Supporting fieldwork for primary education with computing - micro:bit, clip:bit and game controllers

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ABSTRACT

This paper presents the ongoing development of the clip:bit, a clipboard-style micro:bit V2 extension for biodiversity monitoring in schools and community groups. The clip:bit is one component in a wider system to enable schools to engage in longitudinal studies of biodiversity in school grounds and local areas, monitoring the impact of landscape management and children's ecological activities, such as the introduction wildflower meadows or planting hedgerows. The clip:bit was designed in response to needs identified during fieldwork in schools. We describe how the design addresses these needs and point to the way the clip:bit fits into a wider plan for data management and data visualisation. We also discuss the application of an existing micro:bit peripheral, the Kitronik Game Controller, for biodiversity monitoring and compare their use for different cases.

CCS CONCEPTS

• **Applied computing** → Education; Interactive learning environments; Education; Collaborative learning.

KEYWORDS

micro:bit, Biodiversity, Cross-curricular

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1 INTRODUCTION

In 2022 the UK government published a sustainability and climate change strategy for education which pointed to the importance of increasing biodiversity, air quality and access for connecting with nature in and around education settings [1]. It is anticipated that this will not only improve the quality of the environment with implicit health and wellbeing benefits, but also "normalise and inspire young people to live sustainable lives." [1]. The strategy spoke of the need to prepare young people to become agents of change and develop knowledge and skills for jobs in the green economy. Furthermore, the ability to take action is also recognized as a means of ameliorating climate or eco anxiety experienced by young people [2]. Climate anxiety, which characterizes humans' fears and concerns about the consequences of climate change is increasing in young people, but it has been found that educational framings that provide opportunities for action can mitigate against its various negative impacts [3], such as disengagement.

In the north-west of England, the Morecambe Bay Curriculum has been established to address ways to mitigate these issues. This co-created, place-based curriculum aims to enable children to apply their learning practically to create positive social and ecological change in their schools, communities, and the wider world [4]. Place-based education aims to extend understanding of interconnections through active engagement in one's community, and in so doing increase people's capacity to participate in local democratic decision-making [5]. The value of place-based education also comes through placemaking, building emotional connections through familiarity with a place, grown over time [6]. When people develop positive feelings towards natural places this can lead them to prioritize non-human nature [7], boosting positive ecological change. These characteristics make place-based education an appropriate approach for addressing government aims. The tools we describe in this paper are intended to support these place-based activities; using technology as a prompt for environmental noticing and nurturing time spent in local environments; and creating and implementing a range of applied, ecological, data-driven projects, towards children's active participation in the local decision-making.

The Morecambe Bay Curriculum aims to prepare children for work in the blue-green economy [8]; like the green economy, the blue economy is also focused on sustainable development that is low carbon, ecologically responsible, socially inclusive but with a specific focus on sustainable economies in marine and coastal environments. These projects introduce environmental data science; in each year children may be introduced to new environmental knowledge and skills in tandem with programming and data science skills, working from bounded, supervised projects to autonomous, self-generated projects, through which children gain deeper understanding and connection with their local environments and act for social and environmental good.

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In this paper we discuss the development of new hardware and software support for the micro:bit [9], and the appropriation of existing micro:bit peripherals/accessories for the purpose of environmental science projects in primary and secondary school. We discuss the differences between the devices and the cases we envision for their use and we further show how this work contributes to the extension of cross-curricular learning, in line with UK government aims, and local curriculum aims. This work extends the possibilities for ongoing projects including Biodiversity Logbooks [10]. It also sits within a wider development plan encompassing tools for data storage, sculpting and visualizing within a 'Cloudlet' Intranet of Things [11, 12].

The clip:bit has been designed to respond to particular fieldwork needs but its flexibility makes it beneficial for a wide range of environmental science and data gathering projects. It can be used in different ways according to the environmental knowledge and coding experience of those involved. Hence it supports progression from guided projects, designed by educators, to child-led projects, initiated to understand socio-ecological issues and respond proactively to climate concerns.

