2024), and that learning involves our heads, our hands, and our hearts. In making the recycled tote bags, our Rangers would use their heads to reflect on the need to take action to reduce waste in the environment; with their hearts, they would engage with their personal values and their commitment to help others; and with their hands, they would be creating something useful and long-lasting.

The young people were learning that they did not need to go out and buy new products, instead they could create something new from items they already have.

The make!

Firstly, it was essential to check that it was possible to make a bag within the two-hour time frame of our Rangers evening, and that the skills required could be conquered by Rangers. Kathryn, at the Maker Space at King's College London, gamely volunteered to help and provided me with time, space and resources, and worked with me to make a pilot version. Following a relatively simple set

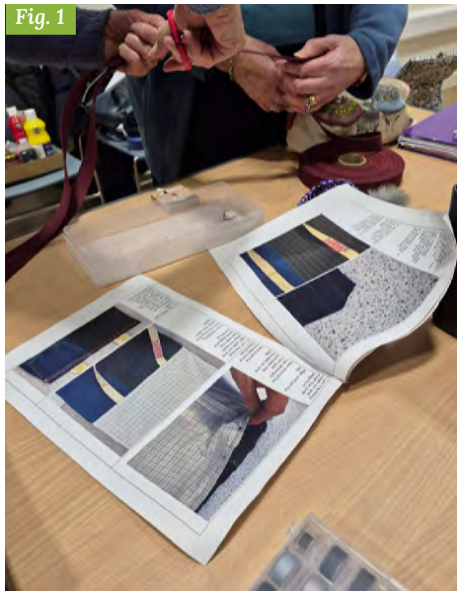
Fig. 1


Fig. 2

of instructions we were soon reassured that it was possible to make a bag in 90 minutes.

However, I knew that the skills levels and sewing competencies within the Ranger group varied greatly. Some had never sewn before, whilst others were taking Textiles GCSE and were confident using a machine and handling fabric. With this in mind, Kathryn and I thought it might be a good idea to have some skilled reinforcements, so I invited the ladies from our local Trefoil Guild to come and help. The Trefoil Guild is a branch of Girlguiding UK open to any member aged 18 and over who want to continue to support the spirit of Girlguiding. Fortunately, our local group comes with a wealth of sewing knowledge and experience!

On the day of making, the Rangers arrived with evident excitement. We began by sharing instructions and demonstrating the construction of the bag (Figure 1). It was important that the young people had some ownership over the design of their bags, and so we left them to select material from the large pile of recycled fabrics we'd amassed (Figure 2).

Armed with plenty of enthusiasm, scissors, and templates, the making process began. We soon found that pillowcases made excellent linings for the bags and were thus chosen to complement the materials used on the outside.

Many of the girls had not used a sewing machine before or had had much experience working with fabric. Many new skills were learnt, including pattern matching, measuring and cutting in straight lines (Figure 3).

Our assistants from the Trefoil Guild were kept busy rethreading the machines, inserting new needles, threading the bobbin (Figure 4), and supervising with the ironing. It was exhausting but worthwhile. Not all the tote bags were complete by the end of the evening, but I was able to take them home and put on the finishing touches.

Fig. 3

Fig. 4

The following week, the Rangers used craft materials to make cards and tags with festive messages to insert into the bags to be read by the Foodbank customers over Christmas (Figure 5). All the Rangers felt rightfully proud of their recycled, re-usable bags.

The last step in our project was to deliver the bags to the Community Storehouse Foodbank. The staff were delighted to receive them (Figure 6). Many commented that the bags looked professionally made, which spoke to the care (heart), thought (head) and hard work (hands) that had gone into their construction!

The role of making and creating in STEM education

It was clear that the young people had enjoyed making their bags and they had learnt something from the project, but how can this be related to STEM education (and perhaps adapted for more formal settings?)

From the perspective of Technology, the project provided young people with the opportunity to use a sewing machine, something they had not necessarily been exposed to at home. They also learnt about the mechanics of the machine, and in some cases watched as I fixed problems. Understanding how to make repairs to clothing and machinery is a skill that not many had developed previously, being rather more used to the disposable nature of the modern textiles and fashion industry.

The project also provided an opportunity for some mathematics: the Rangers had to measure the fabric pieces and work out how to assemble in the correct order, while also employing some 3D visualization to initially construct the bag inside out. We provided them with a template, but larger or smaller versions could be developed

Fig. 5

requiring use of ratios to make the bags in different sizes.

With respect to Science, the project fits with GCSE chemistry, and the requirement to consider production processes and life cycle assessments. Finally, the connection to environmental issues was easy to see. The Rangers had been aware of 'fast fashion' but the make gave us an opportunity to reflect on our own purchasing and re-using habits.

Fig. 6

Final words

Having been brought up in a household where making do and mending was commonplace, and having passed on these skills to my own children, I often do not appreciate that others may not have had the opportunity to develop these skills. The tote bag project enabled a small group of young people to understand that they do not need to go out and buy new products, but instead they can create something wonderful from items they already have.

In late 2024, Girlguiding announced that 'A 'Thrift' badge will be added to the Rangers repertoire. The aim is to encourage girls to channel their inner eco-warrior and learn how to customise, repurpose, and upcycle. The badge was inspired by girls' passion for living sustainably. The tote bag project speaks to this aim.

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05

Rethinking thrifting: Confronting an uncomfortable truth

Winda Hidayanti

Winda is a primary school teacher from Bandung, Indonesia, specialising in teaching science. She completed the MA in STEM Education at King's College London, where her interests in pedagogy expanded to include environmental education, sustainability, and making pedagogies as critical tools for learning and care.

"Acting 'sustainably' feels ethical, but it can mean quietly shifting environmental harm elsewhere."

Textiles have long held cultural meaning in Indonesia. From batik patterns encoding regional identity to woven fabrics used in ceremonies and everyday life, cloth has never been merely functional. It carries memory, labour, and social value. Growing up in Indonesia, I learned early that fabric was not disposable. Clothes were repaired, handed down, reworked into household items, or cut into *perca*, small scraps saved for future use. Waste, while inevitable, was managed through care, restraint, and attentiveness to material value.

As Indonesia has become increasingly embedded in global consumption systems, this relationship with cloth has shifted. Fast fashion, social media aesthetics, and the global circulation of second-hand clothing have transformed how garments are produced, valued, and discarded. For many years, I believed that thrifting, buying second-hand clothing, offered a simple and ethical response to these changes. It felt like a personal act of resistance against fast fashion: affordable, environmentally responsible, and morally reassuring.

That belief was fundamentally challenged when I watched the Indonesian documentary *Sisi Gelap Thrifting: Sampah Busuk Negara Maju Menghancurkan Negara Miskin (The Dark Side of Thrifting: Rotten Waste from Developed Countries Destroying Developing Countries)*. The film revealed how large volumes of second-hand clothing from high-income countries in the Global North are exported to countries in the Global South, including Indonesia, overwhelming local markets and waste management systems. What is framed as reuse or generosity in donor countries often becomes an environmental burden elsewhere: unsold garments dumped, burnt, or left to pollute land and water. This moment marked a turning point in my thinking. Thrifting was no longer a straightforward act of sustainability, but a

complex global practice entangled with inequality, environmental harm, and social injustice.

This essay reflects on that shift in understanding and explores how making, as both a personal and educational practice, can create space to confront these uncomfortable truths. Through an evocative textile object, a six-panel patchwork made from discarded fabric, I examine how making can function as a form of re-education: challenging dominant aesthetic norms, revealing material life cycles, and offering alternative ways of thinking about sustainability in environmental education.

Thrifting as a global practice with uneven consequences

In this essay, *thrifting* refers to the buying and selling of second-hand clothing through thrift stores, flea markets, and informal resale channels. While the term is widely used in the United States and increasingly popularised through social media, its meaning varies across contexts. In Indonesia, thrifting is often associated specifically with imported second-hand clothing (*pakaian bekas impor)*, sold cheaply in physical markets and online platforms.

What is frequently absent from popular narratives around thrifting is the global infrastructure that sustains it. Large volumes of donated clothing from high-income countries in the Global North are exported to countries in the Global South, where they often exceed local demand and waste management capacity. While some garments are resold successfully, many are unsuitable for local climates, cultural norms, or market needs, eventually becoming waste. In this way, thrifting does not necessarily close the loop of consumption; instead, it displaces environmental responsibility across borders.

Indonesia's policy to ban the import of used clothing reflects growing recognition of these challenges. Although frequently framed as economic protectionism aimed at safeguarding local textile industries, the policy also represents an environmental intervention. It acknowledges that Indonesia has increasingly borne the ecological and social costs of global overproduction. This context complicates the widely held assumption that thrifting is inherently sustainable and invites deeper reflection on responsibility, justice, and scale.

Donation, distance, and responsibility: a personal reckoning

My engagement with these issues became deeply personal during my time studying in the United Kingdom. As my studies ended, I donated many of the clothes I could not bring back to Indonesia. At the time, the act felt responsible. Donation appeared to resolve the problem of excess: unwanted clothes passed on, waste avoided, guilt eased.

In hindsight, I recognise how incomplete that understanding was. I had not considered where those clothes might travel, how many similar donations existed, or whether there was genuine demand for them. The emotional relief of donating obscured the broader system in which I was participating. What felt like an ethical gesture may simply have delayed disposal or shifted it elsewhere.

This experience sharpened my awareness of the social justice dimensions embedded within global clothing flows. Viewed through the lens of ecological footprints, thrifting reveals an uneven distribution of responsibility, where the environmental consequences of consumption are displaced rather than reduced. High-income countries maintain consumption patterns that exceed ecological limits, while the material consequences of those patterns are increasingly borne by countries with fewer resources and weaker waste infrastructures. Scott and Vare (2018) argue that sustainability challenges cannot be understood without recognising how human activity is embedded within Earth's life-support systems, and the limits of those systems. Applying this perspective to thrifting complicates its popular framing as an ethical alternative to fast fashion. Individual acts of donation or resale may feel environmentally responsible, yet they often operate within systems that externalise waste, labour, and environmental degradation elsewhere. Recognising this complexity is uncomfortable, but necessary if sustainability education is to move beyond simplified narratives and engage with structural causes of environmental harm.

The aesthetic trap: neutrality, perfection, and invisible waste

Alongside material flows, cultural aesthetics play a powerful role in shaping attitudes toward consumption. Social media platforms are saturated with images of immaculate, neutral-toned homes, minimalist wardrobes, coordinated interiors, and 'timeless' aesthetics promoted by influencers and publications such as Architectural Digest. Within this visual culture, visible repair, reuse, or patchwork is often absent.

This creates what can be understood as an aesthetic trap. Sustainability may be embraced rhetorically, yet its visible signs are frequently edited out. Reused or upcycled items can appear out of place or undesirable, despite their environmental value. I have felt this tension personally: even when committed to sustainability, I have hesitated to display reused or imperfect objects because they do not align with dominant aesthetic norms.

In educational contexts, this tension matters. If sustainability is taught only as an abstract principle, without challenging the visual and cultural norms that shape desire, learners may struggle to integrate it meaningfully into everyday life. Making offers a way to confront this contradiction directly, by producing objects that are visibly imperfect, materially honest, and resistant to curated neutrality.

Making as re-education: learning through fabric

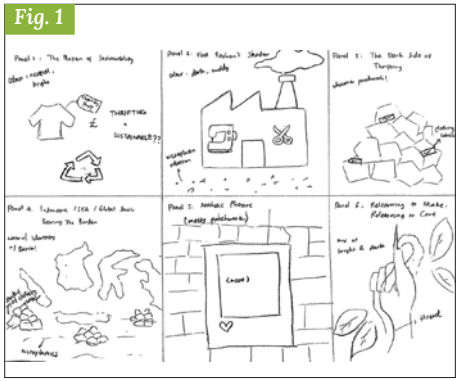
Scholars of craft and design argue that making can function as a form of critical engagement with sustainability rather than merely an aesthetic or technical activity. Hur and Beverley (2022) suggest that craft-based co-design practices enable participants to engage reflectively with fashion systems, foregrounding process, labour, and material responsibility. Making slows consumption, reveals the life cycle of materials, and challenges linear models of production and disposal.

Making also functions pedagogically by cultivating attentiveness and ethical reflection. When learners engage directly with discarded fabrics, they encounter the physical realities of clothing production and disposal, the weight of materials, the fragility of fibres, and the persistence of synthetic textiles. These encounters disrupt the abstract nature of sustainability discourse and ground learning in lived, sensory experience. Rather than offering immediate solutions, making creates space for uncertainty, discomfort, and questioning, allowing learners to engage with sustainability as an ongoing ethical negotiation rather than a checklist of behaviours.

