Citizen Science in Schools: the development of eco-citizenship capabilities

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Declaration

I declare that I have composed this thesis myself and that it reflects the results of my own research. Where appropriate, I have acknowledged the nature and extent of work carried out in collaboration with others included in the thesis.

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Abstract

Young people are taking increasingly public and overtly political action in response to environmental concerns. There is a need for schools to support young people in navigating current environmental challenges, however, the capacity for schools to do this is inconsistent and often inadequate. Research is needed to understand how we can better support schools and young people in confidently responding to contemporary and evolving environmental issues. This thesis explores how environmental citizen science can contribute to lived eco-citizenship in young people while they are in formal schooling. A major finding is that environmental citizen science experiences offer opportunities to connect pupils with scientific research practices in a way that offers authentic citizenship opportunities not ordinarily available in schools. The research took a qualitative, in-depth, multi-method, case study approach, exploring the experiences of school-based participants (n=74, pupils, teachers and scientists) across three different school-based citizen science projects. Drawing on place-responsive and new materialist orientations, situational analysis was the analytical approach applied throughout this research.

This research found that the citizen science practice can be a sensory and relational experience for pupils. Identifying a range of factors that influence the development of eco-citizenship, including, caring for a place and intergenerational relationships, this research contributes to understanding when and how citizen science practice can support schools to respond to environmental challenges. Drawing on capability theory, this research explicitly identifies the significance of more-than-human encounters on the emergence of eco-citizenship dispositions in the pupils. The eco-citizenship capability to live with and in relation to the world of nature was found to be supported by more-than-human encounters during school-based citizen science projects. This is of particular importance for pupils whose relationship with environmental issues is mediated predominantly by their school experiences. Resource-related concerns were shared by the citizen science providers and schools in these cases, representing a challenge to the operational sustainability of citizen science projects with schools. Overall, this study has shown that citizen science practices in schools allow pupils, as young citizens, to make personal responses to environmental concerns across spatial, intersubjective, affective and performed dimensions. The findings suggest that we need to support schools as a vital context for young people to encounter and engage with citizen science practices, as these experiences can lead to the development of important eco-citizenship capabilities.

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According to Gilbert et al (2012); “We are all lichens” (ibid. p. 336). Never was this more true than in the production of this thesis.

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Chapter 1: Introduction

Background to this study

In this short, introductory chapter, I provide personal and professional reflection of my interest in environmental citizen science as a component of science education in schools. Additional background is provided around relevant policy contexts and some of the key drivers of my particular interest in this area. The literature review will address the main thesis themes, however some keynote ideas are noted in this chapter to help readers orient to the focus of the study and the rationale for its execution.

My research interest in this topic was sparked a few years before embarking on my PhD study. In 2015, at the Scottish Educational Research Association conference in Aberdeen, I presented a short and in retrospect, fairly naïve series of reflections on my S2 pupils' responses to the Moorland Indicators of Climate Change Initiative (MICCI) project. Buoyed by the energetic discussion and enthusiastic contribution of the audience, I was left feeling quite sure that there was 'something in this' that I wanted to explore more fully. MICCI was not my first experience of citizen science though, as I had used OPAL (Open Air Laboratories) activities alongside other 'endorsed' programmes (such as the RSPB Big Classroom Birdwatch resources and the RHS's Campaign for School Gardens award scheme) in my science teaching. Committed to taking my pupils outdoors as much as I could, these programmes lent me some credibility, they backed up my assertions about the importance of learning outdoors, and gave me a little more power to convince senior leaders that what I was doing wasn't just 'playing outside'. But what, if anything, did they do for my pupils? And so, it was that wondering that became the seed from which this research has grown.

My first teaching post was advertised as a 'teacher of geography and biology', 'that is me, and there can't be many of us', I thought. The interdisciplinarity that I had hoped for in the role did not materialise. I was a geography teacher, and a biology teacher in two different buildings, learning from two quite different departments. The school was uniquely positioned however, it had extensive grounds, a well-connected location and a highly resourced school community. This alongside a commitment to learning beyond the classroom meant that I was able to participate in, and lead a wide range of school trips. From fungi-identification in the school grounds, a 'who can get the furthest/on the most London transport types' competition, through to a month spent with senior pupils in the rainforests of Guyana, these experiences showed me first-hand the power of learning in 'real-life' situations. On my return to Scotland,

a little disillusioned with formal education, I embarked on a series of short-term roles in non-formal learning settings including museums and National Parks. These experiences broadened my educational horizons and set up some of the networks that would prove invaluable throughout the rest of my career. I headed back to the classroom, fortified by these diverse approaches to learning, where I became a biology teacher with a strengthened commitment to learning outdoors, and remained so for a decade.

This thesis explores experiences of three different citizen science projects from the perspective of the participants, the pupils, their teachers and the scientists involved in developing and leading the activities. The first two, MICCI and OPAL, were familiar to me from my time as a teacher, the third, Soil Fertility Legacies (SFL) came about via one of my PhD supervisors.

MICCI is a project which contributes to the work of the 'Moors for the Future Partnership'. School pupils are supported by a local scientist or ranger in participating in a full or half day fieldtrip to a moorland or peatland local to their school. On this visit the pupils collect detailed biotic and abiotic data about the moorland, including; soil and water temperature and pH, peat depth, and a biodiversity survey identifying common moorland plant and animal species. These data are used to help monitor the health of that particular moorland, and is collated by the Peak District National Park to generate a report on the health of moorlands across the UK. The MICCI project has been running since 2008 and has involved schools collecting data from sites within many of the UK's National Parks. The data that the pupils collect and submit contributes to an understanding of the response of the UK moorlands and peatlands to climate change and the impact of restoration works on these important habitats.

OPAL is a project which ran between 2007 and 2019 and was led by Imperial College London. OPAL developed a range of ecological surveys which enabled people to collect and contribute data on a range of ecological issues in their local areas. The surveys included clear and simple protocols with ready-made data collection sheets, which made using them in a classroom situation particularly attractive. The data collected could then be uploaded and the results viewed as part of an interactive map of the UK. The surveys included; tree health, air quality, bug count and water survey.

SLF is a project in which school pupils worked directly with a PhD student and their supervisor to collect data contributing to their research project. The project built a body of knowledge about the soil nutrients present in soils across the North West Highlands of Scotland. Intended to provide land-owners and managers with practical information about the soil quality in the area, the pupils were involved in soil testing across a number of local

sites. Field data collection was supported by lab-based analysis giving the pupils an experience that emulated that of the PhD student on a smaller scale.

These projects are all differently presented citizen science projects which are intended for use with school pupils. MICCI and SFL worked only with schools. OPAL was intended to widen participation in nature engagement, particularly in disadvantaged groups (Davies et al, 2016), these included but were not exclusive to schools.

Each of these citizen science projects focused on different environmental issues. Teaching environmental issues is an important part of being a science and biology teacher in Scotland. Scotland's curriculum framework, Curriculum for Excellence (Scottish Government, 2009a) states that, alongside eight other learning intentions,

Learning in the sciences will enable me to:

- Recognise the impact the sciences make on my life, the lives of others, the environment and on society
- Develop an understanding of the Earth's resources and the need for responsible use of them
- Express opinions and make decisions on social, moral, ethical, economic and environmental issues based upon sound understanding

Scottish Government, 2009a, p. 1

In practice, these learning intentions are attended to via course content informed by the 'Sciences Benchmarks' guidance (Education Scotland, 2017). These benchmarks define the content that pupils are expected to develop knowledge about, and some of the skills required to be demonstrated; for example, in the third level (which tracks broadly to S1/S2), teachers are expected to evidence that a pupil:

> Explains how the levels of carbon dioxide in the atmosphere have increased over time, for example, through respiration of organisms, deforestation and increased combustion of fuels.
>
> Draws on supporting evidence, quotes and sources to demonstrate an association between carbon dioxide in the atmosphere and increasing global temperatures as a result of the greenhouse effect.

Scottish Government, 2017, p. 28

The benchmarking guidance suggests that a wide range of evidence should be used to demonstrate that pupils are working at the described level, these include 'periodic holistic assessment', but also expressly include observations of pupils engaged in practical activities and 'learning in other environments', for example, the outdoors. As a teacher, I was therefore confident that using a range of outdoor-focused approaches to scientific enquiry with pupils, in particular in relation to teaching environmental issues, was appropriate and supported by the CfE Broad General Education policy context.