2 RELATED WORK

2.1 Prior work and experiential reflection on the challenges of longitudinal environmental projects

In 2021, Edwards et al. [13] presented work on ways that digital education can contribute to a pedagogy for environmental care, illustrating through a series of cross-curricular projects. The work described in that paper led to the hardware and software under current development. The paper described approaches to place-based education, that focused on using interactive technologies to enable children to attend to aspects of local environments, building connections with places, and furthering their understanding of human and more than human interrelationships. In the Biodiversity Logbooks project children (aged 7-11) programmed micro:bit compasses and sensors and used them to build an understanding of microclimates. Cyanotype photography [10] and drawing were used to learn about the types of plants that grow in distinct locations. Some children counted plants species in quadrats to measure biodiversity in a park. The project was effective in helping children notice plant features and the relationship between plant growth, microclimate, and land use [10].

The longer-term educational ambition for this is to engage children in projects that have real-world impacts. For example, one project could be to discover the best site to plant a wildflower meadow in the school grounds and monitor its impact on pollinator numbers. Another might be to monitor flowering times over years to see if seasons are changing. Yet another might be monitoring for the presence of indicator species that signal changes in an environment.

All of these projects involve repeated data gathering and monitoring, potentially over numerous years; data gathered must be stored and manipulated, GPS information is needed to locate sites, and data and findings need to be visualized to support decision-making. Everything needs to be managed by teachers who have varying degrees of confidence and experience in computing. Although this may appear to be creating an additional workload, we know through working group meetings that MBC members wish to embed activities within the curriculum, so that they are sustainable for teachers to deliver in the long-term, rather than leaving teachers dependant on external teams dropping in to deliver short, self-contained projects. The aim is to give teachers control so they can adapt project ideas for their own needs. The cross-curricular nature of the projects provides an opportunity to introduce and support teachers who are not computing specialists to the application of computing in other fields, such as science, geography and art. This is part of the MBC approach which emphasises cross-curricular learning, applied to real-world community issues.

It is possible to gather these data using traditional mapping and tallying but at scale and high frequency this becomes difficult because transcribing paper logs made in the field to digital records takes time. For some primary age children that could represent a substantial proportion of the lesson time, with a significant chance of input errors. It also misses an opportunity to introduce children to the foundations of data science through computing. If the job of transferring data falls to busy teachers, it may be too onerous to be feasible. Anecdotally, one educator told the lead author about the time sink of manually transcribing handwritten fieldwork tallies onto computer after class. Phone based applications such as iNaturalist [14] exist to handle some of this, and while this is a valuable approach to contribute to national and international projects it doesn't provide the opportunity for children to make the tools they use for data gathering and in so doing gain a complete end-to-end understanding. Furthermore, tools such as iNaturalist do not provide the same range of hands-on opportunities for investigating environments, physical investigation, logging and sensing and on a pragmatic note, taking a class set of tablets out for fieldwork presents a risk of loss or damage from inclement weather and mud.

When the lead author attempted to plan the latest round of workshops to extend the ongoing work on the Biodiversity Logbooks project, she found that there were a large number of complicating factors which individually were not insurmountable, but as a whole created fragility and complexity that threatened the viability of the plans.

- It wasn't easy to use GPS boards with micro:bits. There were no custom blocks to assist novices.
- The GPS was time consuming to calibrate and needed calibration every time it was powered at a new location.
- It was still cumbersome for children to manage multiple pieces of equipment including clipboards, worksheets, micro:bits and sensors, in the field.
- The micro:bit didn't have enough buttons to easily conduct plant surveys.
- The limited data storage on micro:bits necessitate regular data uploads which is difficult outdoors and intimidating for teachers who are computing novices. It is hard to see if data are successfully transferred.
- The micro:bit data logging environment didn't have the option to map results. Also the data didn't persist in the logging environment between sessions making it effortful to work with records collected over the long-term.

- It isn't possible to instantly combine and visualize records collected on different micro:bits in the data logger. This makes it difficult to compare records and use the data to inform ecological projects.

