How Can Digital Education Contribute To A Pedagogy For Environmental Care?

Liz Edwards
liz.edwards@lancaster.ac.uk
Lancaster University, Lancaster
UK

Serena Pollastri
s.pollastri@lancaster.ac.uk
ImaginationLancaster
UK

Robert J. Barratt
r.j.barratt@lancaster.ac.uk
Lancaster University, Lancaster
UK

Claire Dean
c.dean3@lancaster.ac.uk
Lancaster University, Lancaster
UK

Figure 1: Digital Boggarts compilation: sensing soil humidity, sensory exploration of the garden, NFC-tagged Digital Boggart Photographs © Andy Darby. The Lost Sounds compilation: birdwatching, programming to make interactive bird prints.

ABSTRACT

In this paper we unpack the theory and application of a pedagogy for environmental care and the place of digital technologies and interaction design within this pedagogy. The paper illustrates its application using exemplar projects, primarily drawn from primary education. We draw attention to the role of digital education in a place-based curriculum and discuss how teaching through local environments can contribute to understanding of global environmental issues and active participation locally and globally.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

Pedagogy, Nature, Education, Digital Naturalist

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1 INTRODUCTION

At the moment an education transformation is underway in Morecambe, North-west England. A nature and place-based education program with sustainability at its core is being co-created within the community, for all levels of education. In terms of schools this encompasses and surpasses the English National Curriculum. The curriculum uses a local lens to connect people to ecological systems to drive participation in environmental action, locally and globally. This endeavor incorporates and extends relevant nature-based pedagogies. Contributions to the curriculum design are being made by educators, researchers, community experts from diverse fields with input from children and young people. In this paper we show how digital technologies can be used within a pedagogy for environmental care, a nature-based pedagogy suited to the aims of this new emerging curriculum.

2 CONTEXT

This section will set out the premise of the pedagogy for environmental care we are developing. It will identify the components and theoretical grounding for the pedagogy and its relevance within primary education.

The anthropogenic hastening of environmental threats leading to the current planetary emergency has been well documented, with climate change, biodiversity loss, and food security amongst

the ongoing challenges. In order to equip people to address these challenges there is an argument that curricula need to evolve.

Though we are increasingly aware of the interconnectedness of human and more than human worlds, many humans live lives that are more disconnected from non-human nature than their predecessors, so the intimacy of day-to-day interactions with non-human nature and the knowledge and emotional connection that brings has diminished [13]. A pedagogy for environmental care responds to this by reestablishing and nurturing human-non-human relationships emotionally, intellectually and experientially.

Evidence supports the possibility of improved outcomes for species populations and habitats when humans prioritize care for the non-human world [8]. This is especially true when addressed in childhood, which is a formative time for seeding connections with nature [3]. The connections made in early years and primary-aged children are especially significant for long-lasting pro-environmental behavior [14]. Although free time is important for exploring and interacting with non-human nature, an appropriate educational approach in school and early years settings has the potential to build and reinforce relationships.

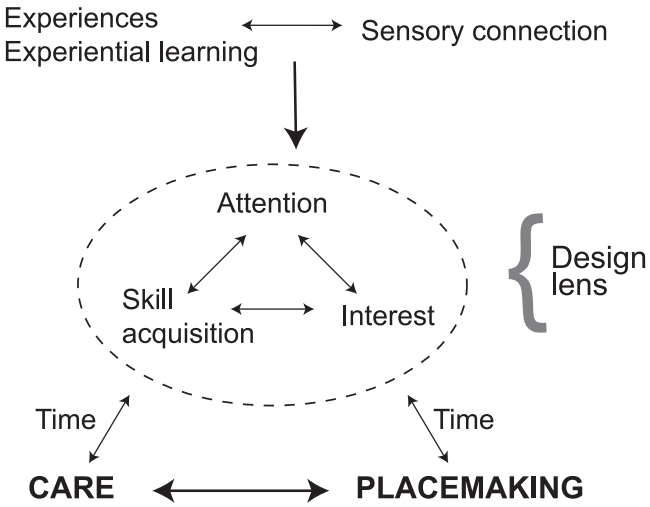

Figure 2: Components in the Pedagogy for Environmental Care that informs the design lens for digital education.