Senior phase, however, for me, was a different situation. With 'high stakes' for pupils, and assessment built predominantly around a single, summative, written exam, opportunities to take time over particular concepts or issues were in short supply. Yet, it was this group of pupils, having chosen to continue with biology, for whom biology and science may go on to form a significant part of their future lives and careers. As such, the chance to engage in meaningful scientific enquiry that exposed the realities and complexities of research, I felt, had the potential to be especially relevant and beneficial for these pupils. Leon-Beck and Dodick (2012) found that undergraduate ecology students struggled with the unpredictability of field studies. The authors suggest that more extensive experience in school may better prepare novice scientists for the challenges that they faced, increasing motivation and improving retention. As my passion for 'projects' became part of my identity as a teacher, I was tasked firstly with supervising the Advanced Higher (AH) Biology projects, then teaching the environmental and behavioural components of the course was soon added to my remit. It became clear to me that these pupils, our 'elite' scientists, reflected the findings of Leon-Beck and Dodick (2012) and found the move to (semi) independent research particularly challenging. It was with this cohort of students that I thought citizen science had the most to offer. Combining learning the knowledge and skills needed for outdoor fieldwork with a contribution to a professional or 'real' scientific problem, I felt, had the potential to build experience that would benefit the pupils in their AH projects, and maybe inspire and excite them too.

My early attempts at understanding what was happening during outdoor fieldwork and citizen science projects, as part of various courses of post-graduate study, utilised a pre-test, post-test outcome-focused approach. This, as discussed in more depth in the literature review, (p. 38), is widely adopted in environmental education research. As Rickinson (2001) suggests, there is a need to more fully understand the *process* of learning and engagement for pupils in the outdoors. Cook (2008) also suggests that there is a need to more fully consider the affective engagement of young people when engaged in outdoor fieldwork. In this research, I move towards a deeper understanding of the processes involved for learners, and the

sensory and relational encounters present when pupils are engaged outdoors. I hope that this will help teachers to understand not only what can be achieved outdoors, but also what is needed to improve provision.

The need for eco-citizenship

We are facing increasingly unprecedented environmental circumstances. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 2019 reports that 100 million hectares of tropical forest have been lost between 1980 and 2000, more than 40% of amphibian species and around 1/3rd of sharks and marine mammals are currently threatened with extinction, and there is a ten-times increase in the amount of plastic waste in the environment (IPBES, 2019). These shocking statistics, and the conflicts associated with them, have become a regular feature in our daily news cycles. The scale and complexity of our environmental situation is writ large in our experiences of the world, causing worry for many. According to the Office for National Statistics (2021), 75% of adults in Great Britain reported that they were worried about the impact of climate change. Young adults (between 16 and 34 years old) were found to be slightly more anxious about the future of environment than older adults. In combating eco-anxiety, Ojala (2018) suggests three common approaches, 'de-emphasising' or considering the problem to be something that affects others and not yourself, 'emotion-focused' or distracting yourself from the subject so as not to experience the negative emotions, and finally, 'problem-focused' or talking to others and making practical changes. As an educator, I am acutely aware of the responsibility that I have in helping young people to understand the environmental issues that we face, but also in building a 'meaning-focused' response. Utilising Lazarus and Folkman's (1984) work on coping, Ojala (2018) describes this as promoting 'constructive hope', suggesting that this "can help them confront the problem and bear the burden of taking on climate change without becoming overwhelmed." (Ojala, 2018, p. 13). This research focuses on my experience of using environmental citizen science as one tool to try and help contribute to developing a 'meaning-focused' response to our growing environmental emergency.

The Anthropocene, though contested, refers to a geological epoch characterised by human related changes to the structure and function of the Earth (Crutzen, 2006). Some, Rull (2017) for example, dispute the severity of the term, suggesting that only if the next ice age is averted by human intervention (intentional or otherwise) could the term 'Anthropocene' be truly attributed. Nevertheless, the impact of human development is and will be visible in the geological record for much time to come. Evidence of early tools, weapons and domestic

items mark the beginning, post-industrial changes to the composition of settlements can be seen across the world (Rull, 2017) and most recently, evidence of plastics and micro-plastics can be found in the deepest oceans and the digestive tracts of many organisms (Lin, 2021). Environmental citizenship is considered an approach that may be able to attend to the challenges of the Anthropocene due to its recognition of responsibilities and its global, non-territorial nature (Wolf et al, 2009). Reis (2020) suggests that by experiencing and connecting citizen science and activism, young people can be offered a way of bringing experiences of pro-environmental behaviour from schools into their local communities. Exploring the utility of citizen science in developing and exposing pupils to environmental citizenship as an experience, my research furthers understanding of the provision of one of a suite of tools that young people may use to tackle these complex global challenges within formal education settings.

Taking positive, practical action for the environment can be one way that eco-anxieties can be overcome (Panu, 2020). Goldman et al (2020) suggest that engaging in pro-environmental behaviours can have a 'catalytic' effect, where the positive emotions associated with engaging or participating in action *for* the environment initiate and build the desire to continue engaging in such actions. This, the authors suggest, can lead to a change in environmental identity, further encouraging action to consolidate and deepen that identity. Engaging in explicitly pro-environmental behaviours may be desirable for young people experiencing eco-anxiety, yet the routes available to them may be restricted (e.g., limited political or consumer power) or conflicted (e.g., peer and family pressures). Giving young people the opportunity to engage in pro-environmental actions within formal schooling has the effect of making these 'compulsory', and thus removing the pressure from young people to make an active decision to participate. Participation in citizen science projects may be one way to activate young people's positive pro-environmental response as part of their formal school science experience.

Education for environmental citizenship

Environmental citizenship is a much debated and contentious term. Dedeoglru and Ekmekcioglu (2020) suggest that there are at least 40 different conceptualisations of citizenship across citizenship literature (ibid. p. 3), the position of environmental, ecological and 'green' citizenships within these conceptions is increasingly important. Hadjichambis and Reis (2020) suggest that "environmental citizenship is recognized as an important aspect in addressing global environmental problems" (ibid. p. 1). As such, an understanding

of what it means to *do* environmental citizenship and what it means, and feels like, to *be* an environmental citizen is crucial in defining and refining this complex conception.

Renshaw (2021) suggests “to address the crises of the Anthropocene, students and teachers need to move beyond complacency towards an engaged and activist civic stance” (ibid. p. 15). In defining ‘environmental citizenship’, Hadjichambis and Reis (2020) include “active engagement and civic participation” (ibid. p. 20) stressing the need to act in both private and public domains, and in collective as well as individual actions. The authors suggest that a move to ‘education for environmental citizenship’ goes some way to overcome the sometimes conflicting and contradictory priorities of environmental education. Dobson (2007) proposes that environmental citizenship can be ‘kickstarted’ via formal education. Dobson asserts that environmental or ecological citizenship are not component parts of citizenship education more widely conceived, rather that all of citizenship education can be experienced via environmental or ecological citizenship. He goes on to advocate involving pupils in practical, project-based activities that would develop them as “young people who know and do citizenship” (Dobson, 2007, p. 285). Citizen science projects can provide these opportunities and can be experienced on a local, national and global scale, thereby giving young people the opportunity to experience environmental citizenship in a practical way.

As discussed in more depth in my literature review, Huttunen et al (2020) describe environmental citizenship as experienced in what the authors term ‘relational space’ or the “networks and relations that evolve beyond the actual local qualities of the place” (ibid. p. 202). They suggest that in these spaces, it is possible to identify environmental citizenship through emerging and diverse actions, rather than the rights and responsibilities evoked in the more socio-legal framings. This description echoes the features of the feminist perspective (Lister, 1997) and the lived (green) citizenship dimensions of Kallio, Wood, and Halki (2020). By connecting local environmental issues to wider scientific and environmental projects, citizen science offers young people a way to enact environmental citizenship within ‘relational space’. This research explores the experiences and reflections of the young people, their teachers and the scientists involved to more deeply understand the potential of utilising citizen science in formal school settings.

The various crises that compose the Anthropocene are in part attributed to a disconnect between humans and nature (Nisbet et al, 2009). Østergaard (2017) describes the particular challenges of science education in connecting students with the environment in order to facilitate learning for sustainable development. The skills of “belonging, caring and (re)connecting to the environment” (Østergaard, 2017, p. 558) are vital to science education,

arguing that ‘science-teachers-to-be’ need opportunities to establish and deepen these skills. Hadjichambis and Reis (2020) emphasise the importance of science education in empowering citizens to actively participate in decisions about socio-scientific and environmental issues. Science education, however, may not easily meet this challenge. Østergaard (2017) argues that some methods of science teaching, by attempting to make complex and abstract concepts visible to learners, result in a distance between the learner and the familiarity of the world around them. Scientific processes too, in attempting to minimise human error and maximise reliability (Roth and Lee, 2002) establish a gap between the knowledge that students access through science and that which they are able to access through their own senses and experiences. The potential of citizen science experiences in connecting pupils (and their teachers) to the relational and sensory nature of scientific enquiry is a key component of this research.

Citizen science: an opportunity to connect science education and eco-citizenship

There are a range of approaches taken in science learning which attempt to bring ‘real’ science into the science learning experience for pupils. For example, Drissner et al (2010) describe a ‘green classroom’ which attempts to develop positive relationships between science pupils and small animals. Taylor et al (2008) describe a ‘scientist in the classroom’ programme which aimed to improve the experience of science for the pupils and teachers involved. Whiley et al (2018) describe a dramatic ‘scenario-based’ approach to science teaching using the cultural trope of a ‘zombie apocalypse’ to engage pupils in an environmental health topic. Among these ideas, Wals et al (2014) suggest that citizen science could be an approach that brings environmental education and science education together and Jenkins (2011) proposes that schools could take advantage of citizen science opportunities to enhance the science learning that pupils are engaged in.