The (eco)vocative object: a six-panel patchwork of misrecognised sustainability

The (eco)vocative object accompanying this essay is a six-panel patchwork textile constructed entirely from discarded clothing and fabric remnants. Patchwork-making is not a new or imported practice within Indonesian culture. Long before sustainability became a formal educational concept, practices of reuse and repair were

Fig. 1



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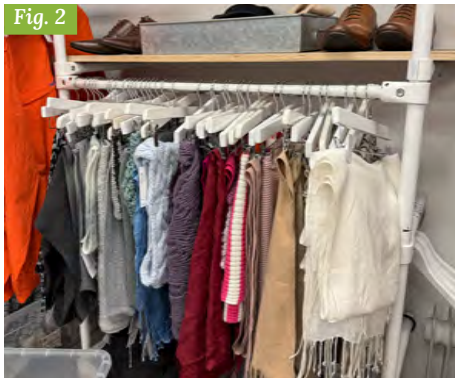

embedded in everyday domestic life. Fabric scraps *(kain perca)* were carefully saved and repurposed into household items, children's clothing, cleaning cloths, or quilts. These practices emerged not from environmental ideology, but from necessity, care, and respect for material value. Situating this object within that cultural lineage is intentional. Rather than presenting making as a novel or externally imposed intervention, the patchwork draws upon domestic knowledge marginalised by modern consumer culture, reconnecting sustainability education with traditions of material restraint.

My plan was for each panel to represent a distinct, yet interconnected, stage in the life cycle of clothing within global consumption systems (Figure 1). My aim was to form a visual narrative that challenges the assumption that sustainability, particularly through thrifting, is a simple or morally resolved act.

All materials used in the object were sourced from textile waste. The background fabric, a beige scarf, was purchased from a charity shop in London (Figure 2). Initially chosen for its neutrality, the scarf later became symbolically significant, as its provenance situates the object within the Global North donation system discussed throughout this essay.

Buttons were salvaged from spare buttons attached to garments, and all additional fabrics were collected from scrap material and clothing remnants. Nothing was bought new, foregrounding the afterlives of textiles and resisting the aesthetic perfection often associated with sustainable design.

Each panel represents a distinct yet interconnected stage in the life cycle of clothing within global consumption systems, forming a visual narrative that challenges the assumption that sustainability, particularly through thrifting, is a simple or morally resolved act.

Panel 1 **The Illusion of Sustainability,** depicts a charity shop with a reuse icon and a bright, clean colour palette. It reflects how thrifting is commonly framed as an unequivocally 'good' practice, ethical, affordable, and environmentally responsible, mirroring my earlier belief that it offered a straightforward solution to fast fashion.

Panel 2 **Fast Fashion's Shadow,** introduces the hidden environmental costs of clothing production. A fast fashion factory symbolises air and water pollution, while embedded plastic fragments represent microplastics released from synthetic fibres. Synthetic textiles are a significant source of microplastic pollution in aquatic environments (Browne *et al.*, 2011),

foregrounding environmental harm that precedes both fast fashion consumption and second-hand reuse.

Panel 3 **The Dark Side of Thrifting,** marks the turning point in my understanding. Piles of discarded fabric symbolise the accumulation of unsold second-hand clothing that becomes waste rather than being reused, reflecting how donated garments from high-income countries can overwhelm markets in the Global South.

Panel 4 **Indonesia: Bearing the Burden,** situates this process locally. An abstract map of Indonesia is overlaid with scattered clothing fragments, while white and patchwork elements reference microplastic pollution entering rivers and oceans. Regions with limited waste and wastewater infrastructure, including much of Southeast Asia, experience disproportionate ecological impacts from such pollution (Browne *et al.*, 2011). This panel visualises how environmental responsibility is displaced rather than resolved.

Panel 5 **Aesthetic Pressure,** confronts cultural resistance to visible reuse. A clean, Instagram-like stitched frame sits atop chaotic fabric scraps, reflecting the tension between sustainability values and dominant neutral aesthetics promoted through social media.

Panel 6 **Relearning to Make, Relearning to Care,** offers no final resolution. A hand holding a sewing needle symbolises an invitation to ongoing reflection. Visible stitches, reused buttons, and unfinished threads emphasise sustainability as a continuing practice of care rather than a finished state.

Collectively, the object resists visual comfort and narrative closure. The exposed seams and reused materials are intentional, mirroring the discomfort required to confront the hidden consequences of consumption. Rather than functioning as decoration, the patchwork operates as pedagogy, inviting viewers to reconsider sustainability not as a feel-good identity,

but as a complex, globally entangled practice shaped by inequality, culture, and material realities.

Making, social justice, and quiet activism in education

In educational settings, such an object can serve as a powerful tool for engaging learners with questions of social justice and environmental responsibility. Patchwork-making encourages attention to material histories, prompting learners to ask where fabrics come from, who produces them, and who bears the cost when they are discarded. Importantly, this form of making does not demand loud or performative activism. Instead, it aligns with what Hackney (2013) describes as 'quiet activism', where everyday practices of making become sites of ethical reflection, care, and resistance. By valuing repaired, reused, and visibly imperfect objects, learners can begin to challenge dominant aesthetic assumptions and reimagine sustainability as something lived rather than displayed. Making, in this sense, becomes a form of pedagogy that supports affective, materially informed learning and encourages learners to stay with complexity rather than resolve it prematurely (Rowsell & Shillitoe, 2019).

Final word: beyond feel-good sustainability

This essay began with a belief in thrifting as a simple and ethical solution to fashion waste. Through personal experience, documentary engagement, and reflective making, that belief has been unsettled. Thrifting, while often well-intentioned, is embedded in global systems that frequently reproduce inequality and environmental harm. Making, particularly textile-based making, offers a way to hold these uncomfortable truths without turning away. By engaging hands, materials, and stories, it enables a form of environmental education that is relational, critical, and culturally grounded. In the Indonesian context, where traditions of reuse already exist, making can reconnect sustainability with heritage while confronting contemporary global challenges. Beyond the aesthetic, sustainability demands honesty, responsibility, and care. Sometimes, it begins not with buying less or donating more, but with sitting with what we already have and learning to see it differently.

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06

Yarn bombing: A tool for community activism?

Michelle Bamford

Michelle is a science teacher who specialises in chemistry. She completed the MA in STEM Education at King's in 2023 where her passions for environmental education and making and creating pedagogies collided. Her passions include knitting, crochet, and spending time walking and cycling along the Norfolk and Suffolk coastline.

"Beautifully crafted acts of guerilla knitting can prompt people to think more about local social and environmental issues."

In recent years, particularly since Covid-19, the modest act of placing knitted or crocheted "toppers" on Royal Mail post-boxes has become a mainstream community practice. These textile artworks are now regularly appearing in towns across the UK as aesthetic interventions, commemorative gestures and community fundraisers. Designs to mark World Book Day, Easter, Remembrance Day, Christmas, and national celebrations such as the Queen's platinum jubilee in June 2022 have brightened our streets and raised a smile. But might such yarn bombing – or guerilla knitting as it is also known – have a more serious purpose?

The yarn bomber as a social warrior

Yarn bombing as the act of decorating public areas with yarn mainly through the crafts of knitting and crochet is now becoming a tool of social change. Some might even describe the acts of creativity as a form of revolution, albeit a quiet and softer one than the term normally implies (Greer, 2008).

Magda Sayeg, is reported to have been the first person to yarn bomb by decorating a door handle of her shop with a knitted cosy in Texas, USA in 2005 (Moore and Prain, 2019). Knitting was brought to the fore through social messaging as Sayeg's art attracted the attention of people passing by, prompting others to join in her effort to experiment upon the urban landscape within her hometown. The potential of community craftivism soon spread. In the UK, yarn bombers have embellished lampposts, road signs, bus shelters, and perhaps most commonly public post-boxes. As unsanctioned public artworks operating outside of formal commissioning processes, post-box toppers and the like depend on volunteer labour and community networks. When paired with explicit messages, they can become instruments for promoting social and environmental justice.

Fig. 1

For example, the St Albans Post-boxes group have been raising money for local charities since 2018. Donations are gathered through QR codes on labels attached to each topper. Public engagement with the cause is further enhanced by sharing a walking trail linking the participating post boxes. In 2024 the town gained worldwide kudos with its Guiness World Record of 102 toppers! This success illustrates the potential impact of small-scale cultural practices and grassroots organisations.

Learning the skill of working with yarn

Historically, the skills of knitting and crochet have been passed down the generations predominantly by women. More recently, yarn-based practices have moved beyond the home and into the realms of social media and high fashion. Significantly, such skills have also been recognised for their pedagogical potential.

The educationalist Seymour Papert (Papert and Harel, 1991) has argued that that there are two ways through which learners can learn – through instructionism (being instructed by others) or constructionism (learning by making). Papert further asserts that learning happens when a learner is consciously engaged in constructing a public entity. Knitting is one such constructionist activity: knitters are engaged in making items out of yarn whilst learning how to engineer their entity in order to produce a tangible product. As they follow a pattern, they develop mathematical skills of abstraction and algorithmic thinking. Greer (2008) has called for knitting to be included in national curricula, and indeed Steiner-Waldorf schools already embed textile crafts within their subject 'handwork' (Avison and Rawson, 2014). Children are taught to knit as soon as they start their formal education at aged seven in Class One, and then introduced to crochet in Class Two. Complexity of handwork lessons increase each year enabling children to develop fine and gross motor skills, mathematical skills, patience, and resilience.

Proof of enthusiastic engagement with knitting as both a communication and a technical skill can be seen in the example of a local school participating in the St Albans record breaking post-box topping event (Figure 1). A diverse group of pupils from Years 7 and 8 who attended the STEM extracurricular lunchtime group worked together, acquiring many new skills, to produce a winter-themed topper. Their efforts helped to raise funds for charity and were featured on the BBC news!

The design of post box toppers can provide a powerful tool in modifying public behaviour by gently nudging and steering towards social and environmentally-focussed actions such as reducing waste, recycling, adopting a make-do-and-mend mindset, or choosing local suppliers, and all in a non-didactic, visually intriguing and tactile way.
The production of toppers can also serve as springboard for wider discussions about production and consumption. Key questions include:

- Are materials used natural (e.g. wool, cotton) or synthetic (e.g. polyester, acrylic)?
- What is the carbon footprint and energy implications of textile production?
- Could recycled or reclaimed yarn be used?
- Can damaged toppers be easily repaired?
- If synthetic yarns are used, how might we prevent their degradation into tiny plastic fibres which will be shed into the environment?

My Great Yarmouth post-box topper

I have lived in the seaside town of Great Yarmouth since 2022. Since that time, I have witnessed the effects of coastal erosion. Four years ago, I could not hear the sound of the sea from my house. Now, I can hear tides rushing up and down the beach. I worry intensely about sea level rising through climate change and the threats to the local wildlife due to increasing pollution. Based on my knowledge of St Albans post-boxes, I decided that I would create a topper for Great Yarmouth to draw attention to the local coastline and its ecological diversity (Figure 2). My hope was that an impactful topper would prompt wider conversations about our local environment and how we may best take care of it.

In order to achieve maximum effect, I decided I would make my topper for a post-box located opposite the popular tourist destination, the Sealife Centre. Not all post-boxes are the same, so it was important to measure the box and calculate the correct dimensions for my design. Next, as the topper had a social and environmental message, I decided that I was not going to

Fig. 2

Fig. 3

buy any new yarn but instead make do with whatever I had left over from previous projects.

Historically, Great Yarmouth was a fishing port. In 1955, Birds Eye developed their first fish fingers in the town! To highlight the centrality of fish in the local economy I needed lots of fish to swim in the sea. I found a simple crochet pattern and made twenty-five herring. The base was made using two strands of yarn and a few different shades of blue which created a rich depth of colour: just like the North Sea! Seagulls are ubiquitous in the town and can be heard squawking from just before dawn until the sun sets. Three crocheted seagulls were thus added. The East Coast is also home to a large seal colony – hence the inclusion of seals.

To add a colour contrast, I made some orange starfish. As a centre piece I created a lighthouse in red and white to represent the lighthouse at Happisburgh – a site on the East Coast that is at risk of coastal erosion.

The final topper is currently part of the exhibition of *(Eco)vocative Objects*, but soon will return to its place on the seafront (Figure 3).

Final words

Post-box toppers and other yarn-bombing ventures illustrate the potential power of highly localised, small-scale creativity for taking a highly visual stand on an environmental or social issue. I hope that the story of my post-box topper inspires readers to use (or learn) skills of knitting and crochet to create powerful, memorable messages that are important to them. But even if you are not yet a yarn-bomber, I hope that seeing such toppers will prompt rich learning conversations about local issues, about the sustainable sourcing of materials, and about the potential of craft skills for social and environmental activism.

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07

Show your stripes

Carrie Anne Philbin

Carrie Anne Philbin MBE is researching physical computing approaches to K–12 computing education at the University of Cambridge, having first completed her MA in STEM Education at King's. An award-winning educator, she has held senior roles at the Institute of Imagination and the Raspberry Pi Foundation and is known for hosting the YouTube series Crash Course Computer Science.

"The subtle shift from blue to red across the LEDs is not just a display, but a visual metaphor for a warming world."

