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Biodiversity Logbooks: Design for noticing nature at a hyperlocal scale

ABSTRACT

This article considers the pedagogical importance of noticing nature at the hyperlocal scale, and the role that design can play in nurturing and supporting these processes. Biodiversity Logbooks are a set of educational resources that promote direct engagement with everyday environments through a variety of creative methods, including cyanotype photography, physical computing, collaborative mapping and journaling. These tools are intended to be used in combination to develop skills of noticing plants in their habitats and understanding how different environments support different life forms. This article argues that while complex environmental phenomena are often addressed at the global scale (with local impacts presented as scalable outcomes), focusing on small, often overlooked details can have beneficial pedagogical outcomes. These consist of increased attentiveness and care for the needs of other species, better retention of knowledge generated through embodied experience and stronger connection with place. In the article, the impacts of the project as described by the teachers who participated in the experience are discussed in connection to broader epistemological issues. These include plant blindness as a widespread phenomenon in urban populations, and the importance of observing messy entanglements and non-scalable dynamics when building knowledge about the environment.

KEYWORDS

Research through Design
plant blindness
education
environmental care
green spaces
children
toolkit

INTRODUCTION

Consider these two common urban environments: a spacious park with large well-managed playing fields and a roadside patch of overgrown brambles and nettles. Both of these types of green spaces are common in most cities around the world, but while the latter is often seen as a sign of poor management and source of danger, the former is framed as a service to the community: a desirable place to spend time in and to live near.

In the past 15 years, urban management practices have focused on the delivery of 'ecosystem services', i.e. natural ecosystems that are delivered as services and infrastructures for the benefit of human well-being (Sadler et al. 2018). This is unsurprising, as cities are fundamentally designed to serve human needs. However, such anthropocentric framing of the environment runs the risk of overlooking the pockets of biodiversity that are hidden within the city. Furthermore, contemporary city management practices carry with them the legacy of modernist and capitalist needs for efficiency and standardization that are reflected in computational logics of decision-making which tend to overlook and erase messy entanglements (including multispecies interactions) that cannot be captured with data-driven models (Mattern 2021).

Patches of unruly vegetation like the one in the example may provide an essential habitat for plants, fungi and insects that may not thrive in overly managed green spaces, with their neatly cut grass, heavy foot traffic and weeds that are managed through extractions or pesticides. Places like these may not serve direct benefits to humans but harbour interactions that are essential for the overall health of the environment (Memmott et al. 2007).

The research project presented in this article is part of a wider programme exploring the role of art and design practices in shifting our relationship to nature in cities, particularly through the development of methods and tools that support noticing and engagement with the entanglements and complexities of nature (Edwards et al. 2021).

This study in particular focuses on pedagogical tools for engaging with green urban areas at the hyperlocal scale, with the purpose of noticing plants in their habitats and understanding how different environments support different life forms.

INDUSTRIALIZATION AND THE RISE OF PLANT AWARENESS DISPARITY

The Industrial Revolution started a transformation in the way humans live and work that has come to shape assumptions about all aspects of life, from the kinds of settlements we build to the ways we work and the values we hold. The current horizon, or set of assumptions that underpin western life, is dominated by rationalization (Feenberg 2010), in which efficient systems are the goal. Efficient systems require scalability (the capacity to scale smoothly and exactly without transformation of elements), and that necessitates standardization (Tsing 2015). However, as Tsing points out, this excludes things that do not fit the standard form and ignores things that are not valued within capitalist ideas of progress. She writes that the 'anthrop' part of Anthropocene 'blocks attention to patchy landscapes, multiple temporalities and shifting assemblages of humans and non humans: the very stuff of collaborative survival' (Tsing 2015: 20).

The sense of non-human things not being 'seen' is being borne in writings about plant blindness (Wandersee and Schussler 1999), otherwise known

as plant awareness disparity (PAD) (Parsley 2020), which is characterized by a tendency to overlook plants and underestimate their value in relation to animals. Plants are dismissed as a homogenous green backdrop whose individual needs are not known or taken into consideration, and this occurs in part because of people's inability to notice and differentiate plants from one another.

This matters because it affects the way plants are valued and their needs understood, which in turn affects policies, for example management approaches of wild plants in local urban environments or the ability to achieve global environmental targets such as UN Sustainability goals (Amprazis and Papadopoulou 2020) or COP26 targets. Countering PAD has the potential for transforming human relationships with our non-human environment at a range of scales.

Although physiological factors contribute to humans privileging animals over plants (Balas and Momsen 2014), social and cultural considerations also substantially reinforce the trivialization of plants, particularly in media and education. Within education, botany courses have declined or have been subsumed into more general courses (Pettit et al. 2014) and zoology dominates in biology books and resources, so 'plant neglect is widespread in biology curricula of all levels' (Hershey 2002: 5). The situation is self-perpetuating because it means fewer teachers have been trained in botany (Hershey 2002). Even amongst well-informed biologists, many tend to underemphasize plants in foundation biology (Wandersee and Schussler 1999). The full range of proposed causes of PAD is beyond the scope of this article but other relevant causes include lack of experience in growing and observing plants (Wandersee and Schussler 1999).

PAD AND THE IMPACT OF SCALABILITY ON CURRICULA

Returning to the initial premise of the pervasive influence of rationalization, the effects of standardization have an impact on education. The National Curriculum for England was created to ensure that all citizens were educated to consistent specifications, and though it is intended as a baseline from which teachers can build, it has become a standardized body of prescribed knowledge and skills that dominate schools education, squeezing out alternate ways of knowing and forms of knowledge that are hard to incorporate in the curriculum structure. These losses are a cost of standardization.