Using citizen science to connect pupils with real scientific projects or scientific organisations may bring an authenticity that isn’t ordinarily available in schools. However, with a range of opportunities on offer to schools, and limited time and resources with which to work, why should citizen science be a consideration for teachers? Jordan et al (2012) suggest that it is the engagement in aspects of authentic science that “distinguishes citizen science as an informal learning experience” Jordan et al (2012, p. 1). The opportunity to engage in practical fieldwork tasks where the quality of data collected matters more than it might in a typical science experiment, may serve to elevate the interest level in seemingly mundane, practical tasks. However, Bonney et al (2009) suggest that a lack of evidence of citizen

science positively affecting attitudes towards science may be in part due to the recognition that scientific enquiry can be time consuming, challenging and at times tedious. The nature of citizen science being related to 'real world concerns' at a local or global scale may increase the socio-scientific considerations that connect science to citizenship learning. Despite an increasing presence of young people in public and political environmental spheres, there is limited exploration of the conception of eco-citizenship experiences and behaviours in educational settings (this is explored further in the literature review). This research contributes to developing an understanding of the mechanisms that formal education can engage to contribute to identifying and building eco-citizenship capabilities. I do this by evidencing the relational experiences of young people engaged in citizen science projects through school.

Policy context

Citizen science in Europe, the UK and Scotland

The research is situated predominantly in Scotland where there is a commitment from the Scottish government to promote citizen science to schools. Education Scotland produced a report in 2015 entitled 'Citizen Science and Curriculum for Excellence'. This report defines Citizen Science as "the gathering, recording and analysis of scientific data by members of the public" (Scottish Government, 2015, p. 2). The report suggests that citizen science can enable young people to engage with science and the scientific community in a way that is meaningful to themselves and society. While this phrasing echoes terms that recur through the science 'Experiences and Outcomes', and also the National level qualifications, it also echoes the democratic participation in science advocated by Irwin (1995). The report explicitly claims that citizen science can challenge the perception of 'science for scientists' rather than science for everyone. The report goes on to make clear links to the subject areas that citizen science is felt to offer an input; science, literacy, numeracy and mathematics, social studies and health and wellbeing. An emphasis on the wider impacts of citizen science on pupils suggests that it can provide motivation, connect with Learning for Sustainability, STEM context and parental engagement.

With awareness of the potential of citizen science projects growing (Hecker et al, 2018), governments and advisory organisations have produced a range of reports and recommendations relating to the development and utilisation of citizen science in policy and practical terms. The next section will describe selected documents from government or advisory bodies from Europe, the UK and Scotland to illustrate the current policy picture

regarding citizen science. There is a stronger emphasis on the policy position in Europe than the UK for two key reasons, firstly, the policy position in Europe is more clearly envisioned, and secondly, following Brexit and related political debate, there appears to be a stronger alignment from Scotland towards the European than UK policy context.

Europe

In 2014 'Socientize' published a white paper on 'Citizen Science for Europe' for the European Commission. The paper provides policy recommendations to improve the understanding and impact of citizen science.

Citizen science is defined by the authors as:

> the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources.
>
> (Serrano Sanz, 2014, p. 8)

This definition is positioned at the fore of the 'Socientize' paper, however it goes on to suggest that citizen science cannot be reduced to a single definition but is rather a dynamic research approach that is evolving in response to the changing research environment reflecting the collaboration and shared goals of those involved. This conflict reflects the discussion had by Eitzel et al in their 2017 paper which analyses the terminology used around the citizen science field. They note that there are contextual and nuanced meanings around the terminology that are a part of the growing and evolving language of citizen science. They suggest that in the use of the most general terms (e.g., citizen science), it should be recognised that these may have unsettled or problematic elements. This is particularly important when considering policy recommendations that cover broad and varied countries and cultures.

The 'Socientize' report describes a broad network of collaboration in which:

> Participants provide experimental data and facilities for researchers, raise new questions and co-create a new scientific culture. While they add value, volunteers acquire new learning and skills and gain a deeper understanding of the scientific work in appealing ways. As a result of this open, networked and transdisciplinary scenario, science-society-policy interactions are improved, leading in turn to a more democratic research based on evidence and informed decision-making.
>
> (Serrano Sanz, 2014, p. 9)

This description is highly idealistic and reflects not only the aspirational practical research goals of scientists and citizens attending to relevant scientific questions, but also suggests that the impact of this collaborative work may lie in the policy/democratic decision-making realm, which is a bold claim. Nascimento (2018) suggests that while citizen science does have this potential to affect local and national decision-making, the diversity of legislative frameworks and differing expectations of participants and professional scientists have prevented greater impact of citizen science in the policy sphere as yet.

The Serrano Sanz (2014) report suggests that there is a need for a new way of acting in order to address the current global challenges with an emphasis on scientific and social values alongside economic concerns. It suggests that structural and political changes are needed to prioritise responsible decision making and encourage joint solutions. There is the suggestion that digital solutions offer a platform to "turn ideas into actions" (Serrano Sanz, 2014). It goes on to suggest that citizen science can operate between the 'macro' world of policy makers and the 'micro' world of research communities, offering a 'meso' position that may be able to bring the 'macro' and 'micro' worlds together effectively.

Two proposed actions are identified at the macro, or policy level across Europe; 'Targeted Programming', the development of funding and support programmes to encourage citizen science projects and 'Mainstreaming Citizen Science', utilising citizen science as a key part of existing funding opportunities and embedding citizen science in existing scientific research. The Serrano Sanz (2014) report identifies key support measures including; evaluation and assessment, access to technology and data policy. The first of the support measures related to education and involves:

> Updating educational programmes in order to promote and to recognise new forms of community engagement and digital skills in the curriculum. New tools and educational materials should foster citizens' autonomy and responsibility for change at an early age (encouraging curiosity, criticism, self-learning, self-expression) through lifelong learning. Educational programmes should stress collaboration between schools and scientific institutions, which needs to be reflected in scientific and educational value systems.
>
> (Serrano Sanz, 2014, p. 24)

The statement proposes updating the curriculum, in particular in relation to new forms of community engagement and digital skills. This may be a challenging proposition for schools, who, across Europe will have widely different positions in relation to citizens' autonomy and responsibility for change. As Yacoubian (2018) discusses, embedding scientific literacy in

school curricula in a way that fosters critical thinking and reflection on global citizenship and democracy contains some key risks that are important here. Firstly, the cultural context of different schools will challenge the vision of embedding citizen science in schools and secondly the differing professional capacities of teachers, while some would embrace the challenge of citizen science, some would inevitably find it burdensome and undesirable. Balancing these differing perspectives is as much of a challenge as the citizen science projects in themselves.

At the Meso level, a further three actions are proposed; contribution to ongoing initiatives, building communities of policy makers, scientist and society, and the integration of publicly conducted and initiated research. Again, the first support measure relates to education, this time focused on 'Training and Learning':

> Providing an educational plan on key aspects of Citizen Science that encompasses all phases of the life-long learning process, from early childhood to continuing adult education. Plans should be adapted to the different cultural settings found across Europe. They should also provide educational strategies for Citizen Science actors and address, among others, scientific procedures, technical issues, community management, sociological aspects or learning methodologies, as well as specific training for policy makers on Citizen Science methodologies.
>
> (Serrano Sanz, 2014, p. 28)

In this measure, there is a recognition of the cultural differences that exist across Europe, and a suggestion of a two-way dialogue between the schools and the citizen science actors. However, the first word in the statement is 'providing', this is a more authoritative term suggesting there is a correct way to do this.

Finally, at the Micro level, two challenge questions are posed, the first asking researchers what they feel can be gained by working with volunteers, and the second asking the volunteers what they feel can be gained by working with scientists. In this case, the support measure relating to education – training and learning states that:

> Citizen Science has an educational value, implicit or explicit. Schools are considered primary targets for the introduction and promotion of Citizen Science. **Collaboration with teachers** can give Citizen Science a boost and increase educational and media repercussion. Early collaboration between teachers and researchers during the development of collaboration activities is essential for success in adapting

participative research activities of students to the national curricula and the specific school contexts.

Customized Training Material for Specific Target Groups: exploiting the full range of media, e.g., online and offline guidelines and handbooks, interactive multimedia, games, scientific protocols, etc. to produce high-quality learning material and teaching unit plans for each target group. Ideally, this material would be designed, developed and tested in a participatory way, involving representatives of the specific target groups.