When I first conceived of this project to tell a story about climate change data using lights, I thought of it simply as a way to bring data to life in a fresh, meaningful and tangible way. I was inspired by Prof. Ed Hawkins' *Warming Stripes* and by the *#ShowYourStripes* global movement, which invites people to recreate local climate visualisations as a creative response to the worsening climate crisis. There is even a day dedicated to sharing these graphics worldwide, a reminder that the accumulated data of our changing climate can be told powerfully through simple design. At first, my motivation was rooted in teaching: I wanted to give my computing students a meaningful challenge that would help them think more deeply about data science, building their data literacy skills, while applying their programming knowledge in practice. With ready access to micro:bits – tiny, pocket-sized computers with built-in sensors, lights, and buttons that students can program to create interactive projects – this seemed the perfect fit. It brought together everything I was looking for: accessible hardware, an engaging climate change theme that matters to young people, and the opportunity to combine data literacy with computer programming skills in a way that would feel relevant and creative. Little did I know that I was embarking on my own journey of making a beautiful display, which would shape my own thinking about the environmental crisis, data storytelling, and aesthetic making experiences.

Data literacy

What makes Hawkins' warming stripes so effective is their striking simplicity. Behind the coloured bands lie decades of carefully collected environmental data (Figure 1). In the UK, for example, the Met Office have collected a wide range of climate measurements, some of which stretch back to the mid-19th century. Anyone, from

researchers to teachers, students, or curious citizens, can access and explore the Met Office data at local and national levels. Such access creates opportunities to build data literacy skills and knowledge.

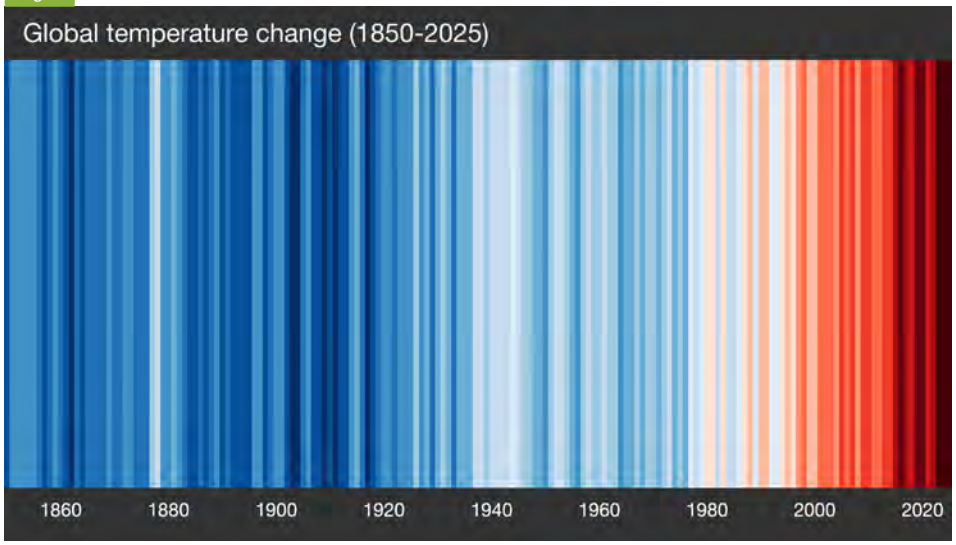
Data literacy refers to the ability to read, interpret, and make informed decisions using data encountered in everyday life. The OECD identifies data literacy as an essential skill for thriving in the 21st century. Although data literacy is rarely taught as a standalone subject in schools, many of its constituent parts are embedded across subjects such as Mathematics, Science, and my own subject, Computing.

Data storytelling is the art of using data to craft engaging, meaningful and visually compelling narratives that help people clearly see and comprehend the bigger picture. The warming stripes are a powerful example of this approach, transforming raw climate data into a clear, emotional story of change in a single graphic. No words are required. By transforming numbers into visuals and visuals into understanding, the gap between raw data and human experience is bridged, as numbers are converted into insights and insights into actionable outcomes.

Aesthetic experiences

The warming stripes are not just informative; they evoke an immediate emotional response to what we are seeing in one simple graphic. The American philosopher, psychologist, and educational reformer John Dewey (1934) argues that aesthetic experiences – moments in which perception, emotion, and meaning come together in a unified and deeply felt encounter – are rich in imagination and foundational to a learner's development and their ability to think creatively. Dewey's theorisation connects the appreciation of beauty and form with cognitive and emotional development. It proposes that aesthetic encounters with art, nature and other sensory experiences promote learning by enhancing understanding of complexity, fostering creativity, and improving problem-solving skills. In summary: learning is not purely rational, but also affective, and that feeling is integral to the learning process.

Fig. 1

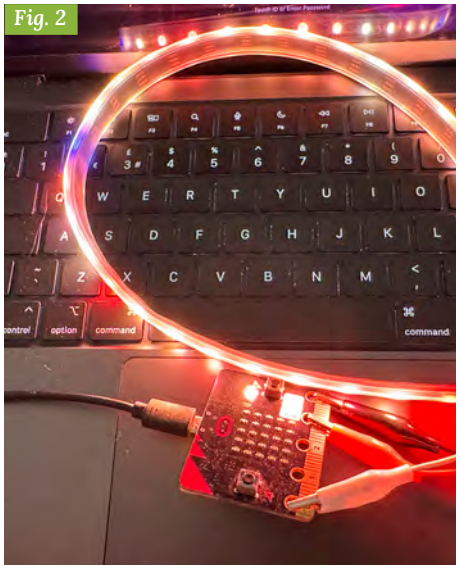


In exploring data storytelling through an aesthetic lens, I began to see the project not merely as a display of information but as an experience of data. The shifting colours and patterns of light invite emotional as well as intellectual engagement, reminding us that data about climate change is not just statistical, it is deeply human.

> The project became much more than an exercise in coding. Computer programming, data literacy, art, and sustainable materials combined to help make sense of complex global issues.

Extracting the average annual temperatures for my part of the world, the East of England, from the past 30 years was a straightforward technical task. Why 30 years? Quite simply, the NeoPixel LED strip I was using (Figure 2), designed as a micro:bit accessory, contains

Fig. 2

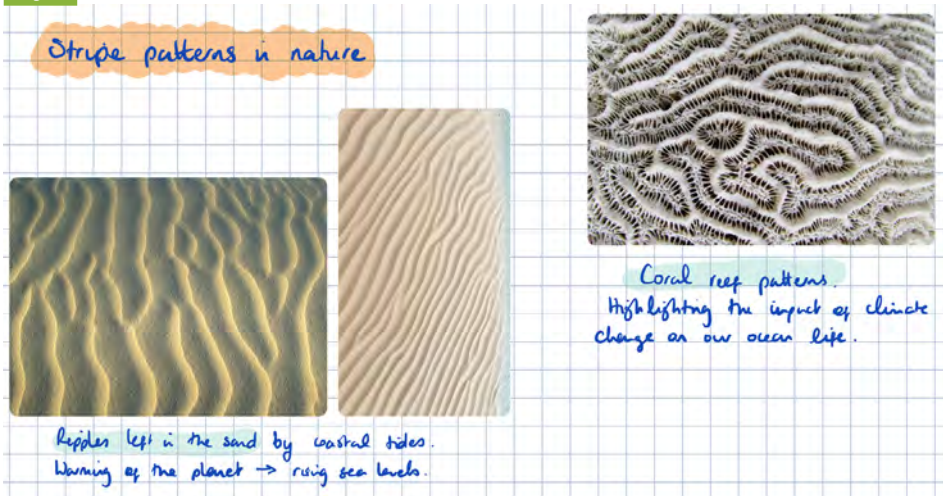


30 individual lights. Once I had assembled my dataset, I identified the extremes: the coldest year (2010, with an average of 7.94 °C) and the warmest (2022, with an average of 10.03 °C).

These became the anchors for my colour scale. I used the RGB colour model (commonly used in electronic systems) to allocate colours to each data point. The coldest point was mapped to a deep blue (RGB: 0, 0, 255), the midpoint around 9 °C to neutral white (RGB: 255, 255, 255), and the hottest point to a vivid red (RGB: 255, 0, 0). My code then assigned a precise RGB value to each of the 30 years, transforming numerical data into a luminous timeline of rising temperatures.

Working with the data in this tactile, visual way brought the climate story to life. Instead of reading that average temperatures are increasing, I had to interpret and manipulate the numbers myself — a process that embodies data literacy: understanding, analysing, and reasoning with data to make meaning from it. With students, this same

Fig. 3



task could prompt discussions about statistical measures such as mean, median, and range, grounding abstract concepts in real-world relevance.

At the same time, mapping temperature to colour became an act of data storytelling, turning statistics into a narrative of gradual but relentless change. The subtle shift from blue to red across the LEDs was not just a display, but a visual metaphor for a warming world. As the lights glowed, they invited both cognitive and emotional engagement. An aesthetic experience that made the data tangible and harder to ignore. What began as a programming exercise evolved into something more expressive: a way of seeing and feeling the story that the data tells.

Textile art

I began to think about how to tell the story of this data to an audience in a way that didn't rely on a screen. The micro:bit itself doesn't need one; the LEDs alone can tell the story of the data through colour. At the same time, I found myself inspired by the crafted warming stripe blankets that kept appearing on my social media feeds. Such blankets comprise beautifully crafted pieces of textile art, often crocheted or knitted, where each row represents a year, and each colour corresponds to temperature. This blending of craft and code, of handwork and data science, struck me as especially powerful. It extends the aesthetic experience of data storytelling, transforming climate data from something to be read into something that can be felt. It reminded me that addressing the climate crisis isn't only about analysing numbers or producing graphs; it's also about making art, telling stories, and creating experiences that help others feel the reality of change in ways that words or statistics alone cannot.

As I developed the idea further, I began to notice stripes and patterns in the natural world: the rings of trees, the layered growth of coral reefs, the shifting lines of clouds. Each carries its own record of time, change, and adaptation, which are natural forms of data storytelling. I was particularly drawn to the patterns left in the sand by coastal tides, which seemed a fitting metaphor for environmental change: dynamic, transient,

Fig. 4

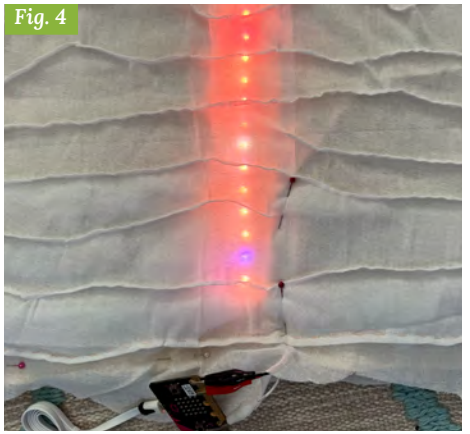


Fig. 5

Fig. 6

and shaped by natural forces. This became the inspiration for my design (Figure 3).

Lacking experience in textile art, I sought out artists whose work resonated with these ideas, such as Nerissa Cargill Thompson (2025) whose *Coastal Dreams* collection reflects the tones and textures of the coast and is created entirely from recycled materials. Inspired by her sustainable approach, I sourced my own materials by repurposing bed linen, shopping bags, and offcuts of fabric and quilting wadding. Once I had secured the micro:bit, NeoPixel strip and battery pack with the fabric (Figure 4) I began hand-stiching my organic stripes (Figure 5).

I learned new techniques like pinch stitch for raised ridges, french knots for small textured details, and always constructed sustainably, even using leftover threads saved from past sewing projects. Each uneven line of stitching stood in contrast to the precision of digital pixels, their irregularity echoing the imperfections of natural forms. The vertically raised fabric protruding from the background, and the addition of natural beads, gave the piece a tactile, living quality, distinct from the neat uniformity of the original warming stripes. In this imperfection, the work felt more connected to nature; a reminder that both data and the environment are alive, dynamic, and beautifully imperfect (Figure 6).

Final words

This project became much more than an exercise in coding or data visualisation. It evolved into a reflection on how we can use computer programming, data literacy, art, and sustainable materials together to make sense of complex global issues. Translating data into colour and colour into fabric revealed that data is not just factual; it is emotional, embodied, and connected to our lived experience of the world. This activity can be easily adapted for other STEM subjects, such as Science or Geography, to tell sustainable stories about data.

Through this process, I experienced that data literacy is not only about reading charts or performing calculations, but also about learning to communicate what data means for people and the planet. Computer programming and physical computing, in turn, become tools for bringing data to life, enabling students to transform numbers into interactive, tangible, and creative experiences. Data storytelling, combined with coding and aesthetic design, makes understanding data visible, shareable, and memorable.

Being mindful of the origins of the physical materials used in this project became an integral part of the creative process, leading to a focus on reusing and repurposing whatever I could find, particularly in relation to fabrics, threads and beading. At times, the sourced material helped inspire a pleasing direction for the piece, such as the use of coloured beads. In this way, sustainable making did more than reduce waste; it became part of the aesthetic and ethical experience, reinforcing the project's commitment to creating with care for both people and the planet.