These limiting factors inspired the development of an end-to-end system for this class of workshops; namely those involving data collection, data storage, data sculpting, and visualizing the results. The clip:bit described here represents the data collection tool at one end of the system. At this end of the system are also the software developments within the micro:bit environment to ease the use of the new hardware and widen the visualization options available for use in the micro:bit datalogging environment. The data storage, sculpting and visualization at the other end of system are beyond the scope of this paper and are addressed in [11], which discusses the Classroom Cloudlet, a mobile, tangible, and transparent classroom approach to Internet of Things Education. This will address how the data collected can be visualised, interrogated, and discussed by children to build understandings of local places and inform their participation in environmental decision making.

3 PLANT SURVEYS USING THE MICRO: BIT

3.1 Methodology

In the project we combine a reflective Research through Design approach (RtD) [15], with a phased Participatory Design approach. This project began with reflections on an ongoing project called Biodiversity Logbooks [10], which involved the design of a toolkit for noticing plants. The lead author revisited feedback from educators and identified strengths and limiting factors of that design, based on her experience of using it, and in relation to new aims for using the toolkit for longitudinal environmental surveys. This led to the development of the current project. Initially a small group explored appropriation of existing hardware, the Kitronik Game Controller [Figure 1], iterating with code to change functionality and informally reflect on ease of use and difficulties for conducting plant surveys. Concurrently, team members began developing a GPS breakout board, with code blocks and map location visualizations for the micro:bit v2 data logger. Reflections on these software and hardware iterations and their limitations caused us to reconsider our needs structurally through two team workshops (five people) in which we identified data flows, patterns linking school projects, technological barriers and needs that could enhance these projects. This led to the co-creation of a vision for an end-to-end structure to support data-driven projects through data collection, data sculpture and management to data visualisation and actuation. This shaped the development of tools to support different parts of the end-to-end structure, including the initial prototype designs for the clip:bit; a clipboard-style micro:bit device for ecological surveys.

The next phase involved working with 6 domain experts from design, computing, environmental science, and public engagement, to learn how they might use the clip:bit. We gave them a paper prototype of the clip:bit and asked them to talk through which prospective tools they might use (and not use) and how they might use specific buttons, wheels, and screens to conduct an environmental survey. We used this information to redesign the paper prototype and we have now created a working clip:bit and related code blocks. The code has been modified as we move from deploying a working clip:bit to considering code progression between different year groups.

In the next phase of research, we plan to evaluate use of the clip:bit and Kitronik Game Controller in primary and secondary schools' projects, involving educators and a small group of 15-16-year-olds (seven people) in the co-design process [16]. The group of 15-16-year-olds has been chosen because they are taking a course in which they design and carry out their own ecological projects.

3.2 Using the Kitronik Game Controller for conducting biodiversity surveys.

By repurposing existing hardware we combined a game controller extension and micro:bit v2 to create a plant species counter. The directional buttons on the left are used to input the identifier of a particular plant species and the 'A' and 'B' buttons on the micro:bit itself are used to count the number of plants in an area. The right hand green 'action' buttons are used to check or save the current record. We further incorporated a GPS breakout board with MakeCode blocks and mapping tool. We anticipate the familiar gamepad interface will be engaging and the compact design will be easy to use in fieldwork. However, the images will need to be carried separately, interaction may be cumbersome if the micro:bit interface is slow; the single scrolling screen makes it hard to keep track of both the plant id and plant count.

3.3 The clip:bit

To address some of these challenges the clip:bit [Figure 2] combines the familiar form of a clipboard with the interactivity afforded by a micro:bit microcomputer, GPS breakout board, input buttons, two dual-digit segmented displays and a battery pack. The size – slightly larger than A5 - was carefully chosen to be sized for young children and to fit in a waterproof case. It keeps together the equipment for fieldwork surveys including paper for notes and drawing, a cyanotype kit and biodiversity ID guides. The buttons on the sides of the clip:bit can be programmed according to individual needs, but we intended that the bottom left, and right buttons would be used to navigate between pages in a concertina-shape field guide, with the page number displayed on a segmented display. The other buttons running down the sides of the display would be associated with ID numbers for botanical (or other) species. The ID number registers in the other segmented display.