(Serrano Sanz, 2014, p. 31)

This suggests that recognition of the particular school contexts is important and that collaboration is essential to the success of projects. Although this is aimed at the micro level, the development of a suite of training materials that can be adapted to specific target audiences is representative of the 'provision' of the right way to do things. Harlin et al (2018) suggests that the balance of scientific and educational tasks within a citizen science project can be challenging and that the adoption of professional training programmes for teachers may go some way to promote citizen science as a collaborative rather than a 'delivered' initiative. This professional relationship enables the balance of learning and scientific tasks to evolve in the interests of the project rather than science or education exclusively.

Across all three levels there is the assumption that citizen science is desirable and that schools and education providers will embrace this approach to science education if the correct resources and support are put in place. While this may be the case in some circumstances, there is a lack of understanding of the complexity around the decisions that are made by and for schools in relation to the activities and learning experiences that they are willing and able to engage in. My research contributes to illuminating and understanding this complexity.

UK

In 2018, DITOs (Doing It Together Science) produced a policy briefing document in which they suggest that there is a disconnect between citizen science projects and the environmental policy context in the UK (DITOs, 2018). The authors suggest that citizen science is unsupported either in policy terms or in resource and funding support, which, they suggest "is unlikely to maximise the potential that citizen science can offer in the UK" (DITOs, 2018, p. 1). The report goes on to identify three key area of further discussion. Firstly, the authors identify the current environmental policy context in the UK as particularly

‘top-down’. This results in a lack of value placed on the perspective of citizens in relation to environmental issues. Secondly, there is currently no direction for environmental bodies to engage with citizen science providers, unlike the position in Europe and the US, for example. This leads to competing organisational and technical challenges which can restrict effective communication. Finally, there is a disconnect between the data needed by policymakers and that which is collected by citizen science organisations. This results in an inconsistent and partial contribution of citizen science to environmental policymaking. Recommendations to improve this situation include, improved infrastructure, resources and funding to develop stronger communication between citizen science organisations and environmental policymakers in the UK (DITOs, 2018).

Scotland

In the 2014 Scottish Government Briefing Paper ‘Citizen Science’ is defined as “the involvement of volunteers, including the public and communities, in scientific research” (Scotland Counts, 2014, p.1). The report provides an overview of Citizen Science and the policy connections, and potential outcomes both for people and the environment. It connects to the EU biodiversity strategy, 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020' which echoes the suggestion that citizen science offers the opportunity to both collect data and involve/enthuse citizens in conservation related activities. The report also makes reference to the UKEOF (2011) report in relation to biodiversity and environmental monitoring and observations, highlighting the value of the combination of environmental research and environmental education to the economy. This suggests that the Scottish understanding of citizen science is positioned within the bigger picture of citizen science emergence as a policy influence in Europe and the UK as a whole.

The Scottish Government (2014) report references an earlier literature review undertaken by ‘The Conservation Volunteers’ and the ‘Scottish Environmental Protection Agency’ (Morrow, 2014) which identifies a link between participation in citizen science projects and “increased environmental knowledge, attitudes and behaviour”. The research was intended to contribute to the development of ‘Scotland’s Environment Website’ (SEWeb) which provides information on the environment in Scotland and aims to increase environmental stewardship. As such the relationship between citizen science activities and attitudes and behaviour is a key area of research for this team. The report found that while citizen science can be effective at engaging participants with nature, it is the experiential learning rather than simply knowledge alone that can impact on the behaviour and attitudes of the participants. They also recognise that the complexity of factors, including motivation, experience and group

dynamics, may have an effect on the behaviour of participants after the project is complete (Morrow, 2014). This report makes no reference to the different types of people involved in citizen science projects and draws on literature with a largely adult volunteer base. As such young people and those involved in citizen science within formal education are not represented within this report and the implications of this omission may result in recommendations that are unsuitable for this particular participant group.

Alongside the clear level of importance placed on data collection activities, the Morrow (2014) report also highlights the promotion of citizen science by Education Scotland, suggesting that citizen science can provide opportunities to achieve Curriculum for Excellence (CfE) outcomes and community and lifelong learning. Schools are identified consistently throughout the report as key partners in establishing and supporting citizen science activities. Schools are however, identified as 'participating bodies' rather than enabling or co-ordinating bodies, which places schools as users of citizen science rather than as creators or instigators of projects. Investment in citizen science has also been responsible for delivering training and pilot projects in schools as well as community groups and volunteer organisations. The report identifies the need for more support for schools to get involved in citizen science, suggesting that improvements to science literacy will be achieved through the hands-on nature of citizen science activities. It also suggests that consideration be given to the inclusion of citizen science in accredited or qualification level courses, suggesting that this benefits the recognition of citizen science as well as the pupils' awards. This promotion of citizen science to schools echoes the assumptions made in the European white paper that it will naturally be a good thing for schools to be involved in. There is no suggestion of further research needed to understand if and how the 'hands-on' science activities advocated in citizen science projects are suitable or appropriate in the schools setting, and if they are, that they will inevitably improve science literacy. In researching the impact of scientific internships on high school pupils, Hsu and Venegas (2018) found that collaborative working and discussion with scientists was a desired outcome, however in reality the communications were often uni-directional, with the scientists reverting to lecture and instruction while the pupils listened and followed instructions. This exemplifies the challenges of achieving the expected or intended outcomes when working with school age young people.

The policy documents from Europe and Scotland clearly place an importance on the involvement of schools and young people in citizen science projects, in contrast to the policy position in the UK. These differences reflect the differing importance placed on the outcomes of the citizen science projects. This research contributes to the need to more fully

understand the impact of citizen science on young people in formal schooling and how this could impact on the policy decisions that it is hoped that citizen science is able to influence.

Research aims

To explore citizen science as a cognitive, affective, sensory and relational experience as part of formal schooling. What does this look like and how do the pupils, teachers and scientists respond to and reflect on their experiences?

To explore citizen science as a lived eco-citizenship experience for young people in formal schooling. What are the opportunities afforded by citizen science and how is the curriculum refracted through the experience?

A note on the capability approach

My research did not take the capability approach as its main orientation at the outset. Robeyns (2017) clarifies the difference between what she describes as *the capability approach* as an "open-ended and underspecified framework" (ibid. p. 29), and *a capability theory* as a more specific application of capabilitarian conceptions to a discrete measurement, e.g., poverty or well-being. I will refer to *the capability approach* throughout this thesis to acknowledge Robeyns (2017) determination on this terminology. The capability approach in its current articulation was defined by Amartya Sen (e.g., Sen, 1980) and has been developed along an alternative pathway by Martha Nussbaum (e.g., Nussbaum, 1988). My research will draw heavily on Robeyns (2017) articulation of the capability approach as having a 'modular structure', by which she means breaking the capability approach up into its component parts in order to apply it to a particular problem. In my research, this involved isolating 'conversion factors' as a key component of my analysis before applying these to the pupils lived experience of citizen science practice.

As my study progressed, in particular reflecting upon the findings of the pilot study, the need to more deeply understand the emerging abilities of the pupils became clear. Robeyns (2017) suggests that the capability approach prompts "us to ask alternative questions, and to focus on different dimensions when we make observations" (Robeyns, 2017, p. 7). The capability approach offered a powerful mechanism by which to do this. It asks "what people can do and be" (Robeyns, 2017, p. 9), which represents a different way of thinking about environmental experiences to the input-outcome approach advocated by many (See section 1 of my literature review for more on this). Using the capability approach allows for the *emergence* of capabilities to be identified rather than a dependence on pre-determined outcomes as found in an outcome focused approach. The application of the capability approach will be described in detail in the methodology (Theoretical Lenses section, p.69). The related analytical dispositions that inform my findings will be returned to in depth in the

discussion (in particular chapter 7, part 2). Robeyns (2006) suggests that the capability approach provides a tool or a framework to 'conceptualise and evaluate' phenomena, rather than a theory which explains, for example poverty or inequity. There is, therefore, a need to include further theoretical explanation alongside the capability approach, in this research the concept of eco-citizenship is used together with the capability approach to define the term 'eco-citizenship capabilities' as an original expression of emerging eco-citizenship.

Therefore, as the study iteratively progressed, the following research questions were settled upon:

RQ1: What contribution is made by fieldwork experiences in curriculum-based environmental citizen science that supports eco-citizenship capabilities?

RQ2: What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities in young people?

RQ3: What conversion factors contribute to the development of eco-citizenship capabilities in young people's experience of environmental citizen science in schools?

These research questions are articulated in a way that is designed to acknowledge the context of the study and the intended audience. It is expected that the findings of this research will be most useful to teachers and those working to support teachers via educational research. Providing an exploration of the contributions that citizen science can make to young people in formal education, and articulating the conversion factors that can support these will enable me to effectively communicate the opportunities and limitations of environmental citizen science experiences. Framing my research questions in this way serves to work within the existing model of education in Scotland at the time of study. There are advantages and possible limitations of this somewhat pragmatic approach, for example, the instrumental nature of the idea of 'conversion factors' may suggest the promotion of eco-citizenship capabilities as a desired 'outcome' of the citizen science experiences. Drawing on the distinction between 'capabilities' and 'functionings' (Robeyns, 2017) in terms of actions selected or taken by an individual helps to consider the nuanced experiences of citizen science in this educational context. Further discussion of the limitations of the approaches taken here can be found in the 'Limitations and personal reflections' section on page 213.