By engaging both mind and hand, logic and creativity, this project demonstrates how technical skills and imaginative thinking can collaborate to address real-world problems.

In the end, this small, glowing textile art piece — stitched from scraps and illuminated by code — stands as both artwork and argument. Learning, creativity, and ethical awareness are inseparable, whilst coding, data literacy, and storytelling together can help students and audiences experience the world in more connected and meaningful ways.

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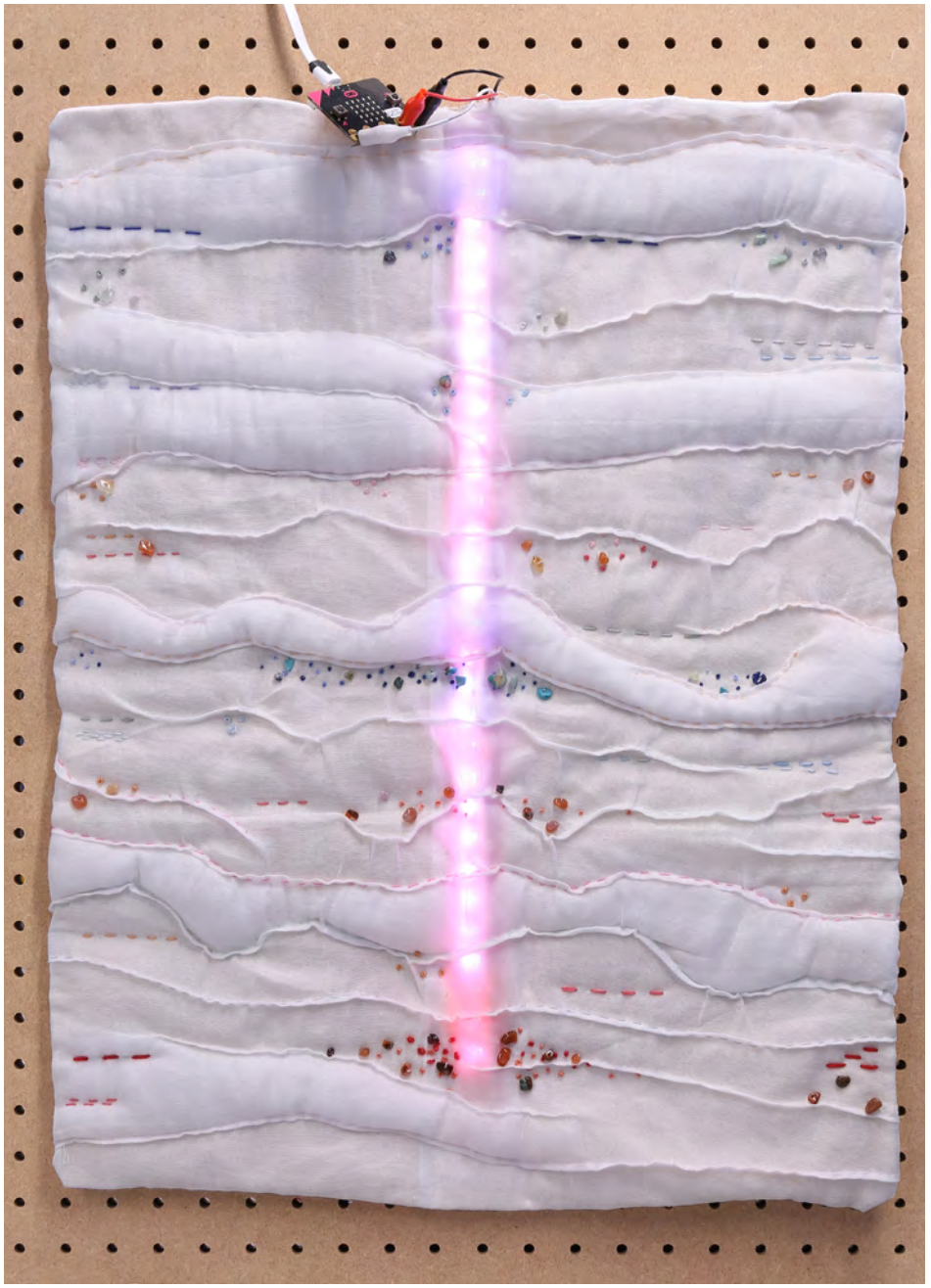


08

Engaging in ecological modelling: Interactive simulations of foxes, rabbits, and pollution

Riccardo Galbiati

Riccardo is a teacher of mathematics, further mathematics, and physics who completed an MA in STEM Education while working at King's Maths School. His research focused on high-achieving neurodiverse STEM students with an emphasis on belonging, inclusion, and amplifying neurodiverse voices within mathematics education.

"Simulating the complex dynamics of an ecosystem within a game makes abstract concepts tangible."

Pollution is one of the defining challenges of our time. From plastic waste choking oceans to chemical runoff damaging ecosystems, human activity has left a profound mark on the natural world. Forests are cleared, rivers contaminated, and countless species face declining populations or extinction (Bondareff, 2017). These environmental crises are no longer distant problems – they affect our daily lives, from the air we breathe to the stability of our food systems (UN Environment Programme, 2025). The scale and complexity of these issues can feel overwhelming, but solutions do exist, and they increasingly depend on skills that go beyond traditional environmental work.

A powerful tool in addressing environmental challenges today involves expertise in working with data and in coding. Modern conservation relies on data: tracking species, modelling ecosystems, predicting climate impacts, and monitoring pollution in real time. Coding, meanwhile, allows scientists and environmentalists to transform raw information into actionable insights. It bridges the gap between observation and solutions, enabling interventions that are smarter, faster, and more effective. For example, analysing patterns of plastic waste in oceans or mapping pollution hotspots would be nearly impossible without computational tools (Swannack *et al.*, 2025).

Teaching coding to young people is equally critical. Beyond environmental applications, learning to code nurtures problem solving, resilience, and creative thinking (Sweigart, 2015). It teaches that setbacks are part of progress, that there is more than one way to approach a challenge, and that persistence can turn an idea into impact. These skills are essential not only for future scientists and engineers but for any individual who wants to understand and shape the world responsibly. When young minds gain the ability to translate curiosity into tangible results, they are better equipped to confront the complex problems our planet faces.

Ultimately, addressing pollution is not only a matter of awareness but also of capability. Knowledge of ecosystems, materials, and human behaviour is vital, but so is the ability to analyse, predict, and innovate. Coding empowers environmentalists to do just that: it turns concern into action and data into meaningful change. As pollution continues to threaten both nature and humanity, equipping the next generation with these skills has been argued to be one of the most practical and profound ways to secure a healthier, more sustainable future (Swannack *et al*., 2025).

My project was designed with these considerations in mind. Its aim was to introduce students to the mathematical principles of predator–prey dynamics, but also to consider the impact of human-induced environmental stressors, through coding and simulation. The Lotka–Volterra model provided the inspiration for the activity.

The Lotka-Volterra model

The Lotka–Volterra model, commonly known as the predator–prey model, was first introduced about a century ago. Alfred Lotka, a Polish-American chemist and mathematician originally applied it to chemical reactions, while Vito Volterra, an Italian biomathematician, independently applied the model to explain the surprising patterns observed in fish populations in the Adriatic Sea observed during World War I. (Researchers had noticed that the relative proportion of predatory fish had increased even though overall fishing had been greatly reduced during the years of the conflict. This was unexpected: prey fish had been the preferred catch, and their proportion would intuitively have been expected to rise with reduced fishing rather than decline.) The contributions of both scientists are recognised in the naming of the model.
The Lotka–Volterra model employs a pair of coupled first-order differential equations to represent the interactions between two species in an ecosystem. The equations in their original formulation are presented below. The model can be applied to explain the dynamics between populations such lynx and hares, foxes and rabbits, or sharks and smaller fish, as well as relationships between parasites and hosts or viruses and host cells. The framework can also be applied to non-biological systems, such as competitive dynamics in economics or computer science, including market share competition, computer viruses versus antivirus software, or cybersecurity attackers versus defenders (Anisiu, 2014).

$$dx/dt = \alpha x - \beta xy$$

$$dy/dt = \delta xy - \gamma y$$

where:

$x(t)$ = prey population

$y(t)$ = predator population

α = prey growth rate

β = predation rate

γ = predator death rate

δ = predator reproduction efficiency

The main idea of this model is that predator and prey populations are interconnected. When the prey population rises, predators have more food, so their numbers increase. As predator numbers grow, they eat more prey, causing the prey population to decline. This, in turn, leads to a drop in predator numbers. With fewer predators, the prey population can rise again, and the cycle repeats (Figure 1).

Fig. 1: The predator–prey cycle

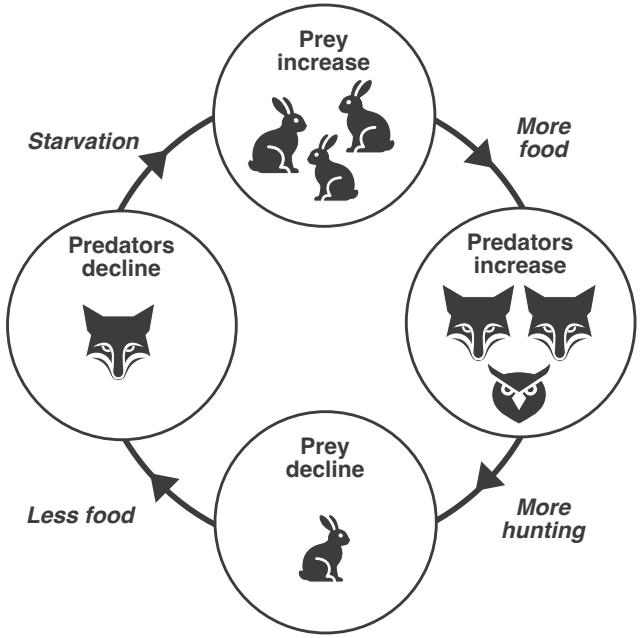
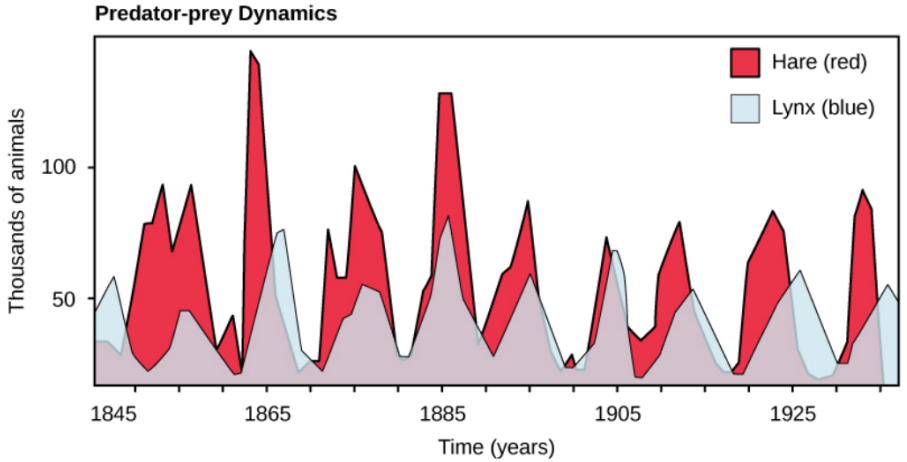


Fig. 2: Predator–prey cycle for the populations of snowshoe hare and Canadian lynx in North America. This graph by OpenStax is licensed under CC BY 4.0. Modified from the original by Matthew R. Fisher



These same boom–bust cycles can be observed in real life populations, like those of snowshoe hare and Canadian lynx in Canada and Alaska (Figure 2).

The Lotka–Volterra model makes highly idealized assumptions: prey grow without limits, predators rely on a single prey, and interactions occur at constant, random rates. It ignores time delays, environmental change, adaptation, and biological complexity. Consequently, it highlights basic population cycles but oversimplifies real ecosystems.

Awareness of such limitations when modelling ecosystems is crucial. Models homogenise populations, treating individuals as interchangeable, or characterising behaviour based on size and growth rates only. When used to manage animal populations, the model can create a sense that humans can define and control the non-human world. The mathematical equations can also distance modellers from the consequences of population management which may include recommendations for the killing of animals (Barwell, 2025).

The predator–prey–pollution model

The predator–prey–pollution model is an extension of the classic predator–prey system. It includes prey, predators, and pollution. Prey grow naturally but are eaten by predators, and are harmed by pollution which reduces their fecundity. Predators depend on prey for food, so their numbers rise and fall with prey availability. Pollution reduces prey numbers, which indirectly lowers predator populations and can dampen or even cause population cycles to collapse. This model helps show how the impacts of humans, and the increase in pollutants caused by human development, can severely disrupt natural ecosystems and the long-established balance between species. The predator–prey–pollution model can be explained thus:

$$dx/dt = \alpha x - \beta xy - \mu px$$

$$dy/dt = \delta xy - \gamma y$$

$$dp/dt = \lambda - \eta p$$

Where:

μ represents how strongly pollution reduces prey numbers

λ represents the rate at which pollution enters the environment (e.g. human activity)

η represents the rate at which pollution naturally decreases or is removed

Solving the problem numerically helps visualize the effects of pollution on the population of predators and prey for different values of λ. The differential equations can be solved with numerical approaches like Runge Kutta methods, which can easily be implemented using Python (Novak, 2022).