3 THEORETICAL FRAMEWORK

This pedagogy for environmental care we have developed integrates principles from placemaking, experiential learning, nature-based education, interest and skill acquisition, philosophy of technology and ethic of care. Goralnik et al. [6] have presented a similar pedagogy in respect of environmental ethics in Higher Education. The pedagogy we present in this paper draws on some overlapping sources but we have introduced new elements and applied the concepts in primary education.

Care is fundamental to this pedagogy because it underlies the personal engagement required to make meaningful connections that can influence attitudes and behavior. Without care, knowledge, emotion and experience can be detached from one another. "No one will protect what they don't care about; and no one will care about what they have never experienced" (cited in [14]). Care forms a dynamic component in a relationship between attention, interest and skills. Attentiveness is implicit within care because attention is required to "learn about, act on and monitor the satisfaction of the one being cared for" [11]. Hence reciprocity and responsiveness are also pre-requisites of care [16]. Attention is a learned skill, which is honed according to context. Skills and care propel one another because an increased skill-level, for example at tending to plants or animals, enables a greater level of care, and the more care is given the more skills are acquired and the more attuned one becomes to the object of care [5, 11]. Increasing skills can stimulate deeper investment and interest in a subject and the interest drives further skill acquisition [2]. It has been shown that if an interest in the natural world becomes intertwined with other interests the effects can be even more enduring and impactful [9].

So, this leads us to understand that attention, interest, skills and care are core aspects of the pedagogy. Making the connections and relationships needed for meaningful active engagement with environmental concerns introduces other elements to the pedagogy, including experiential learning. We make places for ourselves over time, through the emotions we associate with our experiences in that place [20]. Often our nature connections are made through habitual experiences [15, 17, 18] but they can be triggered through singular transformative events [1]. This involves pauses and reflection in a place [20] or bodily engagement and sensory connection [12]. Time spent in nature and nature knowledge does not necessarily equate to nature connection, but both can nourish connection and later pro-environmental action. Paths have been revealed highlighting the link between children's access to nature and adults' engagement in environmental work [3].

4 RELATED WORK

Digital technologies have been used previously within environmental education [19, 22] but in the examples we describe children create their own digital tools for embodied and experiential learning and reflection. Prior research has been done to draw attention to plants as living, responsive creatures, using anthropomorphism and superimposed voices [10]. Other research has used sensors and apps to increase awareness of plant needs [21]. Our approach aims to enhance children's skills to recognize non-human responses in order to be more sensitive to their local environments and their own environmental impact.

5 DESIGN

In this section we use four examples to show how the pedagogy for environmental care is enacted in project-based learning, using digital education in conjunction with other activities. Two projects have been run as pilots, one has been run in several schools and other settings, and one project is under development. We used a Research Through Design approach, and in addition to delivery team reflections analyzed post activity interviews with staff and on some occasions children.