The curriculum does encourage children's engagement with the natural environment as a relevant learning activity, but in practice most of the teaching and learning about plants and their habitats relies heavily on worksheets and diagrams that infer a reductive view of the environment when removed from the context they describe. When used in isolation, they also promote a specific positivist epistemology based on naming, defining and dividing into categories and dismiss any other form of knowing that do not fit within the provided framework. Teachers are increasingly forced to narrow down the scope of the curriculum to maximize the school's scores in statutory tests (Bradbury 2019; Scoppio 2002). This is to the detriment of explorative, field-based, experiential modes of learning.

Many authors have proposed education interventions within education to counter the effects of PAD, most prominently experiential outdoor education (Balding and Williams 2016; Fančovičová and Prokop 2011), place-based education (Amprazis and Papadopoulou 2020) and activities directly involving

plants, such as caring for plants or drawing (Balding and Williams 2016; Krosnick et al. 2018). But this education of plant life may require a new educational framework (Amprazis and Papadopoulou 2020) which is supported by a pedagogical approach that is compatible with these alternate forms of teaching and learning. This is the context in which this work is situated.

RELATED WORK IN DESIGN AND EDUCATION

Various approaches have been used within different stages of education to address PAD, many involving active and situated learning, such as a Swiss programme called 'Nature on the Way to School' in which students were presented with condensed brochures of selected plants and animals with suggestions for observational activities, poems, riddles and suggestions for action. Children were asked to place a picture frame around a plant or (slow-moving) animal that they valued on their route to school and tell passing adults and children about it. This resulted in increased ability among the children to perceive and identify plants and animals.

Several projects have been designed for older children or university undergraduates. These include a project challenge to acquire knowledge to identify and care for an unknown plant from seed (Krosnick et al. 2018), a project to incorporate student's own smartphone photographs of plants in teaching materials (Harper et al. 2015), a project to make an online, georeferenced campus flora database from student fieldwork activities on campus (Struwe et al. 2014), a project to create an app based on exploring campus flora (Pettit et al. 2014) and a project to make plant-focused supermarket trips (Smith 1999). Schools have delivered an outdoor education programme focused on plants (Fančovičová and Prokop 2011).

In terms of digital design, Bio Sketchbook, an 'AI-assisted sketching partner' has been designed for 5- to 8-year-olds, to assist children drawing from observation (Zhang et al. 2021). It transforms children's plant photos into contour drawings on a screen and guides children to add features. It also provides additional information about the plant. The aim is to reduce the difficulty of morphology and perspective by supplying a structure that builds confidence and encourages children to draw what they see, rather than something imagined or remembered. Children found the tool engaging and were able to identify the plants and answer questions about their characteristics, though one child said, 'the plant in Bio Sketchbook did not match what she observed' (Zhang et al. 2021: 469), possibly because of different growth stages, and so the authors have planned to extend the database to include these differences.

These projects all demonstrate the pedagogical value of engaging children in direct experience and observation of place, even when these observations are partly mediated by technology. They show the key difference between noticing and identifying plants, with the skills of noticing being not only foundational for the identification but also instrumental to generate knowledge that goes beyond the key elements that are needed in order to identify a plant.

BIODIVERSITY LOGBOOKS

The idea of designing pedagogical tools for noticing plants in everyday environments took form in 2020, at the beginning of the COVID-19 pandemic, when primary schools in England were closed to most pupils and people were advised to stay home. Over the summer and early autumn, when lockdown restrictions were temporarily lifted, two things became clear: the impact of

school closure on students' confidence and self-esteem (especially for vulnerable children) and the importance of focusing on outdoor activities, which were proven to involve a lower risk of virus transmission.

Both of these reasons led to the development of a project grounded in pedagogies of environmental care, inspired by the works of Goralnik et al. (2012), Krzywoszynska (2016) and others, and part of our broader programme of research on nature visualisation and interpretation through the design of tools, languages and experiences (Edwards et al. 2021). Contemporary pedagogies of environmental care focus on direct experience of nature and creative place-based interventions that enable children to experiment with different ways of knowing and expressing themselves. Art and design can play a positive role in such approaches, because they share a focus on creative methods and embodied explorations as ways to construct knowledge.

The Biodiversity Logbooks were designed in collaboration with teachers at Ryelands Primary School in Lancaster, United Kingdom. As a learning resource, the logbooks themselves are not designed as a stand-alone kit but are intended to be used as part of a programme of educational activities that fit in an interdisciplinary way within the National Curriculum for England and Wales.

The project was originally piloted with 44 children, aged 7 and 8 years, at Ryelands Primary School in Lancaster and was later refined and adapted for 36 students aged 10 and 11 years at St Luke's Primary School in Slyne-with-Hest, Lancaster. Because of COVID-19 restriction, the indoor sessions at Ryelands Primary School in Lancaster were delivered online to students and teachers who attended from their classroom. All activities took place in person at St Luke's Primary School in Slyne-with-Hest.

The Biodiversity Logbook activities are run over four to six weekly sessions that follow a progression of learning. The first session is an introductory workshop, in which students are sent out to explore the outdoor school grounds and find a plant that they wish to observe. Back in the classroom, students are asked to describe and draw their plant, paying attention to its details, its habitat and interesting things that they noticed (Figure 1). The purpose of this activity is to introduce the students to the idea of using modes of artistic expression as a way of looking closely and studying plants. One important goal of this activity is to prevent children from feeling the pressure to produce a nice-looking drawing and resorting to mental models of what a plant 'should' look like. Instead, students are asked to draw their plant as if they were explaining its structure to somebody who might not have seen such a plant before. Through these activities, students learn to pay attention to a variety of plant features and discover that, for example, some plants have complex leaf arrangements, hairs or tiny bugs hiding inside their flowers. The whole class is then involved in an activity of mapping the plants and the different habitats and environments that are found on the school ground.