Chapter 2: Literature Review

Introduction

In this literature review, I will describe the key strands of literature that informed my study as it progressed. This will be divided into two sections, the first focusing on the position of environmental citizen science in relation to formal schooling. The second explores my arrival at eco-citizenship as a sensitising concept for my study.

In the first section, I will describe how the experiences of young people, in particular in curricular contexts, in citizen science are described as part of the wider body of literature on environmental citizen science experiences. This literature, and the assumptions contained within it, informed the first empirical stage of my research.

In the second section, I will explore conceptions of environmental citizenship. This is a contested idea and one in which my own understanding was challenged throughout this research. In this section, I outline and explore the contested nature of the term, alongside some relevant scientific and environmental 'literacies' in which measurements of impact in citizen science projects are described. I will demonstrate the nature of my evolution towards the conception of lived eco-citizenship and how this informed the design and analytical framing of my research.

Section 1: environmental citizen science in formal education

Citizen science definition and background

"Citizen Scientists collect more than data. They collect meaning."

(Louv, in Dickinson and Bonney, 2012, p. x)

Citizen science has recently grown in popularity as a phenomenon. In a crude search (see Appendix 1 (p. 254) for details), the number of titles including the term 'citizen science' in the 'Web of Science' database showed a rise from single figures between 1996 and 2004 to almost 2000 publications in 2021. A mix of factors have enabled citizen science to be significant at the moment; including global communication and data upload, social media and the fact that large numbers of people could be considered free and variously skilled labour (Dunkley, 2018). While citizen science as a phenomenon has a long history (Kobori et al, 2015; Miller-Rushing et al, 2012) and can involve fields as diverse as astronomy (Odenwald, 2018), protein-folding 'games' (e.g., Hand, 2010; Curtis, 2014) and cell biology

(e.g., de Silva et al, 2016., Spiers et al, 2020), it is of particular relevance in the environmental and ecological fields (Pocock et al, 2017; Reisch, 2015). Environmental policy across Europe contains reference to Citizen Science (UNESCO, 2021) and the United Nations (UN) Sustainable Development Goals (SDGs) reflect on the use of Citizen Science as a way of monitoring the development towards the goals (Queiruga-Dios, 2020).

Criscuolo et al (2022) and Lakeman-Fraser et al (2023) emphasise the contribution that citizen science projects make to meeting and monitoring the SDG's. Criscuolo et al (2022) highlight the potential contribution to sustainability objectives and policy decisions of citizen science generated data, but they suggest that there is a lack of connectivity between the citizen science projects and the SDG needs. Lakeman Fraser et al (2023) demonstrate the relevance of a citizen science project (X-Polli:Nation) across a range of SDG's, suggesting that awareness raising and confidence-building are benefits of such projects. These echo findings by Fraisl et al (2022) who report on the use of 'Picture Pile' a photographic tool that can be used to monitor a range of SDG's. The authors suggest that trust between the various users and contributors is vital in the effective use of the platform. These different assertions of the potential contribution to meeting and monitoring the SDG's connects to the policy context within which the schools operate, strengthening the case for participation in citizen science experiences.

Suggestions that environmental citizen science offers a solution to the challenges of the Anthropocene abound. McKinley et al (2017) suggest that citizen science is a 'powerful tool' in attending to conservation challenges. The authors describe two key ways in which this is enabled, firstly in increasing the scale of conservation related efforts, and secondly, in "engaging the public to help make decisions" (McKinley et al, 2017, p 17). Brombal (2019) however, contends that citizen science, when focused on data collection only, is not enough to bring about the significant, radical changes that are needed to truly attend to the complex challenges faced at present. Jorgensen and Jorgensen (2020) propose that the potential for transformation in citizen science lies in its potential to "cultivate environmental citizenship and change attitudes" (ibid. p. 1). The authors suggest that by developing projects which are explicitly 'collective', 'situated' and 'connected', citizen science can transform relationships between people and nature. My research will provide evidence to show if and how citizen science as part of formal schooling is able to engage pupils in such transformative experiences.

There is a wide range of definitions of citizen science, Serrano Sanz (2014) goes so far as to suggest that there can be no single definition, instead suggesting that citizen science is a dynamic research approach that is evolving in response to the changing research

environment reflecting the collaboration and shared goals of those involved. This echoes the discussion had by Eitzel et al in their 2017 paper which analyses the terminology used around the Citizen Science field. They note that there are contextual and nuanced meanings around the terminology that are a part of the growing and evolving language of citizen science. They suggest that when using citizen science as a general term, rather than 'public participation in scientific research', or 'community science' for example, it should be recognised that this may have unsettled or problematic elements. These issues of terminology are particularly important when considering policy recommendations that cover broad and varied countries and cultures. Dunkley (2018) also notes that the term citizen science, especially the citizenship component, can be problematic, but that other terms, e.g., Public Participation in Scientific Research (PPSR), have not been able to command the same widespread use.

The use of the term 'citizen science' as relevant to this study developed around the same time in two distinctively different arenas. In 1995, Irwin proposed citizen science as a way of opening up "the discussion of expertise, citizens and sustainability" (ibid. p. 169). Promoting the democratisation of science, Irwin (1995), drawing on Funtowicz and Ravets (1993) theory of post-normal science, suggests that there is a greater need for transparency in science and technological institutions. He goes on to discuss the impact that recognising a wide range of 'ways of knowing' about science, the environment and sustainability can have on bringing together the natural and social sciences to address environmental concerns. Around the same time, Bonney and a team from the Cornell Institute of Ornithology described citizen science as Public Participation in Scientific Research (PPSR) (Bonney and Dhondt, 1997). In this framing, enthusiastic amateurs work with research organisations to collect and analyse data on natural phenomenon. The star-gazing and bird-watching communities, for example, have a wealth of expertise and commitment to their fields which professional scientists can gain access to, allowing research teams to extend the sample size and geographic range of their studies in a way that no wholly professional research team could realistically achieve (Nielsen, 2012).

Irwin and Bonney's different conceptions of citizen science reflect alternative ways of considering the relationship between 'citizens' and scientific enquiry. For Irwin, the use of the term 'Citizen Science' is used to evoke "a science which assists the needs and concerns of citizens" which at the same time "implies a form of science developed and enacted by citizens themselves" (Irwin, 1995, p. xi). This framing locates people and their needs at the heart of scientific enquiry, with contextual and local knowledge playing an important role in the development of solutions to complex scientific and environmental problems. Irwin goes

on to suggest that “the opening up of science to a wider set of knowledges and sources of enquiry can only be beneficial to the growth of knowledge regarding environmental response” (ibid. p. 175). In contrast, the framing of PPSR focuses on the “the degree to which participants are included in various elements of the scientific process” (Dickinson and Bonney, 2012, p. 5). With its origins in ornithological monitoring, this conception of citizen science evolved around groups of interested hobbyists, prepared to dedicate time and expertise to a cause of interest to them. The relationship between the public participants and the scientific community is defined as one of “selfish altruism” (Dickinson and Bonney, 2012, p. 7) where both are motivated by the shared benefits of collaboration. In this conception, the data collected by participants may seem quite abstracted from the research design or subsequent use of the results (Cooper, 2012) and as such is a very different type of scientific citizenship to that described by Irwin (1995). Haklay et al (2023) suggests that these alternative approaches need not be considered in opposition to one another, rather can be found within and across the wide (and widening) range of citizen science projects.

To more fully explore the concept of ‘democratisation of science’, the two different approaches to citizen science (described before) again do this in different ways. As Kasperowski & Kullenberg (2019) suggest, while the largely contributory approach advocated by the Public Participation in Scientific Research approach can be criticised for being driven by professional scientists and using participants as data collection instruments, motivation to get involved in such projects is often prompted by concerns over environmental issues or interest in particular topics. Alternatively, citizen science as scientific citizenship, in the way that Irwin (1995) describes, is more closely related to initiatives that have their origins in specific environmental or community-based concerns. Thus, the scientific investigation follows an issue of note that has perhaps not been recognised by the formal, professional scientific community (Kasperowski & Kullenberg, 2019). Leach, Scoones and Wynne (2013) suggest that these different ways of knowing and coming to know about an issue may not be compatible, in particular in attempts to make decisions about particular issues. Acknowledging that the way that the pupils in this study will come into contact with citizen science, broadly in line with the contributory model described by Dickinson & Bonney (2012), it is relevant to consider the extent to which this type of engagement can contribute to an eco-citizenship that more fully looks towards a democratisation of science.