Project	Digital Technologies	Technology Use	Activities	Data
Digital Boggarts 12 Y5 children x 1.5 days	Micro:bit Sensors (soil humidity, external temperature) Arduino Uno NFC Shield and tags, Wave shield & speaker	Use Micro:bits with sensors to explore microclimates in a large, public garden. Tell stories with data. Create digital interpretation using audio stories, NFC enhanced boggart characters and digitally enhanced flowerpots.	Programming, Circuit making, Garden tour, Garden exploration, Mapping, Story making, Design technology, Performance,	Post-activity interviews with teachers. Reflections amongst delivery team and gardeners.
The Lost Sounds 1 class Y5 x 2 days; 1 class Y4 & 5 x 2.5 days; 1 class Y2 plus 1 class Y5 x 3 days across both groups (inter-class collaboration); 1 class Y3 x 1 day (shortened version)	Shotgun microphone Audio recorder Pi-top laptop Capacitance sensor Conductive ink Bare Conductive Touch Boards Bird call apps (sometimes)	Listen carefully to birdcalls in a local habitat. Make recordings of bird calls and learn some calls using spectrogram. Listen to an edit chosen recordings. Make interactive bird prints that play bird calls. Incorporate interactive prints in a display to be shared with the wider community.	Guided bird walk, Exploring environment, Observing with binoculars, Learning bird calls, Sound recording, Drawing birds, Printmaking with conductive ink, Recognizing spectrograms, Editing sound (sometimes), Circuit making, Programming, Interacting with display	Post-activity interviews with teachers & children in groups. Reflections amongst delivery team
Biodiversity Logbooks 2 classes Y3 x 5 sessions, spread over 5 weeks. Shortest session 1 hr, longest session 1 day	Micro:bit Miro GPS Sensor Raspberry Pi	Make a compass to use when exploring and comparing the aspect and features of different fieldwork sites. Making a collective map for field notes and cyanotypes. Future work: Using GPS to record quadrat surveys and transects.	Drawing plants, Programming, Image matching for plant structure and families, Making sensory connections, Using a compass, Field trip, Habitat exploration, Field notes, Making Cyanotype images, Digital Mapping, GPS data logging TBC	Teachers contribute to scheme of work. Post-activity interviews with teaching staff.
The Fungi Tell the Tales Y5 TBC	Micro:bit, weather API, Inky:bit electronic paper Sensors (soil temperature, soil humidity, CO2) Raspberry Pi	Use technologies to reveal hidden soil world TBC	Pixel art, Programming, Soil science, Story making, Sensing and recording data, Circuit making, Working with networks and systems	Interviews.

Table 1: Overview of example projects

5.1 Digital Boggarts

Digital Boggarts was run as a 1.5-day pilot project with 12 Year 5 students, in partnership with National Trust Gardeners. It aimed to introduce microclimates and gardening to children through experiential activities in a heritage walled garden. Children learned to program Micro:bit compasses and sensors to explore different zones and consider, "Who would live in a place like this?" The exploration was supported by a tour led by gardeners. Boggarts are fantastical spirits of a place. They were used as a vehicle for children to tell stories, incorporating real and fictional elements about garden life. Children designed Boggart creatures with clay and natural materials, incorporating an NFC tag. Children placed their Boggart on digitally enhanced flowerpots to listen to stories that they and others had created and performed in the garden. Hence the children created a form of interpretation drawn from their experience of the place. Gardeners and teaching staff were interviewed after the workshop and the delivery team also recorded reflections which were analyzed in relation to the design criteria.

5.2 The Lost Sounds

This project has been delivered in varying forms to five classes in four primary schools. Adapted versions have been delivered in an Early Years and multiple community settings. The project aimed to increase awareness of birds and their habitats locally by developing observation and listening skills. Children went on guided walks and made digital recordings of birds. Using careful observation, they made conductive ink prints of the birds found in the habitat visited and programmed them to play bird calls. Working with audio files and programming the interactive prints reinforced careful listening. After the workshop the children's prints were pinned to a 2m wide fabric image of the site visited. The prints were connected to Touch Boards that played bird calls in response to changes in capacitance caused when the prints were touched. This display reinforced the relationship between birds and habitat and provided opportunities for those directly involved to share their knowledge with a wider audience.

The Covid pandemic interrupted data collection but we are able to report on initial findings from interviews with educators and