In the second session, students are introduced to key terms and concepts that will support them in talking about plant structures and features when out in the field. During the session, diagrammatic illustrations are used to describe different parts of the plant, leaf arrangement patterns and leaf structures. Students then work with a set of printed photographs and drawings and try to match them to the corresponding diagram. This activity helps reinforcing the knowledge acquired through the diagrams and also introduces the students to the complexity of trying to match actual plants to their diagrammatic representation, and the need to look closely at details in order to do so.

The third session is a guided activity in which students use programmable microcomputers (Micro:bits) to build and program compasses and sensors to capture light and soil humidity data. These sensors are then used as part of the Biodiversity Logbook kit, which is distributed to all students in the fourth session. The Biodiversity Logbook kit (Figure 2) includes a logbook with study sheets for habitats, plant and leaves, photosensitive paper to produce cyanotype impressions and transparent acrylic to keep the sample in place while exposing it to sunlight.

Students explore two different locations during their fieldwork with the logbooks. These locations are chosen to demonstrate how different plants thrive in different habitats and environmental conditions. Students at Ryelands School in Lancaster visited a section of a large park and an unmanaged patch of land squeezed between a busy road and the railway tracks. The students in St Luke's School in Slyne-with-Hest were taken to the edge of farm fields and along a shaded path leading from the village to the canal. At the start of the fieldwork, students are invited to stand still in each location, and notice how the environment 'feels', using their own senses. They are then encouraged to note their impressions in the logbooks, using keywords or longer descriptions. Children continue their fieldwork by responding to open questions in the habitat study sheets. These questions are designed to prompt them to describe the environment with their own words. These first activities are designed with the purpose of preventing children from immediately using their sensors to 'measure' the environment, without first pausing to use their own senses to pay attention to the place where they are situated.

It is only after an initial phase of embodied exploration that students move on to use their compasses and sensors to augment their descriptions with

Figure 1: Students studying and drawing their plant (left) and a map of the plants found on the school ground (right).

quantitative data on light and soil humidity as well as further information on wind and shade directions. At the end of this phase, students are encouraged to compare what they perceived with their own senses with the quantitative data captured with the sensor. This is useful to highlight surprising results (when perceptions and reading from sensors do not match) and also to discuss the types of data that each method can capture – and, by consequence, what is left out.

At this point, students are asked to choose one of the two areas, and pick one of the plants that they find there. Before returning to the classroom, students are asked to pin the location of their plant on a large map (Figure 3). As they do so, they are also encouraged to map light, humidity and aspect data, as well as general observations about the environmental conditions they encountered. This is done to support a discussion on different habitats, microclimates, land use and seasons. For example, in Ryelands in Lancaster, students noticed that tall, woody plants and grasses are prevalent in the open fields of the park, while smaller, fragile plants (such as chickweed and pinks) thrived in the roadside land, which is protected from wind and foot traffic by brambles and nettle.

Back in school, students produce cyanotypes of their plants using the photosensitive paper included in the kit. Cyanotype is a photographic printing technique that involves positioning samples on paper that is coated with a photosensitive solution (ferric ammonium citrate and potassium ferricyanide). The exposed paper turns blue with sunlight, leaving a white impression of the sample. As a tool for slow visualization, making a cyanotype requires time and care spent arranging the sample on the paper to produce a legible print. Students sit outside waiting for their cyanotype to develop while looking closely at details of their sample to fill the plant and leaf study sheets in their logbook (Figure 4).

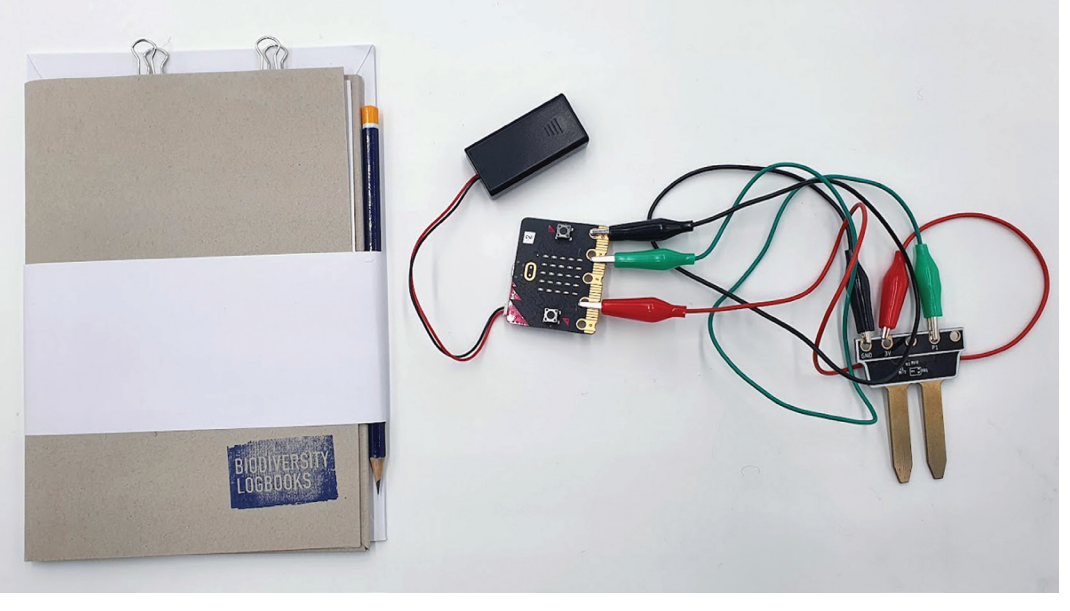

Figure 2: The Biodiversity Logbook kit, including the Micro:bit soil humidity sensor.