Comparing the numerical simulations with and without pollution highlights how increasing environmental stressors affect predator–prey dynamics. In the absence of pollution, populations follow the classical Lotka–Volterra oscillatory pattern, with regular peaks and troughs. Figure 3 shows a scenario with mild pollution (λ = 2), where the oscillations are still present but the peaks for both prey and predators are slightly lower, indicating a moderate reduction in population size. Figure 4 illustrates a stronger disruption (λ = 5), where the cycles are heavily dampened, the regular oscillatory pattern is largely lost, and population peaks are both lower and irregular, reflecting a dynamic under significant stress. Finally, Figure 5 demonstrates an extreme case (λ = 8), where pollution causes the populations of both predators and prey to collapse rapidly, with no recovery, effectively destroying the interspecific interaction and ultimately adversely affecting the wider ecosystem. Together, these graphs reveal a clear gradient of impact: as the intensity of pollution increases, population oscillations are increasingly dampened, the timing of peaks is delayed, and, at high levels, the ecosystem becomes entirely unsustainable.

Fig. 3: Comparison of predator and prey population for λ=2

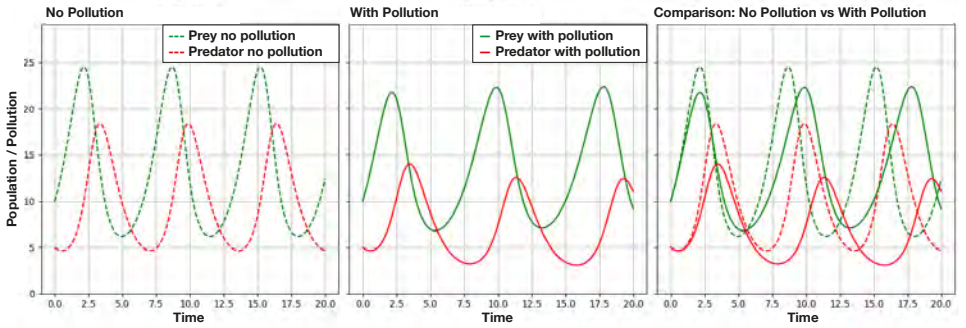


Fig. 4: Comparison of predator and prey population for λ=5

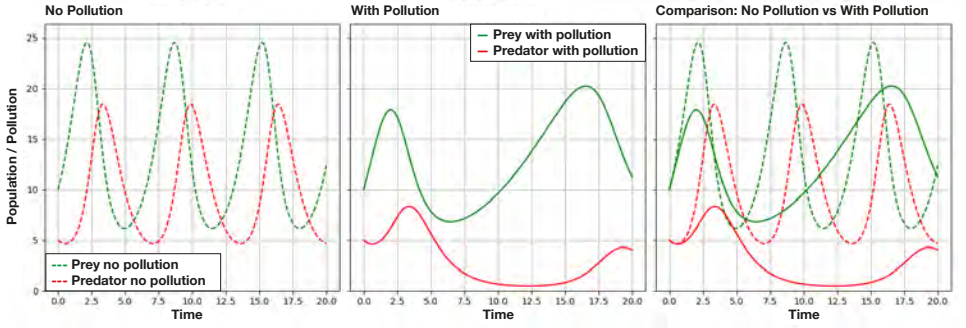
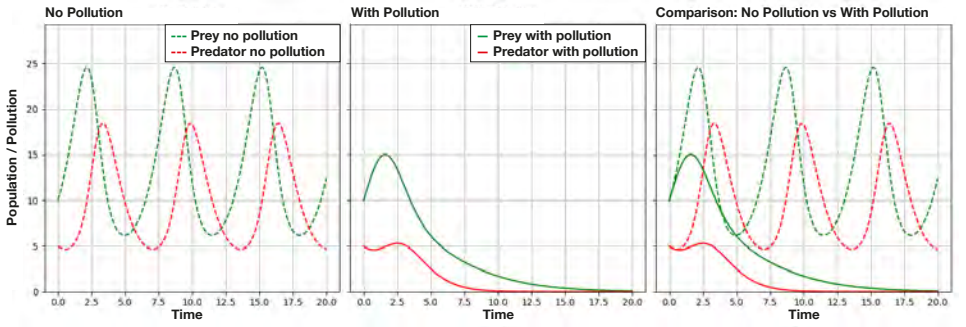


Fig. 5: Comparison of predator and prey population for λ=8



The project

My project began with a simplified Lotka–Volterra framework, extended to include pollution as an additional ecological driver. The core task involves a numerical simulation of the model using code, generating predictions of predator and prey populations over time under different environmental conditions. Instead of solving differential equations analytically or using advanced numerical methods, students work directly with a discrete, grid-based approximation that captures the main dynamics of the system. Depending on students' prior experience, the activity could be approached at different levels of complexity. More experienced students might discuss the model conceptually in terms of population interactions and the effects of parameters such as predation and pollution rates. Students less familiar with differential equations can still engage fully with the activity by focusing on the key ideas of population interactions.

The simulation is inspired by the interactive game Minesweeper: a player assumes the role of a rabbit navigating a grid while avoiding foxes and plastic pollution (Figures 6 and 7). Students can create and/or play two versions of the game: one including only foxes as hazards, and another incorporating pollution as an additional threat. By comparing these versions, students can observe how environmental stressors such as pollution alter population dynamics and reduce the chances of survival.

While developing this simulation and example game, several coding challenges arose. One of the first issues was learning how to represent the grid effectively in Python, ensuring that for each cell one could track whether it was visible, contained a fox, or contained plastic pollution. Creating a simple Minesweeper-style game was also a significant challenge. Introducing pollution as an additional hazard required careful thought, both conceptually — deciding how it would affect the game dynamics — and technically, in terms of coding the correct distribution of hazards based on the chosen pollution parameter. Finally, the project required engagement with Python itself, including debugging, finding workarounds for unexpected behaviours, and structuring the code in a clear, maintainable way. These challenges provided valuable opportunities to practice computational thinking and problem solving in the context of ecological modelling.

Fig. 6:

Fig. 7:

Creating a game to simulate an ecosystem combines computational modelling with interactive pedagogy to explore ecological dynamics and environmental challenges.

The activity can also be used by students with different levels of coding expertise. Advanced students might implement the game logic and hazard distribution themselves, while others could work from partially completed code. This flexibility ensures that the activity remains accessible while maintaining a strong focus on modelling, computational thinking, and ecological interpretation.
The activity can also be adapted to be more open-ended, encouraging students to develop their own game ideas based on the model. For example, students could design a survival game where the player controls a rabbit navigating a landscape while avoiding plastic pollution, or invent entirely new scenarios that explore predator–prey or environmental dynamics in creative ways. This flexibility allows a task such as this to be tailored to the interests and abilities of the students: some may wish to focus more on coding and game mechanics, while others may choose to delve deeper into the mathematical side of the model. Others may be keen to identify the critical points when populations are at risk of collapse, and/or experiment with ways of returning the model to equilibrium. By providing opportunities for student-led exploration, the activity fosters creativity, critical thinking, and engagement with ecological and computational concepts in a more personalized and exploratory manner.

Final words

Creating a game to simulate an ecosystem offers a means of combining computational modelling with interactive pedagogy to explore ecological dynamics and environmental challenges. Starting from the Lotka–Volterra predator–prey model and then extending it to include pollution offers students to experience first-hand the impact of environmental stressors upon population outcomes. Visualising these dynamics through simulations reinforces the link between model parameters and real-world ecological processes, making abstract concepts tangible.

Inviting students to participate in coding the simulation and creating and playing the Minesweeper-inspired game provides opportunities to engage with the mathematics of the underlying models as well as to develop computational thinking, problem solving, and logical reasoning. The interactive format highlights the consequences of hazards — both predation and pollution — while giving students immediate feedback on the effects of

different scenarios. By adjusting the complexity of the code or designing their own variations of the game, learners can explore the model creatively.

Crucially, unlike more traditional mathematical models — which can objectify animals, disregard their status as living and sentient beings and justify their reduction to numbers — this activity has been designed to encourage environmental reflection and awareness. Working with the model allows students to appreciate the interdependence of predators and prey within ecosystems and the fragility of these relationships under human pressures such as pollution. Rather than abstracting away ethical or ecological consequences, the activity highlights the real-world impact of human disruption on ecosystems. In this sense, the approach aligns with the goals of critical mathematics education, which focuses not just on mathematical or technological fluency, but on promoting reflective knowing (Barwell, 2025).

In this game, the impact of pollution is made visible and personal through gameplay. By bridging modelling, coding, and hands-on interaction, students gain a multidimensional understanding of human-driven environmental pressures upon predator–prey relationships. Working with an amended Lotka–Volterra model can prepare students to think critically and act responsibly as future scientists and informed citizens.

An example game can be played here:

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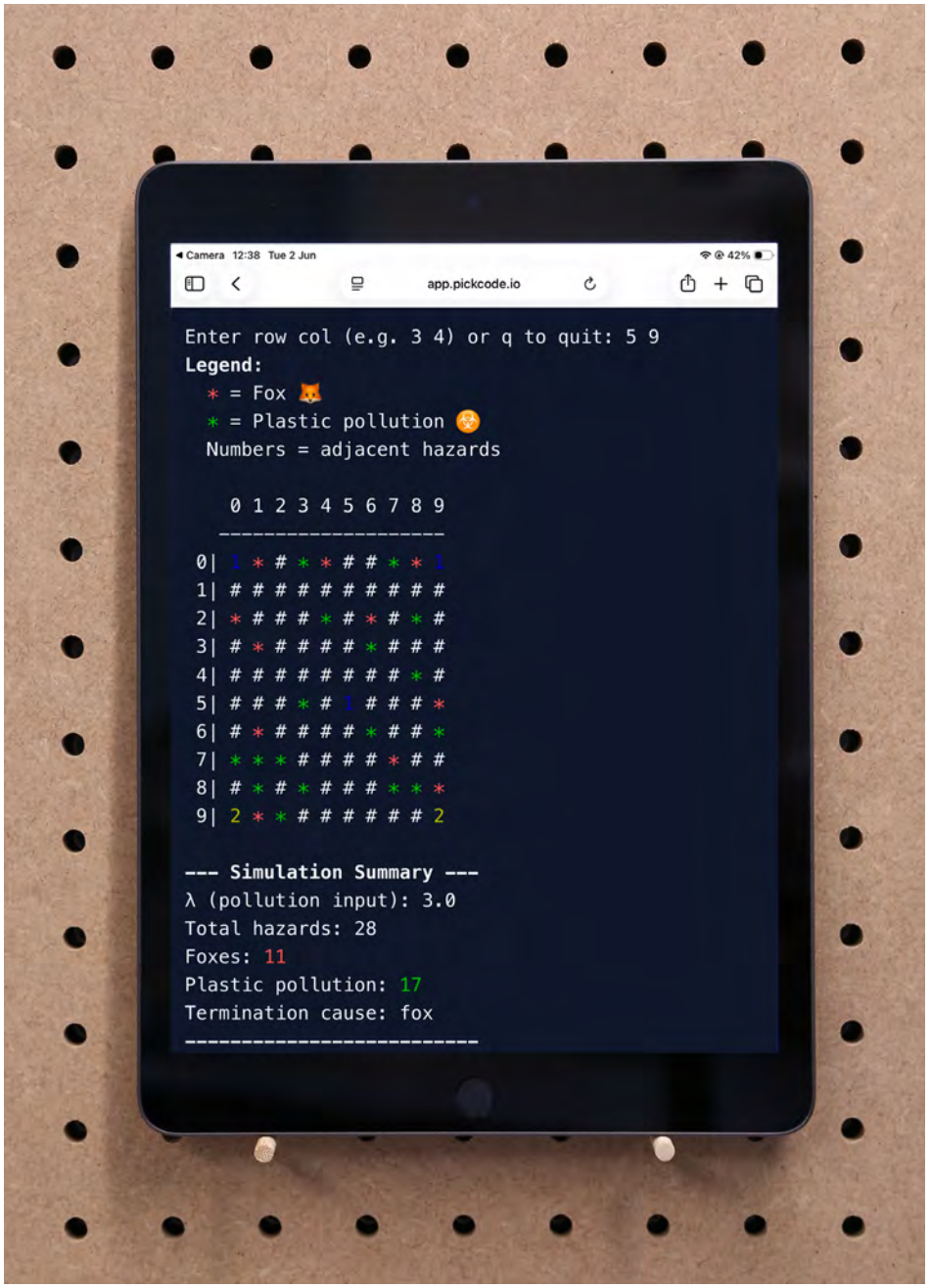


09

Creating songs together: Taking action through emotion

Jonathan Berliner

Jonathan is a PhD Candidate at King's studying the experiences of neurodivergent secondary chemistry students. He is also a teacher of maths and science in an alternative provision for students with emotional-based school avoidance, and an expert in using songs in the classroom as a way of bringing science to life, making it understandable and memorable for all learners.