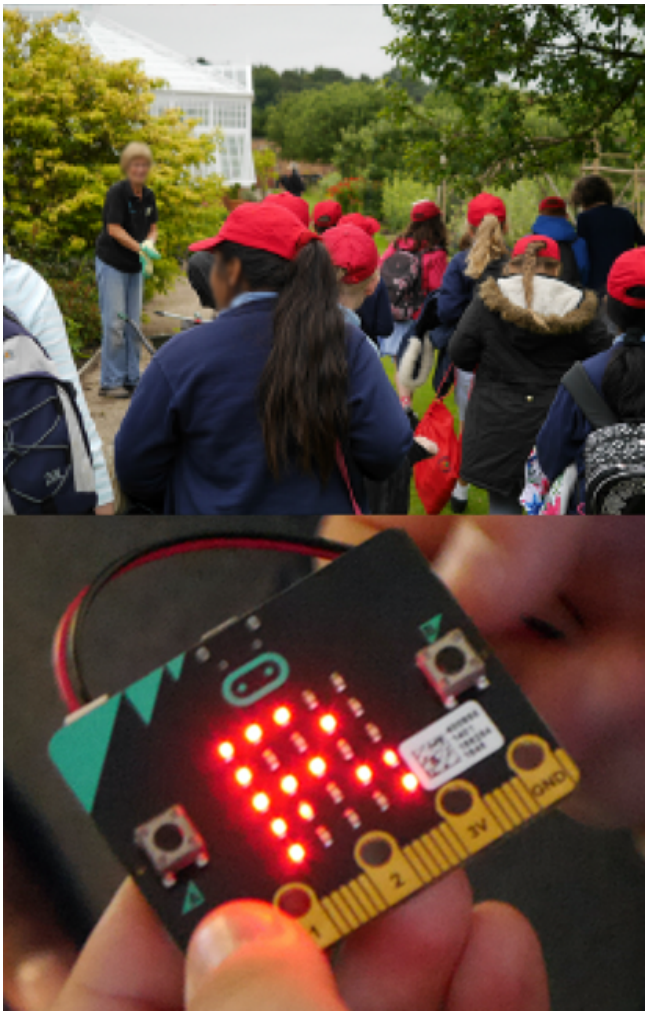

Figure 3: Digital Boggarts activities: garden tour, programming Micro:bit sensors to explore microclimates in the garden. Photographs © Andy Darby.

children. The children reported learning new bird calls and developing new skills, with different activities appealing to each individual. One teacher noted that the technology acted a hook for the outdoor activity. Children and staff reported pride in seeing others interact with their display and being able to share their new knowledge with parents and other children.

5.3 Biodiversity Logbooks

The first phase of this pilot project has been run over four sessions with 44 children in Year 3. The aim was to encourage children to notice plants by introducing the observational skills, language and experiences to recognize plant structures and families, and also to understand the relationship of site on plant types. The teachers interviewed reported the workshop's effectiveness in helping children to notice and the crucial role of noticing in active learning about non-human nature. Making cyanotypes in which images are gradually exposed in sunlight was a magical process which helps isolate and reinforce plant features. The Micro:bit compass played a key part during fieldwork for noticing the differences between north and south-facing aspects.

In the next phase students will build on programming and other skills to conduct plant surveys and record key locations with GSP modules attached to Micro:bits. They will revisit sites through different seasons incrementally adding to computing and other skills.

5.4 The Fungi Tell the Tales

This is a current project under development that draws on a secondary school project called 'The Social Network of Soils' [4] and adapts it for primary age children. The project aims to reveal the hidden and interconnected network of biota that affect soil formation and soil health. This connects to related work about food security.

Stories will be told through characters with names that allude to the behavior of soil creatures such as "pathmakers". The interaction between the characters and the impact of external events, such as rainstorms are revealed through a network of Micro:bits, located in the environment. The Micro:bits are connected to sensors and e-paper screens which display story fragments and pixel images, created by children. Digital technologies form a bridge to non-human worlds.

6 DISCUSSION

The following section discusses the relationship between the example projects and the pedagogy for environmental care. It draws attention to the role of digital education in a place-based curriculum. We will discuss how teaching through local environments can contribute to understanding of global environmental issues and active participation locally and globally.

The example projects outlined above fulfil the criteria of a pedagogy for environmental care, particularly because of how digital education is delivered. Digital elements are used to pull people outside, to slow them down to notice what might otherwise be missed, enhancing their senses and developing their skills. For example, digital recorders were used to create pauses in walks, to listen to bird calls, building identification skills, which were later reinforced through the coding of the interactive bird prints. The Micro:bit compasses prompted exploration of the site to reveal connections between aspect and plant growth. The sensors in the Digital Boggarts project were used to stimulate sensory engagement and draw attention to garden microclimates by connecting felt experience with temperature and humidity data. By blending digital education with a range of other activities we provide multiple hooks to latch onto, to deepen interests and environmental connection. The digital activities are designed to immerse participants in the environment and provide opportunities for reflection and emotional stimulation that seed nature connection, placemaking and ultimately environmental care. These activities have been designed to be repeated at different times over different seasons to encourage habit-forming outdoor interactions. This work aims to give children the skills to be more sensitive to their local environments and their own environmental impact.