We were able to return to Ryelands school in Lancaster for more sessions several months after the original set of activities. We repeated the fieldwork and observed how places had changed over the seasons. We then used the cyanotypes to identify similarities and differences between different plants,

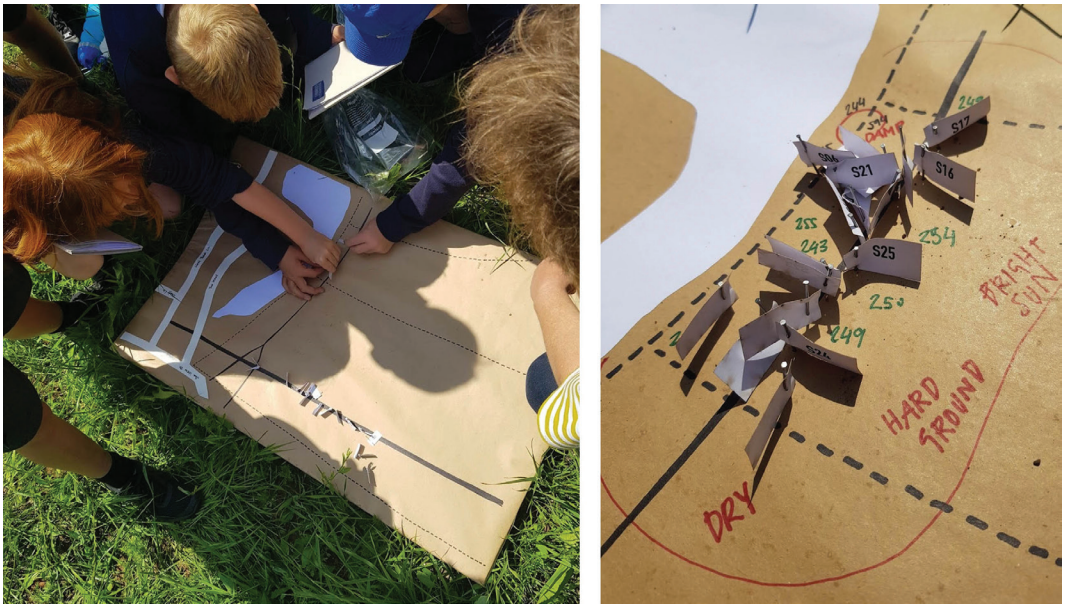

Figure 3: Students mapping data recorded with the sensors and observations on plants habitats.

Figure 4: Students studying their plants while waiting for the cyanotypes to develop.

comparing prints and commenting on how plants from the same species leave very dissimilar impressions according to their stage of growth.

Finally, we returned to the park for a collective exercise of mapping the biodiversity of a transect across a piece of land. Working in small groups, students placed quadrats (50 cm × 50 cm wooden frames) on the ground and counted the number of species that they could find. We compared the results from twelve individual quadrats, to identify the areas with more diversity and those in which just two or three species could be found. This was an opportunity to talk about human and non-human use of the spaces and how they might affect plant life. For example, if there was a path through the quadrat and how that might affect plants: Would the ground be too compacted for them to grow? Would plants growing be crushed? Or would the shorter grass give more light allowing more plants to grow? This final activity sparked a discussion that touched upon several of the themes introduced in the initial sections of this article, including the impact of interventions focused on human well-being on local biodiversity, the importance of multispecies entanglements and the way in which slowing down and noticing small-scale details that we usually overlook may contribute to nurturing care for everyday environments.

DISCUSSION

Revealing assemblages and relationships

Biodiversity Logbooks employ tools that help people notice local environments at different temporal and physical scales to tune into the differences between patches of land, the kinds of plants found there, the microclimate and the effects of human land use and management. Although attention is drawn to individual plants, the focus on interrelationships and interactions is the key. 'Why do the plants in this area have tall, woody stems?' Why do the number of different plant species differ between the football field, the park margins and the woody scrubland?' Study of plants in classrooms can focus on typical features of plants isolated from their habitat but in the field, the wider context and interrelationships between humans and non-humans are brought to the fore. Diurnal and seasonal time are made present. This helps increase awareness of the system of interdependencies and interwoven assemblages that make a place.

Tsing argues that humans have come to expect standardization and scalability as part of progress, but that this has caused the polyphony of non-human rhythms and temporalities to be hidden or excluded. By honing noticing skills, we can tune into these rhythms and counter the effects of standardization, brought about by scalability. The Biodiversity Logbook fieldwork gives space for children to explore habitats. Children can see for themselves that plants are physically different, not a green, indistinguishable mass; the delicate plants shielded from full sunlight and strong winds by thin trees, shrubs and railway fencing; hardy and the woody plants growing tight to tree stumps or on unmown slopes, exposed to sun and wind but safe from grasscutters. Children can see that plants have different needs that suit them to particular environments, and if the conditions change or their growing partners are lost, they may not survive.