Funtowicz & Ravets (1993) describe ‘post-normal science’ as science in which “facts are uncertain, values in dispute, stakes high and decisions urgent” (ibid. p. 744). They go on to identify an ‘extended peer community’ which can operate in this ‘post-normal science’ arena. An ‘extended peer community’ is described as an extension of the peer-review process

found in traditional, or ‘normal’ science, and includes particular knowledge of local conditions and circumstances, often in relation to a particular issue. Funtowicz & Ravets (1993) caution that such groups often work in isolation, with limited systemic support and a lack of power in relation to policy and decision-making structures. In an analysis of the correlation between various typologies of citizen science and the PNS framework, Haklay et al (2023) found that most citizen science typologies can be located within applied sciences or professional consultancy, which fall outwith the ‘post normal science’ zone. In particular, projects involving large numbers of participants across wide geographical areas were least likely to demonstrate the relationship building and collaboration that is a critical component in the ‘extended peer community’ of post normal science. In looking towards the lived eco-citizenship experiences of pupil participants in citizen science projects, this research is cognisant of the opportunities and limitations for their inclusion (or exclusion) from the ‘extended peer community’ present in post normal science.

Lozano et al (2012) suggests that “education today frequently place a heavier emphasis on the development of specific skills than on development of the whole human being” (idib. p. 136). Wals et al (2022) echoes this assertion, suggesting that efforts to measure educational outcomes can lead to curriculum and pedagogy that are “confined to effective knowledge transfer” (ibid. p. 535). In response to global challenges that include the climate crisis and biodiversity loss, Wals et al (2022) argue that there is a need for curricula that are rooted in the local school community while being “nested in the wider world” (ibid. p. 569). The imperative to recognise different ways of knowing highlights the need to notice and legitimise forms of knowledge production that are context specific and locally situated. Competence focused educational thinking emphasises the “results that an individual can achieve through an action, choice or behaviour” (Lozano et al, 2012, p. 139). However, the lived experiences of pupil participants in (often) their first contact with citizen science experiences may not yield the identifiable actions that are demanded to evidence competence. Roche et al (2020) note that the educational and scientific ‘outcome’ goals of citizen science projects could be more closely aligned, drawing on frameworks to measure learning outcomes, such as that by Phillips et al (2018). In contrast, the capability approach (Sen, 1980, Nussbaum, 2011) offers a way of considering education that is somewhat different to competencies or outcome focused approaches in that it has the potential to notice and develop the “critical and reflective capabilities” (Lozano et al, 2012, p. 143) of the pupils. In attending to the emerging and lived eco-citizenship capabilities that pupils demonstrate in and through the citizen science experience, using the capability approach as a theoretical lens offers a way of

emphasising possible and potential ‘ways of knowing’ that pupils may come to as opposed to the identification of pre-determined learning ‘outcomes’.

It is claimed that engaging school pupils in citizen science projects has the potential to increase the diversity of participants (Edwards et al, 2018) however, this involves designing projects with cognition of a wide range of experiences and skill levels. However, data quality concerns are particularly acute when citizen science projects involve children. The variation in children’s ability to accurately and consistently follow protocols gives rise to concerns over the reliability of the data provided, or additional costs involved in checking and cleaning such data (Makuch and Azcel, 2018). The majority of citizen science volunteers are older, white, male and highly educated (Edwards et al, 2018). This means that evaluation and understanding of the learning experiences of participants has not, thus far, been strongly developed to account for the unique experiences of young people participating as part of their formal education. Makuch and Aczel (2018) suggest that designing citizen science projects for and with children can help to make projects more inclusive for a wider range of people with diverse backgrounds. Also important in research and evaluation of citizen science projects is the use of tools and approaches that are relevant and accessible to young people, as my project does. It is hoped that this may yield insights not found elsewhere in the existing body of research.

Citizen science and education

Mueller, Tippins and Bryan (2012) consider the potential influence that citizen science can have on young people in schools and in their communities. They suggest that citizen science, as experienced in its most common, contributory form does not do enough to challenge the positivist traditions of scientific enquiry. They go so far as to suggest “teaching about rather than engaging in is a widely known problem in schools, and citizen science offers very little that the textbooks or teacher lectures do not already disguise” (Mueller, Tippins and Bryan, 2012, p. 3). Cooper (2012) responds suggesting that the typology that Mueller et al (2012) describe is only one approach to citizen science and that co-created and collaborative approaches (Bonney et al, 2009) enable students to contribute to more of the decision making involved in a project in a meaningful way. Gray et al (2012), also in response to Mueller et al (2012), describe the experience of students involved in a co-created citizen science project. They suggest that for a truly co-created project to be possible, both the scientists and educators need to adjust their traditional ways of working. For educators this may mean embracing uncertainty and for the scientists, giving up some control of the research protocols. The authors reflect on the challenges of achieving this in

their project, suggesting that in order to authentically co-construct scientific inquiry in the classroom, extensive resources and support are needed and the experience ran “counter to the currently dominant expectations” (Gray et al, 2012, p. 5) of both the education and citizen science communities.

Weinstein (2012), in response to Mueller, Tippins and Bryan (2012) suggests that both the education community and the science communities share a ‘problematic lack of democracy’ which most citizen science approaches do not challenge. Calabrese Barton (2012) extends this argument, suggesting that *place* is missing from the conception that Mueller, Tippins and Bryan (2012) describe. She asserts that rooting citizen science firmly in the local community has the effect of engaging young people with knowledge that is relevant to the wider “social, economic, and political dimensions that are inherent in science” (Calabrese Barton, 2012, p. 4).

The meaning of the data collected in citizen science projects may have very different meanings to the education and natural science communities (Mueller, Tippins and Bryan, 2012). By way of example, Radhakrishna et al (2017) describe the challenges of initiating a citizen science project in rural India. They, in part, attribute the culture of a hierarchical and results-driven education system to the difficulties in implementing and measuring the impact of their project. Druschke and Seltzer (2011) candidly describe the failures in a citizen science project from the perspective of the scientists involved. Despite generating the data required, the participants did not demonstrate the changes in knowledge or attitudes that the researchers had hoped. In advocating for greater consideration of the needs and desires of the participants, the authors hope this will improve the impact of future citizen science projects. Gray et al (2012) suggests that the role of teachers as communicators, rather than generators of scientific content and knowledge results in a reliance on ‘professional’ scientists. In relation to citizen science projects, this perception limits the potential for teachers, and their students to create and contribute to scientific enquiry.

Calabrese Barton (2012), also writing in response to Mueller, Tippins and Bryan (2012), discusses the idea that citizen science has not traditionally been about the democratisation of science, instead it is about mobilising large numbers of people to ‘get more work done’. She suggests that this links more effectively to the capitalist goals of science as technological advancement than any democratic intent. Cooper (2012) identifies two areas of challenge in drawing conclusions about the impact of citizen science on learning outcomes. Firstly, a lack of published studies. Cooper suggests that studies may be only put forward for publication where positive results can be reported, limiting true conclusions from being drawn. Secondly, she suggests that many of the participants of citizen science

projects have high initial knowledge or skill level, which results in low or no change in these as a direct result of the project. This research contributes to this field by exploring the embodied and relational experiences of the pupils participating in the citizen science projects, and by demonstrating the factors involved in identifying emerging eco-citizenship capabilities for the pupils.

Typologies of citizen science

Shirk et al (2012) (fig. 1) describe the different ways in which the public can be involved in citizen science, suggesting five typologies of public participation in scientific research (described also in Bonney et al, 2009); contractual, contributory, collaborative, co-created and collegial. These typologies exemplify the level of involvement of the participants in the research process and the relevance of the research to particular groups or individuals (Reisch, 2015). The emphasis on participant experiences allows a citizen science project to be influenced by the desired outcomes through a deliberate project design approach, which can be particularly useful in complex conservation projects where there may be tension between the different interested parties (Shirk et al, 2012). The connection between the typologies and the participation model is suggested as a descriptive tool to highlight the nature of inputs and outcomes in citizen science projects. The authors recognise that there will be variation within as well as across the participation types that they have defined, this is particularly relevant when considering the participation of school pupils in citizen science projects.

Table 1. How public participants interact with scientists through public participation in scientific research (PPSR)

Public action in each PPSR model	Members of the public...
Contract	... ask scientists to conduct a scientific investigation and report on results
Contribute	... are asked by scientists to collect and contribute data and/or samples
Collaborate	... assist scientists in developing a study and collecting and analyzing data for shared research goals
Co-create	... develop a study and work with input from scientists to address a question of interest or an issue of concern
Colleagues	... independently conduct research that advances knowledge in a scientific discipline

Figure 1: Shirk et al (2012) Typologies of public participation in scientific research (PPSR)

Wiggins and Crowston (2011) suggest that the participatory model of citizen science typologies, whilst useful, does not accurately reflect the organisational and structural differences between projects. They suggest a series of typologies that include; action oriented citizen science, where projects are planned by citizens to advance a local agenda, conservation projects which support ecological and conservation based agendas, often highly focused on 'place', investigation projects are singularly focused on data collection from a physical location, virtual projects are those which take place entirely online, and finally education based projects where learning and educational outcomes are the primary goal of the project.