We believe this plays a role in local and global environmental education because it makes abstract concepts like biodiversity and threats to habitats concrete and immediate. These projects connect children to the place in which they live [7], making them appropriate for the placed-based experiential education described in the introduction. However, the locally relevant content is also a route to wider global issues such as food security, land use, global agriculture, and the impact of climate change on human and non-human worlds.

7 FUTURE WORK

One of the key challenges of this work is how to make the activities self-sustaining so that there is depth of knowledge and sufficient resource to embed the activities within the curriculum for the area year on year. Addressing progression of activities within and between educational Key Stages is an ongoing area of research. The development of The Fungi Tell the Tales and Biodiversity Logbooks are an immediate focus.

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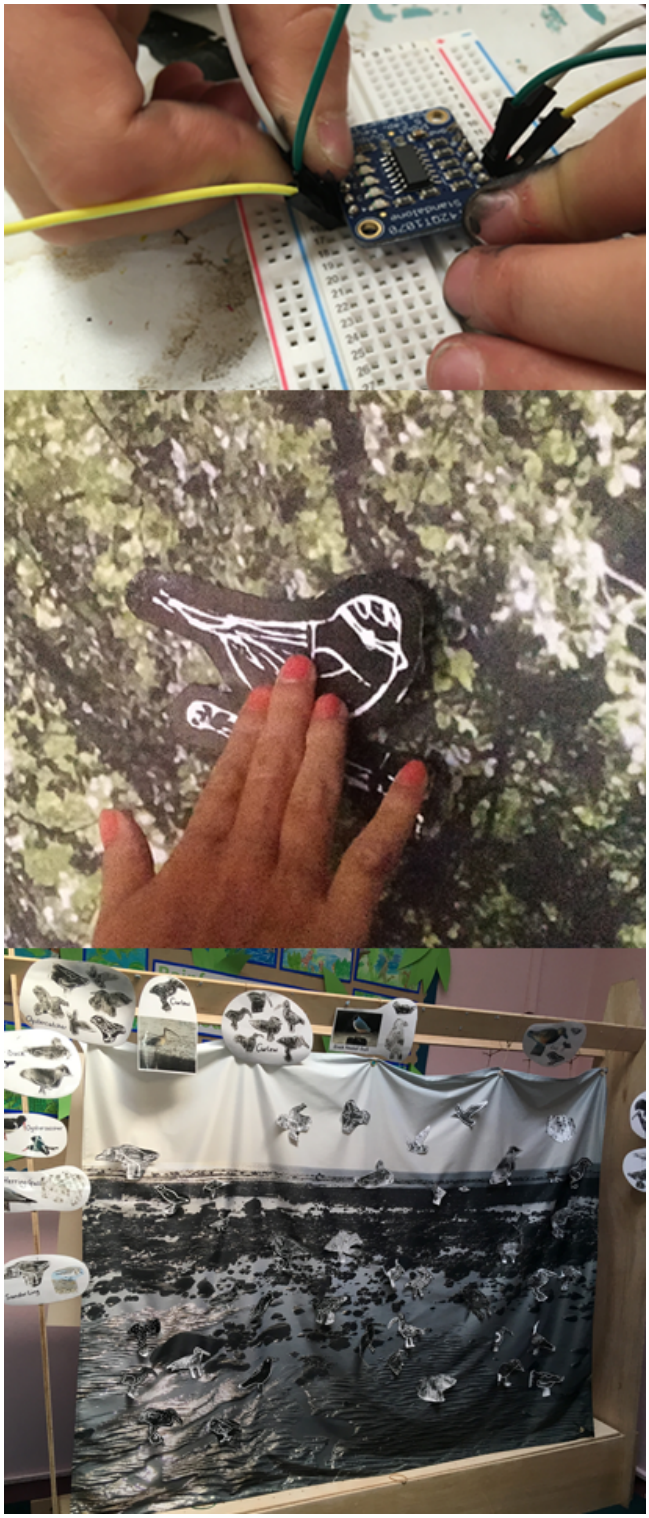

Figure 4: The Lost Sounds activities: wiring a capacitance sensor, close up of a conductive ink bird print, interactive display.

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