Scale

What is lost through standardization may go unnoticed because of the cultural tuning which focuses on efficiencies gained, but Tsing argues that it has

affected our ability to notice the relationality, precarity and interdependencies between human and non-human lives. Progress pulls everything into a single conforming rhythm which drowns out the polyphony of multispecies temporalities (Tsing 2015). Tools that reinvigorate the art of noticing can draw attention to entangled lives and the creations of human, non-human assemblages (Tsing 2015). These tools for slowing down and speeding up, or focusing in, or gaining broader perspectives can help us notice not only individual rhythms but also of relationships and dependencies that may be hard to see from a uniform perspective.

The critique of scaling is not only that things may be lost or go unnoticed. Scalability is the exact replication of an original, which means there is no allowance for change. There is no opportunity for transformation, sparked by serendipitous encounters, or the infiltration of contextual particularity; there is no 'contamination' of the archetypal model. Tsing contends that this is problematic because precarity and indeterminacy, which are inherent in non-scalable assemblages, are crucial in providing conditions for emergent transformations and interactions between species (Tsing 2015). Using noticing skills to follow paths of assemblages helps draw attention to dependencies, relations and the resulting 'contaminated diversity'.

Timescales

Extending the timescale of the project by repeating the activities across seasons makes the changes and relationships more apparent. In autumn, we could not re-enter a scrubby copse we had explored the previous winter because the understorey and brambles had grown so dense but observing that from the street was still useful for pointing out seasonal changes. Revisiting was intended to habituate outdoor activity in local areas to build a sense of connection to place as described in Newman and Dale (2013), Dunn et al. (2006) and Pyle (2003).

Biodiversity Logbook, as a whole, is designed to intervene in temporal scales to aid noticing. It uses designed tools to intentionally slow children down in a space they might usually race past on the way to school, creating pauses to stop and really look at a plant and its habitat, whether that be staying still to notice felt experiences or stopping to use tools to measure features of microclimate. The questions in the logbook aim to prompt reflection and noticing. 'Does this place feel shady or is it a suntrap?' 'Where is the sun now?' What is the ground like here?' 'What features does this plant have … and why?' Slowing down enables closer looking, but it also enables one to give full attention to the landscape, which for Tuan (1977) is part of the place-making process. In fact, Tuan calls places pauses. Individual encounters with these places are unlikely to change one's relationship to the place (though that is possible with particularly memorable encounters), but that aim of Biodiversity Logbooks is to seed an ongoing relationship with one's 'local patch' around the school, through which the place may come to be valued over time, as it becomes associated with prior feelings and experiences (Tuan 1977).

A report on children's access to nature found that in 2009, in the United Kingdom, fewer than a quarter of children were regularly using their 'local patch of nature', compared to half of adults when they were children (Moss 2012). Biodiversity Logbooks are only one part of a cumulative process for re-establishing or igniting a connection.

In terms of the tools, some were intended to create a change in temporal scales to prompt noticing. For example, the cyanotypes enforced a slow process in which the image of the plant emerged gradually in sunlight. The children waited and watched excitedly as the image transformed, in a process they experienced as magical. The fact that the process was quicker in summer and much slower in winter reinforced the children's awareness of the angle of the sun and the changing seasonal experience of the sun for plants. In addition, the cyanotype itself became a tool for noticing. The process creates a white silhouette against a blue background, making it easy to use as a tool to see leaf attachments to stems and leaf patterns (Figure 5). One of the differences between this and simplified illustration in a handout is that the image is created from a real plant and the idiosyncrasies that exist between real plants of the same species are made obvious. When the group's cyanotypes are put together, plants of the same species, growing in different microclimates, a short distance away from each other show some of the variations that occur at the different life stages of a plant. In the first iteration of the workshop at Ryelands school in Lancaster we used the cyanotypes to reinforce noticing differences and distinct plant features, such as leaves that grew from the base of the plant compared to leaves that grew from the stem. In the second iteration the children looked for similarities between their cyanotypes and others and created groupings of prints that were used to talk about the similarities between plant families. We introduced just a handful of families that we were likely to see at the fieldwork sites, but though the activities helped children to notice some of the features that would be in plant keys, we did not attempt to identify individual plants beyond family because it can be disheartening. We brought in shop-bought herbs and vegetables with leaves, to show the similarities with the wild plants found during fieldwork.

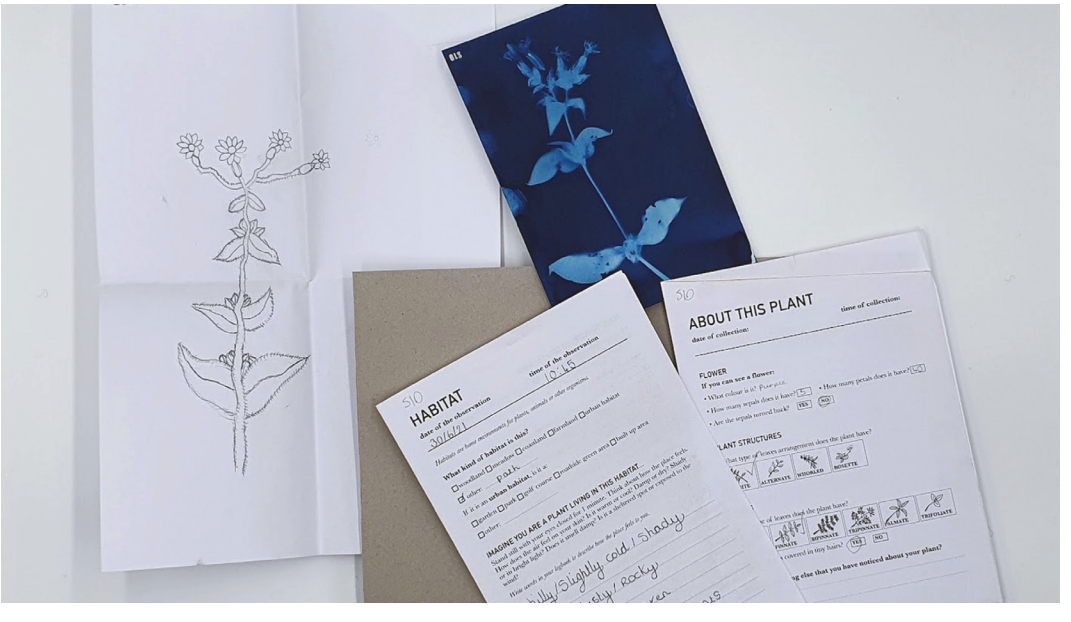

Figure 5: One of the students' logbooks completed with habitat and plant study sheets, an analytical drawing of the plant and a cyanotype.