As with the game controller version, the micro:bit is used to keep a species count or quadrat percentage count with the data automatically saved when the recorder moves to the next record and updates overwrite earlier records. GPS locations will be automatically stored with these records and to simplify the interaction, tallies are shown as LED dots or scrolling numbers on the micro:bit display. Conducting prototype 'walk throughs' shaped the progression from the paper prototype to updated board design. An environmental scientist who works in engagement yielded valuable insights, such as the difficulty of using a scroll wheel and low-profile buttons in gloves with cold hands. They showed that drawing on the clipboard wasn't hampered by the buttons, and the pressed button inadvertently wouldn't send a record unless it was completed by a value input using the micro:bit buttons. We plan to integrate clip:bit data

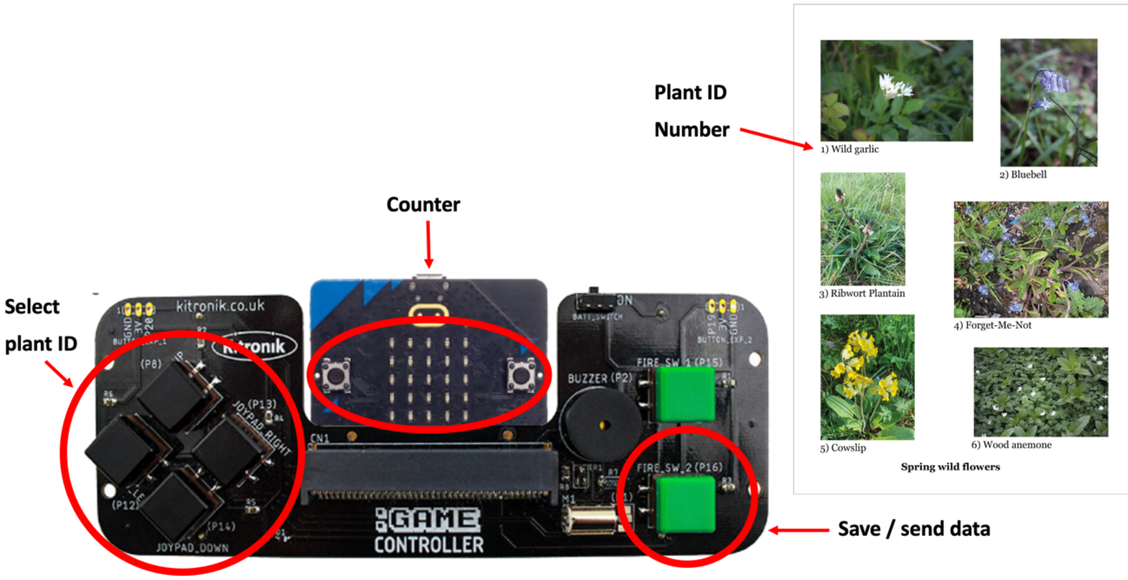

Figure 1: Initial prototype for plant recording using Kitronik controller. A GPS extension is in development (not shown). The plant ID sheets include plant ID numbers used in the 'game controller' monitoring system.

Figure 2: clip:bit with plant ID sheet (left) and clip:bit without micro:bit (right)

collection with the Classroom Cloudlet [11] so data can be safely and easily stored for comparison and evaluation in long-duration studies. The flexibility of the design means the clip:bit can be used progressively with different age groups, adding new code blocks, and monitoring techniques as the child moves through primary and into secondary school.

4 FUTURE WORK

The next stage is to use the clip:bit and Game Controller with educators, school groups and community groups, comparing use with different age groups, on different kinds of ecological projects. This will be followed by co-design workshop with teachers to iterate on the design and explore use cases. The clip:bit hardware and software will also be continually revised in response to insights of users, feedback and reflections on current use and potential new use cases. In this paper we describe specific uses of the clip:bit for a particular environmental educational purpose, but we recognise that the clip:bit has a wide range of uses across different parts of the curriculum, for example in recording voting choices, recording distances and traffic surveys. We will explore additional uses of the clip:bit and adaptations needed for these uses. We are also excited to explore the integration of the clip:bit with Classroom Cloudlet [11] and the development of additional tools to support interactive, end-to-end data systems for supporting cross-curricular projects.

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