Haklay (2018) argues that participation in citizen science is complex and suggests that existing models do not fully articulate this complexity. He argues that more deeply understanding participation will lead to better citizen science experiences for projects and participants. The 'educational' typology of Wiggins and Crowston (2011) is useful in that it acknowledges the particular needs of education-focused citizen science, however as Reisch (2015) suggests, the boundaries between the typologies are not fixed. Wiggins and Crowston (2011) found that in projects that they classified as 'educational' there were more data analysis opportunities and there was more emphasis on critical thinking skills than in other types of projects. However, school pupils may participate in collaborative or contributory citizen science projects that are not developed specifically with the needs of schools and school pupils in mind and may participate in ways that are significantly different from the typical adult volunteer participant. Understanding the different ways in which schools, pupils and citizen science projects interact with each other will enable best practices from both perspectives to be identified.

Young people in the citizen science literature

Ballard et al (2016) found that in two US based programs, young people were supported in developing environmental and scientific capacities. This involved the young people identifying and developing skills and knowledge in an authentic, environmental science context. The authors suggest that by providing long term, regular and authentic environmental science experiences, the citizen science programmes involved provided young people with a way to positively engage with a conservation issue. They acknowledged that not all the young people involved developed the skills and capacities described, suggesting that further research is needed in understanding how and why such developments take place, or do not within citizen science projects. This research goes some way to responding to this research need.

Lorke et al (2021) observed young people (n=81) involved in citizen science 'BioBlitz' activities in the UK and the US, in order to determine the activities that young participants actually engage in as part of the experience. The team identified five different types of engagement, *exploring, observing, identifying organisms, documenting and recording.* Of these, the engagement type most deeply connected to the intentions of citizen science to contribute to developing environmental monitoring and knowledge, 'recording', was found to be the least prevalent in their sample. The authors suggest that this highlights the need for improvements in the design of citizen science programmes for young participants. The participants in the Lorke et al (2021) study were engaged in citizen science via informal routes, generally through museum education programmes. The findings are relevant to formal education settings, however, as the recommendation to consider ways to fully engage young participants in all aspects of a citizen science project is one to reflect on for school-based citizen science practitioners.

As further explored later in my literature review, Roche et al (2020) describe the diverging and often competing emphases between the citizen science and mainstream education fields. They suggest that the goals of 'scientific progress' and 'supporting learning' may not always align (ibid. p. 3). Issues around learning intentions, scientific communication and the learning/data collection environment can all pose challenges for learners and citizen science organisations to get the most out of citizen science experiences. The authors go on to suggests that alongside these challenges lies the opportunity for citizen science practitioners and teachers/learners to work together to develop authentic opportunities to take a transformative approach to learning about, and acting for the environment. This would enable "attending to learning and practicing science in ways that are more in tune with learners' motivations, with local places and in ways that are socio-culturally distributed among all participants" (Roche et al, 2020, p. 7).

Learners in the citizen science literature

It has been suggested that Citizen Science could bring a number of opportunities that schools could take advantage of to enhance the science learning that pupils are engaged in (Jenkins, 2011). Pike and Dunne (2011) build on earlier assertions that a challenging curriculum (Miller and Osborne, 1998) and lack of relevance (Roberts, 2002) is partly responsible for persistently low levels of students taking science subjects into post-16 education in England. Based on a series of interviews with science and non-science students, a key finding for the researchers was that science was not considered enjoyable by most of the students in their sample. They go on to suggest that science engagement

could be improved if science education involved “more discussion-based learning and greater relevance to the everyday” (Pike and Dunne, 2011, p. 498). Jenkins (2011) responds to Pike and Dunne (2011) by suggesting that using citizen science to connect pupils with real scientific projects or scientific organisations may bring an authenticity that isn’t ordinarily available in schools. The opportunity to engage in practical fieldwork tasks where the quality of data collected is important to the project may serve to elevate the interest level in practical tasks. Furthermore, Jenkins (2011) suggests that the nature of Citizen Science being related to ‘real world concerns’ at a local or global scale may have an impact on connecting students to the socio-scientific issues that affect themselves and their communities, serving to build meaning and context into science learning.

Roy et al (2012) states that, in a semi-systematic literature review of citizen science projects in the UK, 21% of their sampled projects were specifically targeted at school children (p. 22), and that the inclusion of educational resources increases the ‘thoroughness’ of a project. However, when considering the motivations involved or the impact of technology, schools and school pupils were noticeably absent from consideration. As Martin (2017) discusses, the most likely volunteers in science-led citizen science projects are those with higher-than-average educational qualifications. This is in direct contrast to the school pupils who have yet to achieve these qualifications and could generally be considered non-scientists. There is a challenge for those involved in citizen science projects to consider a wider range of participants in the way they encourage and support their progression. This may lead to more diverse adult volunteer participation as a different range of values are considered in relation to project data and experiences.

In literature on school-based citizen science, there are many studies which consider a single citizen science project, examining the impact of the experience on the young people involved. Hiller and Kitsantas (2014) for example, uses a quasi-experimental approach to understand the impact of a Horseshoe crab citizen science programme on the self-efficacy, science interest and content knowledge of middle school pupils. The authors found that the pupils who had experienced the citizen science activities has higher levels of achievement than pupils who had not, furthermore, they proposed that the career goals of some pupils had been influenced by the experience. Paige et al (2010) and Patterson (2012) reported increased engagement from pupils involved in citizen science experiences focusing on magpies and mountain lions respectively. Patterson (2012) suggesting that “years from now, these students will still remember hiding the cameras, reviewing wildlife photos and sharing their research findings like “real scientists”.” (ibid. p. 44). This research will contribute to the growing body of research which looks in depth at the experiences of young people involved

in environmental citizen science projects. Edwards et al (2018) suggest that there is a need for more research utilising ethnographic approaches to understand *how* participants learn, rather than relying on self-report via surveys. Drawing the experiences of pupils involved in different environmental citizen science projects together, as my research does, builds on this body of research to more deeply understand the experiences, opportunities and challenges of projects in different contexts for the young people involved.

Geoghegan et al (2016) undertook a literature review, a survey of ECS volunteers and interviews with citizen science stakeholders. Their report identified the dominance of altruistic motivations, e.g., 'to help wildlife,' in encouraging participants to engage with citizen science projects, however, enthusiasm and enjoyment were highlighted as consistently important to the participants. They also suggest that there is a potential gap in the existing literature that could consider more deeply the emotional dimensions of citizen science participation. Education is identified as a significant motivational factor in encouraging scientists to adopt a citizen science approach to their research. An emphasis may be on education about a particular topic, but the authors also reflect on the importance of education relating to the scientific process or scientific literacy (Geoghegan et al, 2016). Harlin et al (2018) describes the importance of balancing educational and scientific goals in citizen science projects involving school pupils. Aligning to specific school curricula can make a project more attractive to teachers and ease workload concerns, however, the application of this across national and international contexts can be practically challenging.

Edwards et al (2018) suggest that the educational value and participant learning outcomes of citizen science project participation is an area that is in need of further research attention. Harlin et al (2018) propose that citizen science when incorporated into formal education can bring three key opportunities; firstly, an opportunity to learn scientific and disciplinary knowledge, secondly, the chance to positively influence perceptions of science and thirdly, to motivate and engage participants. In my research, understanding the conditions in which these transformative and motivational experiences can take place, and the situational factors that influence them will contribute to this important area of research.

Blaney et al (2016) undertook a cost-benefit analysis of citizen science in the UK. Their report took a literature review and case study approach to identifying the gaps and opportunities that citizen science offers to potential end users, e.g., government departments, agencies and public bodies. However, they also identified some benefits to the volunteers (e.g., engagement with scientific research and increased education, health benefits and connection to nature) and wider society (e.g., increased environmental awareness, increased scientific knowledge and improved environment). The authors suggest

that further research should be undertaken into understanding the link between citizen science participation and the wider societal benefits from an individual and community perspective. The report makes no mention of schools or young people's involvement in citizen science projects. This report was intended to contribute to environmental policy, therefore the absence of young people's perspectives is an example of the need to more fully understand the role and experiences of young people and school pupils in citizen science research.

If schools and citizen science organisations are to achieve the benefits that have thus far been suggested, how might they do this? Yoho and Vanmali (2016) suggest that citizen science can be a valuable pedagogical tool in dealing with controversial topics in biology, suggesting that the data contribution to research as an 'additional benefit'. Teachers have a range of challenges in terms of time and resources available to implement new programmes, as such, ensuring that citizen science projects 'work' is crucial to engagement with school settings. Harlin et al (2018) suggest three ways that citizen science projects can be utilised within formal school settings:

> Type 1: Adoption and adaptation of an existing programme
>
> Type 2: Autonomous local development
>
> Type 3: Local partnerships between scientists and teachers
>
> (Harlin et al, 2018, p. 414)

The cases examined in this research represent the type 1 and 3 projects. The MICCI and SLF projects contain a mixture of type 1 and 3, while the OPAL project represents type 1. Harlin et al (2018) suggest that "further research is needed to evaluate the outcomes and challenges of each of these types of citizen science projects in schools" (ibid. p. 417). This supports assertions by Bela et al (2016), who reviewed citizen science literature from across Europe and suggest that transformational impacts for learners are often reported on the basis of assumptions rather than observation and that there is a need for "reliable and transparent measurement of transformative effects" (ibid. p. 998). My research, in exploring the experiences of school pupils engaged in different citizen science projects, contributes to meeting this need for further research in this area.