Ingold (2018), drawing on Dewey, advocates the value of an education system shaped by the 'habit principle' in which education 'produces beginnings' rather than being channelled by ends. This comes through a way of being that is attentional, relational and responsive to others and the world around. Ingold envisaged it as going on a journey, with teachers and all forms of others, continually co-responding (*sic*) with one another and following a path that emerges as the journey is undertaken. It is through the ongoing correspondence that individuals are transformed from within, and it requires openness and a willingness to surrender control to fully engage with the world (Ingold 2018). This resonates with Tsing's emphasis on the value of precarity and uncertainty, being open to encounters that 'contaminate' and cause transformation. Within the National Curriculum as it stands, this can be difficult because learning outcomes are prescribed, limiting the openness to follow paths of interest and opportunity.

Biodiversity Logbooks create a loose structure that can be adapted and transformed to suit different needs, interests as well as particularities of place. The activities are open, with opportunities to ask questions that can be pursued beyond the project. Although we created a set of tools and activities for noticing, the fieldwork makes the outcomes less predictable because of the variability of weather and terrain, serendipitous encounters and the interests of children and teachers in the group. So, although these activities have been designed to be reused elsewhere, those delivering the sessions can make diversions to incorporate interests and follow additional paths of exploration.

Following the first set of Biodiversity Logbook activities the teachers and children in one school undertook related activities independently, including making bug hotels to encourage pollinators, creating and tending veg beds and caring for class 'pet plants'. Some of these were initiated by teachers while children took charge of others. We were invited by teachers to return to the class so that the children could tell us about these new activities. The children expressed pride in their achievements for the environment and for the knowledge and skills they had gained.

Though these outcomes suggest a degree of correspondence and openness to change, it would be disingenuous to present Biodiversity Logbooks as an example of Ingold's vision. Although the activities can be adapted and run in different ways, when we delivered them we had intentions for individual activities and an intended progression, linked to National Curriculum learning outcomes. There was a degree of space to be co-responsive within the workshops, but overall they were envisioned as a way of introducing skills and knowledge through which children might find new beginnings in an ongoing relationship or co-respondence (Ingold 2018) with their locale. Teachers and children in one of the schools embraced the opportunity to kick-start new activities but the mode of teaching requires time, a supportive school culture and teacher confidence. We planned and reflected on Biodiversity Logbooks with a head teacher who said that the quality of teaching could be influenced by the confidence of the teacher and their surety in giving space and time to unpredictable and less tangible elements, like sitting outside on the ground and just feeling the elements and responding to the affective experience of the place. In a way this speaks to the capacity of teachers to notice and co-respond and to value this mode of learning. It also indicates that teachers who are more confident in these domains, through their own experiences, may find it easier to embrace

the precarity of the context. Hence Biodiversity Logbooks were intended to build confidence in botany, which is not a specialism amongst many primary school teachers.

Specialist ecologists were intentionally not involved in delivery of the activities, though they did advise in the development phase of the project. This was to ensure that the activities were not perceived as something special that children and teachers could not do for themselves in their home areas. We hoped children would continue these activities out of school and to that end we included additional cyanotype paper and logbook materials in the packs. As indicated above, we also hoped this would give teachers confidence to engage in fieldwork with plants, knowing that it is okay not to know everything and to learn with the children. And the more fieldwork in local spaces becomes part of the everyday curriculum, the more connections children will feel with these places.

Education, ethic of care and 'togethering'

Indeterminacy, reciprocity, transformation and vulnerability are recurring themes both in writing about nature connection and education. Ingold (2018) critiques the idea of education through knowledge transmission and argues the case for attention in different forms, such as active listening. His ideas about attention incorporate care and have parallels in the 'ethic of care' (Noddings 2015; Krzywoszynska 2016). In both, is the idea that to give care, one must give full attention (active noticing) in order to respond to the needs of the other, and one must have the capacity (skill) to respond (reciprocity). Ingold put forward the lovely distinction to explain the attitude that characterized awareness under 'the principle of habit', distinguishing between 'awareness of' and 'awareness with'. 'Where "of-ness" makes the other, to which one attends its object, and ticks it off, "with-ness" saves the other from objectification by bringing it alongside as a companion or accomplice. It turns othering into togethering' (Ingold 2018: 19–20). In this we can see that although the activities that are done matter, the way they are done also matter. Hence the need to design and deliver in a way that supports 'with-ness' and 'togethering'.