"Creating and singing a song can enhance students' engagement with the natural world and inspire them to live more sustainably."

Learning about environmental problems is central to solving them, but simply knowing the facts of our environmental impacts may not be enough to change our behaviour or motivate us to demand the political change that is necessary. This is painfully demonstrated by our sluggish collective response to biodiversity loss, increasingly frequent extreme weather events, and mass migrations from sinking coastal areas caused by climate change despite decades of scientists' warnings. Whilst doom-laden, fact-based messages can motivate people to act through evoking fear, their effect is limited as they fail to provide hope, and this can negatively affect mental health (Troy *et al.*, 2024). Perhaps, then, we need to change the medium and delivery of such messages? Traditionally, educators have tended to worry more about what students are thinking, rather than what they are feeling. In recent years, however, cognitive scientists have concluded that thinking and feeling are not separate processes. Emotion is part of how we evaluate situations and decide how to act. Emotion and cognition are also embodied in that they depend on our physical state (Winkielman *et al.*, 2015). We learn with our bodies and emotions, not alongside them. In turn, education researchers are increasingly advocating for the greater consideration of emotional and physical aspects of knowing in order to support learners' rounded engagement with content (King *et al.*, 2025). With respect to teaching about environmental issues, how then might we foreground emotional and physical forms of engagement?

One relatively reliable way to stir emotions is through music (Levitin, 2006). We know that chords and timbres evoke comparable emotions across cultures meaning our responses to music are likely to have deep evolutionary roots. At the same time, many responses to music are culturally specific, and discrete forms and types of music can provide

a major part of a culture's identity. Similarly, choir members, football fans, and most world religions can attest to the fact that singing together has the power to inspire deep feelings of belonging. Through the shared vibrations of vocal cords and ear drums, groups of singers think, feel, and act together as one. In short, singing has the power to unite people. Perhaps this is why the protest song has long been connected with the history of social change. Songwriting and singing have been a way for the powerless to regain agency by spreading awareness, serving as an act of defiance, or by providing a call to action.

By writing songs about environmental issues with my students, I have sought to develop emotional and physical responses to complex concepts thereby deepening their understanding, and enhancing their feelings of connectedness and agency.

Songwriting with students

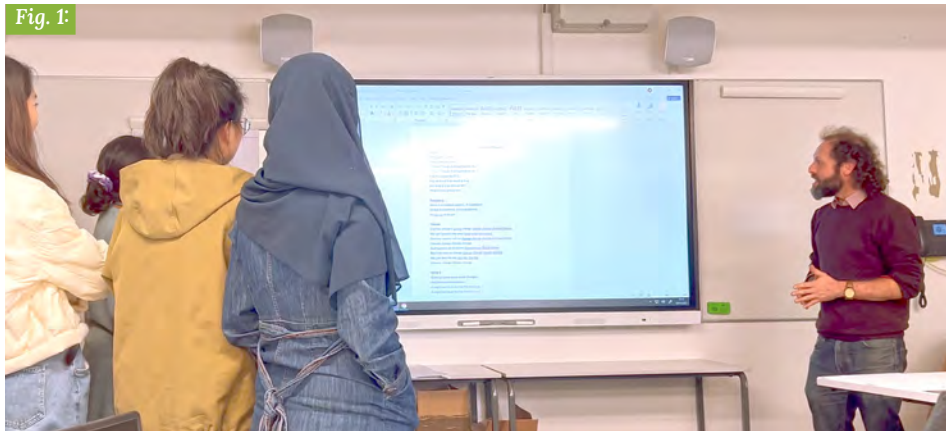
There are many ways to incorporate the emotive power of music in education but having students create their own songs can foster a deeper connection to the music for several reasons. By writing their own lyrics, students can articulate the thoughts and feelings that resonate most deeply with them. They can also choose the types of music that inspire the desired emotions, and their feelings of belonging are enhanced by singing songs that connect to their cultures and identities. Though songwriting is a specialist skill, the process can be scaffolded to allow those with limited musical skills to contribute and, by being collaborative, a whole class can share the same sense of achievement. A collective songwriting activity therefore has the potential to fulfil basic psychological needs of connection and competence, whatever the group's skill level.

In my experience, the hardest thing for novice songwriters is the decision-making that is necessary in the songwriting process. In STEM classrooms, decision-making is often determined by whether a solution provides a right or wrong answer. By contrast, determining which lyric or aspect of a performance works best is often subjective. Without experience, it can be hard and time-consuming for learners to decide which creative approach works best. The educator must therefore find a balance. Fewer creative decisions make the task easier but may limit the connection the students might feel toward the song. Too many creative decisions can take up too much time. For the song presented here, the students had around an hour to write the song, which is a challenge for even the most experienced songwriters. To speed up the process and help them create a performance-ready song, their decision-making was heavily scaffolded.

> Singing together can foster hope that through collaboration we can more of an impact working together than we can alone.

Whilst musically gifted students might wish to compose their own melodies, this takes time and can make the song harder for others to learn. Changing the words to a well-known song means that students with minimal musical experience can still be involved. Since the choice of song is one that can spark lively, time-consuming debate amongst students, I took the executive decision, and chose the song *Let It Be* by the Beatles. I felt that it would be known by most of the students, and,

Fig. 1:



significantly, it has a hopeful, hymnal melody with a simple lyrical structure. To further aid the songwriting process, the students were split into small groups to write different verses. An entire class writing each line would be a case of too many cooks, but if the verses are split then this a useful division of labour allowing each student to see their contributions in the final product.

Whilst music can directly affect emotion, the lyrical aspect of songs provides the opportunity to use narrative structure. Like music, narrative structure appears to be another deeply intuitive way to present information, transcending culture and connecting with our emotions in ways that facts and arguments cannot. When students are split into groups, each group can tell a different part of the story, but the entire class would first have to agree on the story they wished to tell. Stories often revolve around the resolution of a conflict, and this class chose to sing about climate change. The first verse would describe the context of the problem, outlining the role of greenhouse gases in warming the atmosphere. The second verse would address the central conflict of the narrative and the problems that a warming atmosphere might cause. The next verse would describe the process of solving the conflict, and the song would finish with some kind of resolution. In many songs, there is often a chorus, or at least a line that repeats throughout, and this should sum up the central message of the song. A fifth group was dedicated to the chorus.

As the groups considered their lyrics, they discussed the issues of climate change, engaging deeply with the topic and asking themselves what the most important things were to say. Doing so led them to engage with several STEM topics. The chemistry of the atmosphere was explored through researching greenhouse gases, while aspects of physics were considered in reflecting on the nature of electromagnetic radiation that either penetrates or gets absorbed by the atmosphere. Groups discussed various technologies that might help reduce the severity of the climate crisis, and the importance of forests in absorbing carbon. They discussed how 1.5ºC of warming could be accurately determined when the atmosphere's temperature is in constant flux. Some students conducted independent research to check their facts or discussed the best way to frame an argument. Given more time, students could have additionally considered wider socio-scientific issues about the role of researchers, governments, and corporations in responding to the climate crisis.

As each group finished their part, they typed them into a collective document, and the song began to take shape. Inevitably, some lines worked better than others. I offered suggestions that might make their wording fit the original melody a little better or might be a little easier to sing, and after a few tweaks the complete song came together. This is a moment ripe with emotions. There is a sense that collaboration can produce an outcome greater than could be achieved by individuals working alone. It is empowering, it is surprising, and it is joyful.

The creative process can be unpredictable, and that is partly what makes it exciting. The sentiment of the original lyric 'Let It Be' is one which espouses the wisdom of meeting life's problems with quiet acceptance. In contrast, the group charged with writing the chorus came up with the lyric 'Change or Die', providing a message of such stark urgency that when sung to the original melody, the juxtaposition created a comic effect. This cut through the message of impending doom allowing us to face the alarming reality of climate change with a degree of humour, although the seriousness was not lost.

Singing with students

Whilst the activity could finish there, songs are made to be sung. After singing through the song a couple of times to become familiar, the group sang the song to other students (Figure 1). This is yet another opportunity to imbue a learning experience with positive emotion. Not only do the performers connect with each other in literal harmony, their performance is an act of giving. Audiences share in the emotions that the performers transmit through their body language and their music, and reflect it back through the expressions on their faces and their applause at the end. Singing is also a physical act. If done with enthusiasm, it is invigorating, involving deep breathing and exertion, thereby releasing many of the same hormonal rewards of exercise.

Final words

By themselves, songs may not change the world. But they can speak truth to power. We cannot create a sustainable future by singing, but we can engage the emotions that might motivate behavioural change for the better. Further, songwriting can give space for people of all ages to share their concerns and discuss what meaningful action would look like to them. Singing together can foster hope that through collaboration, just like a choir, we can have more of an impact working together than we can alone.

Watch my song performance in full here:

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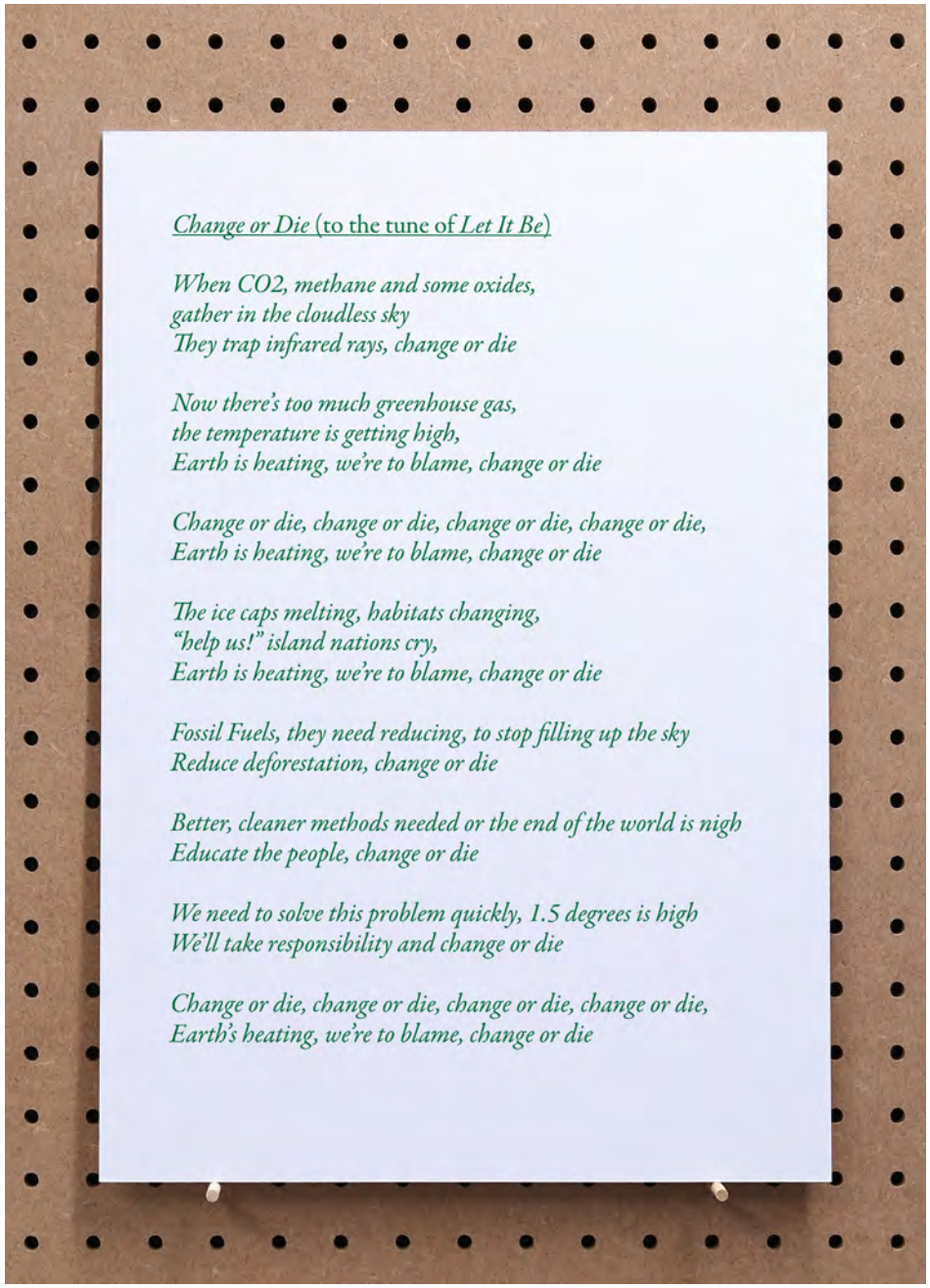

10

Simulating nature

Gaz Lawrence

Gaz Lawrence a.k.a. Gareth Campbell is an interdisciplinary artist and STEAM educator from Bristol. He has previously worked as a secondary science teacher where he developed a passion for making science education more creative. He founded The Museum of Science, the Arts & Interdisciplinary Collaboration (MoSaic) in 2022 to demonstrate the power of cross-curricular learning and to dismantle the traditional art-science divide.

"In inviting viewers to feel awe without certainty, I want them to question their own engagement with the natural world."

When were you last tricked into falling in awe with nature? By 'tricked' I do not necessarily mean deceived in a negative sense, but rather being momentarily drawn into an emotional response before your critical thoughts have had time to catch up.

Jacob Bronowski, in the final line of one of his poems, writes, 'We gape at wonders and forget to see' (Bronowski, 1957). Although he is referring to space and celestial phenomena, the line feels equally applicable to the natural world closer to home. It reminds us that awe alone is not enough; without curiosity and reflection, it is possible to stand in the presence of something remarkable and still fail to fully understand or value it.

I have become acutely aware of this trickery since I visited Singapore in 2018. I couldn't help but succumb to admiration whilst lying under *Supertree Grove* in the Gardens by the Bay (Figure 1). These structures, rising to 50 metres, reminded me of what a small role in global ecosystems us humans should be playing. As I peacefully lay there watching these eighteen monoliths being lit to music, I caught myself thinking, 'Isn't nature incredible?' But beneath my admiration for the beauty grew a quiet awareness that this awe had been engineered. The canopy above me was not alive, only animated. I was suddenly struck by the irony of these natural forms being built not grown. Steel twisted into organic forms. Photovoltaic cells in place of palisade cells. Photosynthetic becoming simply synthetic. Biomockery rather than biomimicry.

However, in acknowledging the contradiction, I came to realise that this is what makes the gardens so compelling. In turn, the experience prompted an exciting proposition: given that data and scientific information do not, on the whole, result in meaningful engagement with the climate

Fig. 1

crisis, might emotionally charged experiences be more effective in shaping and changing how we think, feel and act?

Recent education policy in the UK has leaned heavily on the idea that cultivating 'awe and wonder' about nature will lead to pro-environmental behaviour. While, at first glance, this may feel like a potentially promising approach, is it enough? Awe without critical reflection risks becoming pacifying rather than transformative (Booth, 2025). We see this in classrooms. Awe during a science demonstration can lead students to believe that the phenomenon they are observing is a magic trick and not a source of curiosity, inspiration or long-term engagement (Willingham 2009). (Of course, in my days as a science teacher, a bit of magic wouldn't have gone amiss — I'm sure the frogs we dissected would have been much happier if being sawn in half was merely an illusion...)

Earlier on the same the day that I experienced the *Supertrees* in Singapore, I had photographed my now ex-partner sat majestically on a driftwood throne elsewhere in the Gardens by the Bay. Upon my return to the UK, I used this image to create a painting as a comment upon humanity's dictatorship over nature and the irony of building artificial trees in the place that was once lush rainforest.

Making is an exploration

I see the process of painting, or indeed any making, as a way to facilitate thinking rather than simply illustrating an idea. Painting only makes sense to me as a verb, rather than as a noun. The physical object is just a byproduct of the process. At least, this is one way I justify the piles of unsold canvases in my studio.

Making similarly has the potential to be used in education as a method of enquiry. In *Singapore*, the figure sits at the centre of the canvas on what appears to be a naturally formed throne of intertwined branches, though its exaggerated curves hint at something shaped or staged. The figure is crowned with the icosahedral head of a bacteriophage, a virus that infects bacteria. They have an eerily alien-like head: it is in the shape of a platonic solid and is made from protein. It is a form that I find both beautiful and unsettling. The virus is seemingly insignificant but can attack a living organism much larger than itself — a fitting analogy for humanity and our current relationship with nature. This is further exaggerated by the bright colours of the stained-glass crown, reminding us that it does not belong in this lush green junglescape. The movement of water over stones draws the viewer's attention to my efforts to emulate natural processes through static representation. The painting itself can be seen as an echo to the Supertrees that initially inspired the piece: an artificial construct attempting to approximate nature but inevitably falling short of the living original. This failure is not something I seek to hide; instead, it becomes part of the meaning of the work. In hindsight, I wish I had named this painting something a little more poetic than simply *Singapore*, as it is intended as an indictment of humanity as a whole, me included, rather than a particular city, colonial power... or indeed my ex.

I have long admired the work of Henri Rousseau. I could sit in front of his painting *Surprised!* in the National Gallery for hours and hear the rain fall upon a starving tiger waiting to pounce (Figure 2). Having been fortunate enough to see tigers hunt in the wild, I find it remarkable that Rousseau was able to create a piece that can transport me to a tropical landscape when he himself never left France. What draws me repeatedly back to Rousseau is not the accuracy of his jungles. His forests are not biologically correct. However, they are compelling, emotional constructions. They are built from second-hand accounts, botanical studies, and illustrations, and assembled into a vision that

feels believable. Rousseau doesn't claim to show us the jungle as it is, but instead he shows us the jungle as he understood it from a distance. This distinction became increasingly important as I worked on *Singapore*. I am not attempting to reconstruct a historically accurate pre-colonial rainforest. What I tried to paint is a speculative landscape built from memory, research, and absence. Like Rousseau, I am working with what is available to me. And some might say, like Rousseau, I am doing it with artistic naivety.

Facilitating curiosity and criticality

This approach of querying one's own relationship with nature, mirrors how I work creatively with young people. In my most recent workshop series, I asked students to imagine undiscovered exoplanets. My aim here was not factual precision but the development of transferrable skills such as curiosity and experimentation. Accuracy in art matters, but it must coexist with creativity: it is important to think about how shadows from two suns are cast by particular rocks, but is not necessary to be overly concerned with whether the forms of such rocks obey the laws of science. Like Rousseau, imagination allows learners to enter spaces they cannot physically access. Couple this with critical reflection and we can help young people to question what is missing, what has been simplified, and what is being lost. The arts also have the power to induce curiosity and help learners develop intrinsic motivation to learn more. These same qualities are essential to the scientific method, yet they are often under-nurtured due to tight outcome-driven curricula.

Fig. 2

The arts, like the sciences, induce curiosity and support the development of transferable skills such as experimentation.

As I worked on *Singapore*, I realised that the painting was not only a commentary on our chokehold on the planet but also on my own complicity. My reliance on materials transported across continents. My privilege in being able to aestheticize the very environmental decline I was critiquing. My use, in this instance, of plastic-based paints. And, let's be honest, my decision to visit somewhere on the other side of the world for just 24 hours, not something I make a habit of, but a rare decadence once enabled through the perks of dating cabin crew. These contradictions are uncomfortable, but they are also unavoidable. Recognising my own complicity has altered the way I approach making and teaching. I am cautious about my creative work being perceived as virtuous. In practical terms, this has changed how projects are introduced. Acrylic paint, for example, is no longer treated as a non-toxic medium but acknowledged as a petrochemical product with a lifespan far exceeding the artwork itself. This does not lead to its outright rejection, but it does require justification. I encourage my students to articulate why a material is necessary rather than accepting it as the default. This is a key skill to learn how to make more sustainable choices in their future careers and lives. Indeed, research into teachers' beliefs about sustainability education suggests that approaches which emphasise reflection and student agency rather than factual completeness alone are better equipped to deal with the complexity of global environmental issues (Taube 2024). I aim to create a space in my own education practice where learners are not asked to arrive at a single 'correct' understanding, but to examine how their own assumptions, choices, and contradictions shape their relationship with the world.

At a time when ecological crises are communicated through datasets and projections, the acts of making can engage learners in different ways.

My classroom conversations have also become much more transparent. We openly acknowledge that we all have habits and desires that are detrimental to the climate. I have spoken honestly about my own inconsistencies, for example, flying and using synthetic materials. This honesty reframes the classroom as a shared space of inquiry rather than moral instruction. I have found that students are less defensive when contradiction is acknowledged rather than concealed. In this way, creating becomes not a performance of environmental responsibility, but a method for examining it.

The themes of *Singapore* have carried through my work over the past few years and have recently been revisited through another ongoing project, *The Art of Astrophysics*, in which I depict my own imagined exoplanet landscapes. This has led me to ask what our future experiences of nature might entail. Will we need to construct environments that follow the laws of nature simply to remind us of the awe we once felt, before we pressed self-destruct?

Using my learning from a 2024 project *Nature's Fractals*, I have been trying to replicate the patterns we find in nature through my linework and the organic shapes that recur across many of my paintings. For years, I have been contemplating ways of combining these themes with *Singapore* to create a follow-up work. *Asterism I* is the painting sat on my easel at time of writing. It is the first in what will be a series of oil paintings, depicting organic forms composed of a seemingly metallic substance. Subsequent artworks will expand upon this and will combine the golden ratio and the golden angle to mimic flower-like spiral structures that can only be fully perceived from the viewer's position, much like the asterisms and constellations that emerge only from our particular vantage point on Earth. I now merge traditional media with digital tools, using 3D modelling software to augment my imagination during the making process. Once again, the work attempts to bridge the space between the natural and the artificial. In *Asterism I*, the central figure no longer occupies the role of nature's monarch. Instead, they sit in a posture of reverence, gazing upward at a constructed asterism. The shift mirrors my own experience beneath the Supertrees, looking up in awe at something undeniably beautiful, while

remaining aware that the encounter has been carefully orchestrated. Using geometry drawn from natural systems and intuitively drawn organic shapes I am deliberately trying to recreate that sensation of natural wonder, while the unnatural depiction of materials and lighting allow the artifice to remain visible.

Final words

In a moment when ecological crises are often communicated through datasets and projections, the acts of making offer a different mode of engagement for learners. Discomfort, irony, and contradiction become productive rather than problematic, creating space for self-reflection. When people encounter my work that is simultaneously reverent and uneasy, artificial yet governed by natural laws, I want them to question their own responses to environmental spectacles. Awe becomes something to interrogate rather than simply consume. If *Asterism I* and *Singapore* are to function as educational objects, they allow us to consider what it means to recreate nature at the moment of its disappearance, and whether our future relationship with the natural world will be one of stewardship, simulation, or remembrance. In inviting viewers to look up once more, to feel awe without certainty, I hope my work creates pauses long enough for these questions to take hold. I am trying to trick my viewers into falling into awe with nature once again. But this time with a critical lens.

The original and prints of 'Singapore' are available from my website (www.gazlawrence.art). Please note that the original painting of 'Singapore' is part of my Veblen Experiment. Most products obey the law of supply and demand, except Veblen products such as luxury watches, Champagne or, fine art. I am testing whether 'Singapore' is a Veblen product or an inherently undesirable object. The price of the painting increases by £50 on the first of every month until it sells or remains in my possession for the rest of my life. This month is the least expensive this painting will ever be.

Opposite: 'Singapore' by Gaz Lawrence

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11

The Mapuche loom: Weaving the environment into education

Mariana Muñoz-Gómez

Mariana Muñoz-Gómez is a STEM educator and inclusion specialist with a strong focus on supporting neurodiverse learners through the implementation of innovative pedagogies. Following her MA in STEM Education, she now works in a specialist autism centre.

"Weaving reminds us that knowledge can be built with our hands and that patterns and colours can have a deeper meaning, beyond the aesthetic, about our relationship with the environment."

I was born and grew up in Chile, that long and narrow country at the west of the Andes in South America. I learned to knit from my mum there, when I was a child. She taught me how to use crochet hooks and knitting needles: first simple patterns like chains and rectangles, and then, little by little, with patience, the more complex stitches. I remember it was difficult at first. I'm left-handed, so I had to imitate my mum as if she were a mirror. It wasn't easy; it took many attempts and perseverance, but after a while, I got it. Later, in secondary school, knitting became a shared ritual with my friends during breaks. We made scarves and hats, choosing our favourite colours and making each garment personal and unique. I loved the feeling of creating something warm and useful, something that started as a thread and ended up as so much more.

When I was offered the opportunity to reflect on the environmental crisis through creation, the idea of making a Mapuche loom came to mind. The Mapuche are an indigenous group inhabiting southern Chile and Argentina. They are a people with a rich culture and artistic traditions, particularly in weaving and metalwork. Textiles produced by the Mapuche loom, or 'Witral' in the Mapuche language, are known for their geometric designs, patterns, and symbolism.

Chile is a country with a deeply Eurocentric view of the land and progress. Despite having an Indigenous population exceeding ten percent of its total population (INE, 2024), the knowledge and worldviews of Indigenous peoples are not part of the school curriculum. Much of what I knew about the environment during my childhood came from Western scientific frameworks, completely obscuring the Indigenous perspective. But this perspective existed long before the Chilean state; the Mapuche people and other Indigenous peoples developed ways of life that recognised the interdependence between human beings and nature. The

Mapuche have a perspective that values and recognises the importance of caring for the environment, and we can no longer ignore it.