It has been suggested that a different educational framework may be needed to reshape human relationships with the plant world and address PAD, and Ingold reinforces the consequence of this ontological shift. At the current time, in the areas in which we work, educators, researchers and others are coming together to develop the Morecambe Bay Curriculum that seeks to restructure both content and pedagogy. The lens that informs this is ecologically, community and sustainability-focused. Though it does not sit outside the National Curriculum, it aims to enrich and extend to change children's relationships to the place in which they live and the wider world. A range of pedagogical approaches feed into the curriculum but the principles of inquiry-led outdoor education, where children take on an active role in shaping and leading their studies, are amongst the guiding principles. Biodiversity Logbooks were shaped with educators involved in developing the Morecambe Bay Curriculum and its approach and their reflections have fed into interactions of the tools and activities. The Department for Education has made plans for school grounds to become a more important place for biodiversity education by 2023 (Department for Education and Zahawi 2021). Biodiversity Logbooks could contribute to the way this is achieved.

Global environmental issues

The project is intended to encourage children to get to know their local habitats and notice plants and habitats to address PAD. But it also has the potential to feed into bigger regional understandings of changing biodiversity. The skills in Biodiversity Logbooks will help children take part in Bioblitz events (counting species through citizen science) and contribute to records such as iNaturalist or County Records. It is hoped that in the future children will be able to make transects between schools and record a bigger picture of biodiversity across the area. This project is a way to make a personal connection when discussing changes to biodiversity globally, indicating that tools for looking at hyperlocal scales are potentially relevant at bigger scales, whilst maintaining the qualities of non-scalability and mutability.

Knowledge and skills

It was reported to us by teachers in one of the schools that children were proud of their specialist knowledge and language, for example the ability to identify the difference between Basal Rosette and Cauline Alternate leaf attachments. The children enjoyed the feeling of knowing more than adults and being able to teach them and share that knowledge with them. Through Biodiversity Logbooks, we also sought to introduce skills that included the elements that might be part of the real work of naturalists, ecologists and other environmental scientists. When we talked to an environmental scientist in the planning phase, they told us that the activities we planned echoed those undertaken at degree level, albeit in a simpler form. In part, our aim was to 'make it real', so that the students would feel a sense of pride in their achievements. It was also a way of modelling real naturalist skills and of the kinds of activities in potential future jobs to children who might be unaware of these possibilities. Chalwa's work (1992) has shown a connection between childhood nature experiences and taking up work as environmentalists in later life. It was also important to demonstrate the transferability of skills and how interdisciplinarity can contribute to knowledge generation about the environment. In the introductory sessions with schools, we showed images from Anna Atkins's cyanotype book of seaweed, the first book of cyanotype photographs, produced in nineteenth century, to show the direct relevance of the skill and also the importance of the skill of laying out plants, ready for exposure – a skill needed by the children themselves to make their own cyanotypes. We also introduced natural history drawings and paintings by John Ruskin (1819–1900), a local man, as well as an internationally recognized botanist and polymath, again to show the connection between the types of creative work that students would be engaged in and the professional value of these skills. In addition to showing these examples of naturalist skills in action, the activities were designed to stimulate children's interest, whether in drawing, photography or computing, as it has been shown in Hecht et al.'s (2019) research about naturalists that long-term interest in nature grew in tandem with the development of other interests and the interest is strengthened by 'interwoven experiences'.

Digital tools

Children are spending less time outside (Wood et al. 2019) and digital technologies are assigned some of the blame for taking time that might otherwise be

spent outside, though this is a simplification of a series of changes to contemporary childhood that compound the situation. In Biodiversity Logbooks, we use digital tools for several reasons. One is to extend the range of skills acquired through the project and highlight the existence of environmental data science and citizen science pathways that use digital skills. Another is to connect children's existing interests in computing with ecological noticing, drawing on Heche et al.'s (2019) research that shows the resilience of environmental connection through interconnected interests described above. The project incorporated different kinds of activities so that there would be something of interest to everyone. The importance of skills and interest as components in the ethic of care has already been established.

Children built their own sensors, partly so they were invested in the whole process for active engagement, and also so they understood how the sensors worked. One of the main factors with regard to noticing was how the Micro:bits were used as a prompt to focus children's attention on their own senses and affective experience of place. The children were asked to feel the soil and gauge warmth and wetness against Micro:bit readings. Disparities in readings were discussed. For example, on one outing in the dry weather, it was hard to get the humidity sensors deep enough into the ground to get a true reading of humidity. The discussion helped to reinforce the value of using one's own senses in combination with other sensing equipment. One of the values of using digital sensors is that it enables to notice things at a resolution that are difficult to gauge accurately with human senses.

Bio Sketchbook (Zhang et al. 2021) also aims to get children to notice plants by revealing patterns. The difference in Biodiversity Logbooks is that we are encouraging children to use their senses to directly interact with the plant, without the screen as an intermediary – to touch and feel the plant and see whether it has furry leaves or shiny water-resistant ones. The children learn to draw in their own style and we discuss the mutations between plants of the same species that makes plant identification challenging. Rather than focus on particular species and identify their features, we use tools to identify general features that can be used to distinguish between different categories of plants. So, in Bio Sketchbook the noticing starts specifically and focuses on the individual plant in isolation, whereas in Biodiversity Logbooks the noticing skills start more generally and incorporate habitat.

Design for noticing

To notice is 'to distinguish the thing from its surrounding' (Mason 2002: 33). Although 'ordinary noticing' (Mason 2002) is part of human existence, intentionally noticing specific things is an effortful endeavour that can be developed through practices that prime one to notice. For example, 'marking' is an in internal process of ascribing connections that help the noticed thing come to mind. 'To mark something is to be able to remark up on it later to others' (Mason 2002: 33). Recording makes noticing explicit in a concrete form that can be revisited, shared or reflected up on later.