My motivation to work with a Mapuche loom cannot be separated from the meanings that are embedded within the loom itself. Beyond its physical form, Mapuche weaving is a symbolic language that allows relationships with land, memory, and community to be articulated. Such symbolism is not simply an aesthetic choice, but a way of listening. A way of acknowledging that wisdom has always been present, offering a vision of balance that we urgently need. If we truly want to address the environmental crisis, we cannot rely on the same worldviews that contributed to it. We need to turn to the voices that were silenced: voices that have long spoken about care, territory, and the responsibility we have to the land and to each other.

Symbolism in patterns and colours

In Mapuche weaving, patterns are forms of communication. The geometric motifs that appear repeatedly on the loom, such as rhombuses, triangles, and crosses, encode ways of understanding the world and relating to it. As Mella (2020) explains, these shapes are not conceived as abstract geometrical figures, but as schematic representations of lived experience: eyes, paths, animal traces, or bodily forms. When discussing Mapuche weaving, one cannot fail to mention the Guemil: the Mapuche cross that represents the four cardinal directions. It is present in numerous designs and is fundamental to understanding how the Mapuche perceive the land, but also how this symbol transcends to broader realms, such as the cosmos, culture, and nature. It is a figure that represents the world as a whole, as a composition of these different dimensions. As I began to work with these motifs myself, I became more aware that choosing a pattern also meant choosing what kind of relationship with the land and with memory I wanted to foreground. In this sense, Mapuche textiles function as visual maps of belonging and identity.

Colour carries a similarly layered significance. Traditionally obtained through natural dyes derived from plants and minerals, colours are deeply connected to the environment and to the knowledge required to work with it. Working with colour during the weaving process made me reflect on how colour is not only seen but lived, tied to time and an intimate knowledge of the environment. Beyond their symbolic value, colours also play a structural role in patterns reinforcing contrasts and making patterns emerge.

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Geometry as a way of seeing

As a maths teacher and amateur weaver, I have noticed the connection between the art of weaving and geometry. Weaving textiles with geometric patterns requires planning, the ability to imagine, and the capacity to translate that vision into a concrete plan of stitches and colours.

The geometrical structures found throughout Mapuche fabrics remind us that mathematics transcends different cultures and nations; it is not merely an academic or Western construct, but an ancestral way of observing and understanding the world. In Mapuche textiles, the figures and patterns represent a vision of the land, the cycle of life, and the relationship between human beings and nature. In this context, weaving reminds us that knowledge can be built with our hands and that patterns and colours can have a deeper meaning, beyond the aesthetic, about our relationship with the environment.

While geometry provides one way of understanding the structure of Mapuche weaving, it does not capture the full social and embodied dimensions of the practice. Weaving is more than a way of organising space and patterns, but also an activity that is gendered through relationships of knowledge transmission and power.

Weaving and gender

In Mapuche culture, as in many other Indigenous cultures, weaving has been primarily a task performed by women. This is evident in Mapuche folklore and traditional stories:

> *One day, a little girl was washing hominy in the river when an old man came and kidnapped her; he took her to his lands. The old man married the girl. They say he told her: 'I'm going to Argentina, and when I return, you must have all this wool spun for me.' The man left, and the girl was left crying – she didn't know how to spin! – close to the bonfire. Then the Choñoiwe Kuzé, the Old Fire, spoke to her: 'You don't need to worry so much; I'll call Lalén Kuzé to help you.' A little while later, the Old Spider appeared and said to the girl: 'You have to do it like me; watch me, and you'll learn to spin.' So the days passed, and when the man returned, the wool was spun. Every night, Lalén Kuzé went to help the girl, and together they finished the work.*
>
> (Mella, 2020 p.23)

This story reveals various aspects of Mapuche culture. On one hand, there is the concept of marriage in which the woman is taken from her community to become part of her husband's, symbolised by kidnapping. It also highlights the role of women in the division of labour, where they are responsible for textile work. Both of these notions can leave a bitter taste when read in the context of the 21st century, but they are nonetheless evidence of how societies were structured not so long ago.

However, there is a third aspect in this story which I would like to emphasise. This concerns the cooperation among women within a patriarchal society. To understand this third aspect, it is important to know that in both Spanish and the Mapuche language Mapudungun, objects have a defined gender. In this case, the two deities mentioned are the old fire and the old spider: both are feminine. Despite the patriarchal context in which this story is framed, it also speaks to how women learn from other women, how knowledge is something ancestral, and how it is passed down from woman to woman through the generations. The story also speaks to female empowerment: a chain of female support. In the help the deities offer the girl, a form of sisterhood emerges, a cooperation that fosters care and resilience even amidst patriarchal structures.

Within Mapuche culture, women have historically played a central role not only as weavers, but also as guardians of environmental knowledge and defenders of territory. Through practices such as weaving, women sustain relationships with the land, preserve ancestral knowledge, and transmit values of care and balance across generations. In this sense, weaving can be understood as a form of ecological and cultural resistance: a quiet but persistent practice that affirms ways of living in reciprocity with nature.

This interpretation resonates deeply with my own experience as a woman who learned to work with textiles from an early age. Learning to knit as a child, guided by my mother's hands, was not simply a technical process but

also an introduction to the practices of care and attention. For me, experimenting with weaving using a Mapuche loom enabled me to reconnect with this embodied knowledge, now reframed through questions of gender, environment, and territory.

The creation process

Before beginning the weaving itself, I had to make a few key decisions about the materials, symbols, and colours that would shape my creation. I chose to work with wool, a material I have been familiar with since childhood, but also one that holds a deep connection to Mapuche textile tradition and to nature. I also chose to include elements of nature from the country in which I now live – the UK. I thus used branches and dried seeds that I found during walks in Epping Forest and Hampton Court Park. For the central motif, I selected the Mapuche cross (Guemil). This was to represent the multidimensional character of the land and nature. Colour was another deliberate decision. I chose red, since it represents blood, particularly menstrual blood, which is why this colour is associated with fertility (Mella, 2020). I also chose green because, according to the Mapuche vision, it is associated with the earth and the world of plants, or in a more symbolic sense, with abundance and prosperity (Mella, 2020). From my perspective, using these two colours is a way of representing nature as something that grows and changes, sustained through cycles of life, regeneration, and transformation.

Having decided what I wanted to weave, it was time to begin. The start was slow, both because I wanted to be careful and avoid making mistakes (after all, it had been years since I had last woven on a loom).

After weaving about 20 rows, I began to feel more confident in what I was doing. The piece was taking shape, and I started to get excited about how beautiful it was becoming. I was delighted by the symmetry and the contrast of the two colours in the same piece (Figure 1).

Fig. 1

Fig. 2

I had overcome all the difficulties and managed to produce a beautiful piece, full of meaning and an ancestral vision of nature.

My first major difficulty arose when it came time to weave the eight-sided cross motif. It was then that I realised my first big mistake: I had chosen an odd number of vertical threads. This did not seem so serious at first, but then I noticed that if I wanted to create symmetry, each level of the cross needed to be worked with an even number of threads. Since I had already made significant progress, I had to make the decision to move forward, shifting the cross one space to the left. The motif would not be centred, but at least it would be symmetrical (Figure 2). After saving my work from its first major crisis, it was easy to continue. Weaving came more and more naturally to me, and the second half was taking considerably less time than the first. Nothing could go wrong now!

Fig. 3

I spoke too soon, because at that moment I faced my second major difficulty: how to remove the completed piece from its frame. I tried to be careful during this process; I knew how delicate it was. Despite all my care, when I removed it from the frame, the piece completely lost its shape. I could not believe it; this had become a disaster, an impossible mission to separate the threads and try to maintain the shape that had taken so much work. I was so upset that I even forgot to take a photograph of this step! After much patience, and using all my weaving tools, I managed to recover most of the shape from before.

After this heroic rescue of my creation, only the final steps remained. I added a thick branch as the top frame, and at the bottom, I joined the 25 threads into just 4 thicker, more colourful ones. I also incorporated two dried seeds into two of these strands (Figure 3). Seeing the final result, I could not contain the huge smile on my face. I had woven this little tapestry all by myself. I had overcome all the difficulties and managed to produce a beautiful piece, full of meaning and an ancestral vision of nature.

Weaving into the classroom

Building on this creative experience, I believe that working with the Mapuche loom holds significant potential for educational contexts, even though I have not yet had the opportunity to implement this activity directly with students in my current role.

The first and most obvious setting is in Chilean primary and secondary school classrooms. An activity like this could be

modelled from an interdisciplinary perspective, integrating Mathematics and Science in primary education or the subject of Science for Citizenship in secondary education. From a science perspective, it could be approached through environmental care and its impact on people. I think it would be an excellent activity that, in addition to addressing curricular content, would serve to foster reflection and understanding of the environment from a local Indigenous perspective.

Working with the Mapuche loom has been both a personal and political act.

The second educational setting I envision is here in the United Kingdom. Showcasing diverse perspectives and creative responses to the environment from all over the world, and indeed inviting contributions from students and families representing the breadth of global diaspora, would help enrich students' understandings of different ways of knowing beyond Western traditions.

Final words

Working with the Mapuche loom has been both a personal and political act. On a personal level, it allowed me to reconnect with forms of knowledge rooted in the body and in my memory, a knowledge I first encountered as a child learning to knit and later to weave. The process reminded me how learning can emerge though making. At the same time, engaging with Mapuche weaving is inherently political. Choosing to centre Indigenous knowledge challenges dominant, Eurocentric narratives that continue to shape environmental education and obscure other ways of understanding the relationship between human beings and nature. The finished piece serves as a reminder that environmental care has long been practiced through ancestral systems of knowledge, with a focus on balance and responsibility toward the land.

As an educator, this experience has reinforced my commitment to creating learning spaces that acknowledge and give voice to silenced perspectives. Integrating practices such as weaving into education is not only a pedagogical choice, but an ethical one. This is a way of inviting students to question inherited assumptions and to imagine more just and sustainable ways of inhabiting the world.

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Conclusion

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Re(crafting) the Maker Movement

The Maker Movement is widely understood to have evolved, at least in part, from Papert's constructionism, which positioned the most powerful learning experiences as those involving the active construction of public artefacts that act as objects-to-think-with (Papert, 1980). While Papert himself emphasised the importance of process, arguably valuing it as much as the final product, it could be argued that contemporary interpretations of the Maker Movement have been shaped by more neoliberal framings of his work. In such interpretations, greater emphasis is often placed on the production of tangible outputs, particularly those that might be marketable or aligned with entrepreneurial goals (Chachra, 2015). As discussed in the Introduction, this has contributed to the marginalisation of forms of making that prioritise care, repair and maintenance (Jain, 2016).

In organising this book around a collection of objects, following in the footsteps of Turkle (2007) we acknowledge that we too risk foregrounding product over process. However, the essays brought together in this volume collectively resist such a reading. They demonstrate not only the central role that the process of making plays in the development of thinking, reflection and understanding, but also that the products of making can take diverse forms, moving beyond marketable artefacts to include those that foreground repair, re-use and environmental responsibility. But the selected objects also do something more: they share the stories and experiences of their makers, and in so doing reflect important societal messages, be they from within an individual school, across a community, or bridging international contexts.

In this sense, we propose a re-envisaged view of making, what we might call *(re) crafting.* This is not simply a return to earlier forms of practice, nor a rejection of contemporary tools and technologies, but a reorientation of values. It is an approach that places repair, reuse, recycling and repurposing at its core, while also recognising and valuing the wide range of cultural, social and material practices through which making is enacted. Crucially, it positions process, rather than product, as central to the educational value of making.

We offer the following principles as a way of articulating this perspective:

Repair, reuse, recycle, repurpose – centring practices of care and maintenance, and working creatively with existing materials

Relationality – understanding making as embedded in relationships between people, materials and more-than-human worlds

Respect and revaluing – recognising diverse cultural traditions of making and challenging hierarchies that marginalise them

Reflexivity – critically engaging with the social and environmental dimensions of making

We hope this volume leaves you inspired: by the diversity of STEM-related objects and the tangible passions of their makers; by the values that shape their creation; and by the possibilities these suggest for a more socially and environmentally just maker culture. In (re)crafting our understanding of making, we offer not just objects to think with, but processes that invite us to imagine a more just future.

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Credits

Cover image:
Alex Hadwen-Bennett
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The cover image for this volume was created through a process of digital making that mirrors the ethos of the chapters found throughout the book. Close-up photographs were taken of each individual creation featured in the book, capturing textures, materials, and traces of making. These images were then assembled into a digital patchwork, bringing together diverse practices, materials, and stories into a single composite image.

This patchwork was overlaid onto an image of the globe, situating these creations within an environmental context and emphasising the global dimensions of the socio-ecological issues explored in the book. Additional vintage paper textures were incorporated into the design to evoke a sense of tactility, echoing the handmade qualities of many of the objects themselves. The resulting image operates not simply as a representation, but as an (eco)vocative object in its own right.

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Further information:

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