The role of design in this work is to create processes (like marking) and tools that sensitize children to notice or prompt different forms of noticing, such as comparative noticing and wondrous noticing. The aim of stimulating different kinds of noticing is to embrace a wider range of ways of knowing and thereby counter the exclusions and limitations that shape the dominant, post-industrial education systems. Wondrous noticing, in particular, is of the

magical, affective and experiential type that can lead to transformative learning (Grocott 2022), as children do not limit their focus to the identification of plants but engage in embodied and open-ended encounters with the natural world. This approach draws on the more expansive and whole being ways of knowing that are integral to traditional and Indigenous knowledge systems (Kimmerer 2013; Martin and Mirraboopa 2003).

Deep wonder describes the experience of 'wondering at', rather than 'wondering about' something. While the latter implies inquisitiveness, the former is 'an emotional response' where we are confronted by the mysteriousness of what we encounter that 'defamiliarises the familiar, making it appear in a new light, as if seen for the first time' (Schinkel 2017: 543). Schinkel's example that is most relevant to Biodiversity Logbooks is that 'you may be persistently aware of the beauty and mysteriousness of the animals, plants and flowers around you, each living their own life parallel to you' (2017: s546). In a state of deep wonder, we appreciate the object of wonder in and of itself, recalling the state of 'dwelling' described by Heidegger (1971).

The Biodiversity Logbooks are a toolkit designed to scaffold the experience of noticing (Sanders 2002). Standing together as a group, we watched the cyanotype images emerge, leaf and stem and flower, becoming bolder through the alchemy of light, paper and composition. There was a sense of wonder as the images revealed themselves and the commonplace plants 'became new' to the children. The opportunity to encounter this sense of wonder was designed. For example, the weight of the bulldog-clipped Perspex held things secure, allowing the pause needed for children to see and feel the wonder of the process, rather than losing the moment, scrabbling after a plant and paper whisked away by the wind. The activity provides space and time for wonder. As Wall Kimmerer reflects on her own fieldwork with students, '[w]e have to unlearn hurrying. This is all about slowness' (2013: 233). Schinkel shows how deep wonder may be the basis for love of the world and so is potentially transformative to education, getting closer to reciprocity that is integral to an ethic of care and the more expansive ways of knowing encompassed in traditional ways of knowing.

The *in-situ* map was designed to sensitize the children to the act of marking what they had been tasked to notice – the affective character of the site where they found their chosen plant. Though the children recorded information about the location in their logbooks, when they made the collective map, they were also asked to recall and share sensory aspects about the microclimate of the habitat and through this make associations that made sense of their plant in that place, which they might recall at a later time. Wall Kimmerer has noted that when her students work with monitoring tools they stop looking. In the Biodiversity Logbooks fieldwork, the tools and process drew attention to sensory noticing.

The information design of the logbooks provided prompts that enabled the act of comparison needed to differentiate plants and use a plant key, for example, it accentuated structural differences in the way leaves join a stem. This approach differs from that of some ID guides like 'ispy' that organize plants by colour in a way that is immediately accessible (at certain times of year) but does not encourage pattern noticing that characterizes the skill of naturalists and botanists. Design tools and strategies have been used to bring children into the practice of noticing plants. Individually the tools help to focus noticing at different scales from the detail of plant morphology to wider aspects of human–plant interrelationships. Collectively, they expand the study of plants

to embrace a wider range of ways of knowing beyond plant identification to include the emotional and affective experiences.

CONCLUSION AND FUTURE WORK

Through the Biodiversity Logbooks project we explored the use of design to nurture skills of noticing nature at the hyperlocal scale (particularly plants). We have done so, inspired by contemporary pedagogies of environmental care, but, and this is a crucial aspect of the project, we did so within the context of conventional primary education. The learning outcomes and lesson plans for all activities were designed to fit in an interdisciplinary way within the UK National Curriculum for primary education, covering a variety of subjects such as science, geography, literacy, art and design. This was particularly important to us, as it allowed to assess the impact of embodied experiences of noticing at the hyperlocal scale through the use of art and design methods in achieving key learning outcomes, thus making the case for the integration of such methods within conventional school curricula.

The feedback received from teachers (and our experience in follow-on visits to schools) demonstrates that the Biodiversity Logbooks not only provided a relevant addition to the school curriculum, but it also resulted in students internalizing and operationalizing the knowledge acquired by using the cyanotypes for describing their plants, teaching key vocabulary to others and being more involved in environmental initiatives in school.

In light of students' interest, one of the schools initiated further activities, which expanded the work on noticing started with the Biodiversity Logbooks.

The project has been presented to the local network of schools involved in developing the Morecambe Bay Curriculum, a comprehensive educational programme aimed at enriching the UK National Curriculum with a place-based programme of interdisciplinary activities of experiential learning that are aimed at fostering stronger connection with the local environment.

There is a clear interest from local primary schools in incorporating the project within their learning activities, but a significant limitation to do so is the overreliance on resources that are created and delivered ad hoc. As the project funding ran out, we are exploring ways of creating a set of resources that can be independently accessed by teachers. This will be a project in itself, which will require the development of a comprehensive set of adaptable resources, including support and training for teachers. Furthermore, given the potential of the approach and the existing portfolio of project of this kind that has been developed at Lancaster University in the past few years (Edwards et al. 2021), a possible strategy would be the development of a platform to host and disseminate projects of design for environmental pedagogies of care, which could be delivered independently or in combination.

Such a platform could include a number of projects focusing on the hyperlocal scale as a gateway to understand complex interrelations and entanglements. The activities conducted with the Biodiversity Logbooks do focus on the hyperlocal scale and have helped children to explore plants as part of their habitats and understand the impact of urban nature decision-making processes on specific plants and local biodiversity.

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