In utilising citizen science to influence or meet local, national and European policy objectives, there is a need to represent the experience of more current participants, and of potential future participants with rigorous and reflective evidence rather than assumptions. A

deeper understanding of the experiences of young people in formal education settings contributes to this research need.

Young people in contemporary citizen science literature

Herodotou et al (2022) suggests that there remains a limited understanding of the participation of young people in community and citizen science, in particular in identifying who participates and how their engagement is facilitated. Dunkley (2022) echoes this, suggesting that the benefits for young people, individuals and communities, of engagement in ecological citizen science are lacking in academic literature. García-Holgado et al (2020) highlight that emerging technologies have been vital in the expansion of citizen science. Aristeidou et al (2021) describe the contributions of young people following 'Bioblitz' engagement with the online 'iNaturalist' (www.inaturalist.org) platform, suggesting that the contributions of young people to such platforms is underrepresented in citizen science research. My research contributes to this growing body of research by reflecting some of the diverse ways that school pupils can engage with citizen science projects.

Weisberg et al (2023) is an example of a single citizen science project operating across multiple school communities. Along with single projects in single schools, this remains a particularly common type of research in relation to citizen science in school experiences. Other examples include Prendergast et al (2022) and their 'Pollinators in the Playground' project and Frigerio et al's (2019) reflections on a project involving primary school pupils in monitoring the endangered northern bald ibis. Weisberg et al (2023) found that there were limitations to the involvement of the students in all aspects of the scientific process, for example, the collected data was analysed by the research team rather than the students due to lack of familiarity with the analytical tools. However, the project found that the students demonstrated increased awareness about sea-lions and were highly engaged in the process. A study by Herodotou et al (2022) took a mixed methods approach to an exploration of the learning outcomes identified by young participants (11 – 19 years old) in online Zooniverse citizen science projects. Their findings suggest that "enhanced knowledge, development of science-related skills and competencies, and opportunities for enacting science agency" (ibid. p. 15) can be identified as benefits of participation. However, Williams et al (2021) suggest that, in line with Bela et al (2016) that citizen science projects are at risk of tending towards an "optimistic view of the positive effects" (Bela et al, 2016, p. 997). Williams et al (2021)'s findings evaluating a classroom-based citizen science project suggested that while content knowledge improved, expectations around increased science identity and nature connectedness were not met. These contrasting findings suggest that

there is a need to more deeply understand the experiences of pupil participants *during* the citizen science event to identify *how* such outcomes are achieved (or not). This research's exploration of the experience of pupils engaged in different citizen science projects in different school contexts intends to contribute to this meeting this gap in current literature.

In considering the mechanisms of citizen science participation, García-Holgado et al (2020) highlight that in research focused on children and young people's engagement in citizen science projects, in general, the children are not involved in identifying or setting the research intentions and do not get a choice in the activities they undertake. Furthermore, Constant and Hughes (2023) identified a lack of awareness of citizen science projects, and the cost of participation (e.g. travel and unpaid time) as barriers to young people participating in citizen science projects. Engagement in such projects during time in school has the potential to raise awareness of the existence of citizen science as a route to environmental participation for young people, and also to reduce some practical barriers as these are supported by the school. This study looks to demonstrate the utility of citizen science in school settings as a mechanism of facilitating eco-citizenship capabilities in young participants.

Dunkley (2023) takes a relational approach to a citizen science project, drawing particular attention to the "ecological kin-making practices" (ibid. p. 13). The participants in her study are adults however, and there remains the opportunity to engage with similar relational approaches with young participants in ecological citizen science projects. Furthermore, Sharma et al (2019) observe that engagement in an online citizen science project 'BeeWatch' has the potential to facilitate "close human interaction with observable species (ibid. p. 19) which can change perspectives on human-nature relationships. Again, that particular research involved voluntary, adult participants. My research looks to engage with relational interactions of humans-nature in relation to school pupils as they experience citizen science activities.

Measuring the impact of citizen science experiences

This section will consider the existing theoretical models that attempt to describe environmental action and pro-environmental behaviour, the models will be summarised and critiqued in relation to their ability to relate to the educational experience of school pupils. Following this, existing theoretical models of citizen science will be considered and examined, their relevance to school-based citizen science will be considered and the existing gap in research identified.

Modelling environmental action and pro-environmental behaviours

In developing their model of environmental action (fig. 2), Schusler et al (2009) draw on Emmons (1997) to describe environmental action as an intentional attempt to achieve a particular environmental outcome. Both scientific knowledge and civic engagement are utilised to inform and evaluate the action and whilst in an ideal situation, participation in environmental action would enable participants to define and analyse the issue in question before developing or enacting solutions, it is recognised that in practice participants may be only partially involved in aspects of the action. They also highlight that many forms of action may be present throughout a project, for example natural habitat surveying or community food growth. In their model, Schusler et al (2009) suggest that short term participation in a local environmental action will result in positive environmental and community change, the process of creating this change has the result of developing the learners' capacity as citizens in a democratic society. As such this encourages further and longer-term participation in actions which will transform their environment and their communities.

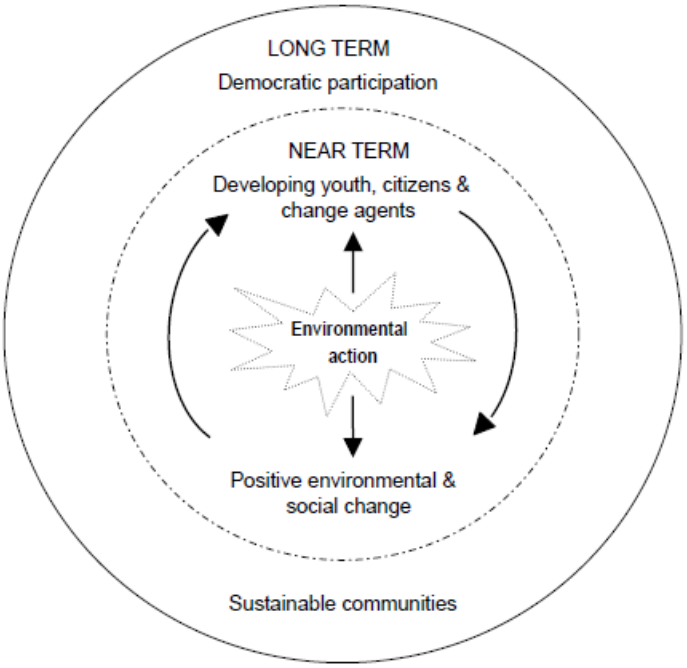

Figure 2: Schusler et al (2009) Model of Environmental Action

There is an assumption in this approach that the environmental action will result in a positive environmental or community change, however there is no certainty that the environmental action that is enacted will indeed have a positive result. Consideration needs to be given to the impact of a negative or a neutral impact of an environmental action. An example the authors give of an environmental action is the sustainable growth of food for a community,

the possibility of crop failures due to adverse weather, incorrect care or vandalism are all persistent challenges for food growers, particularly inexperienced growers. As such, if there is a negative or neutral outcome of the action, does this model suggest that a negative or neutral feedback loop will then be enacted, resulting in a lack of commitment to longer term democratic participation? Due to the complex and challenging nature of environmental action, in particular those environmental actions involving young people in a non-voluntary school setting, this would be a desperate situation indeed. In developing the model, Schusler et al (2009) draw on the action competence approach proposed by Jensen and Schnack (2006). This approach outlines the development of a participants' ability to critically assess a situation and act upon that assessment. If this approach is taken to the model, then a negative or neutral outcome may develop further capacity and resilience in the participants, which is a positive outcome for them, but not specifically for the environment or the community in the short term. A further challenge of this model that Schusler et al (2009) identify is that there is limited scope to understand the educational practices that would facilitate this type of positive feedback from local environmental action to global democratic participation. This is an area that is identified by the authors as a research gap and one which understanding the particular practices around citizen science and its impacts on citizenship learning may be able to contribute to.

In 2002, Kollmuss and Agyeman suggested that the factors that influence whether or not an individual engages in pro-environmental behaviours can be complex and affected by factors external (e.g., institutional) and internal (e.g., emotions) to the person. Early models of pro-environmental behaviour suggested a linear relationship between environmental knowledge, attitudes and behaviour which in reality is much more complex (Kollmuss and Agyeman, 2002). Influenced by earlier works by Hungerford and Volk (1990), Hines et al (1986-87) and Blake (1999) Kollmuss and Agyeman (2002) propose a model which attempts to integrate the wide range of factors influencing pro-environmental behaviours and outlines some of the key barriers to engaging in this (fig. 3).

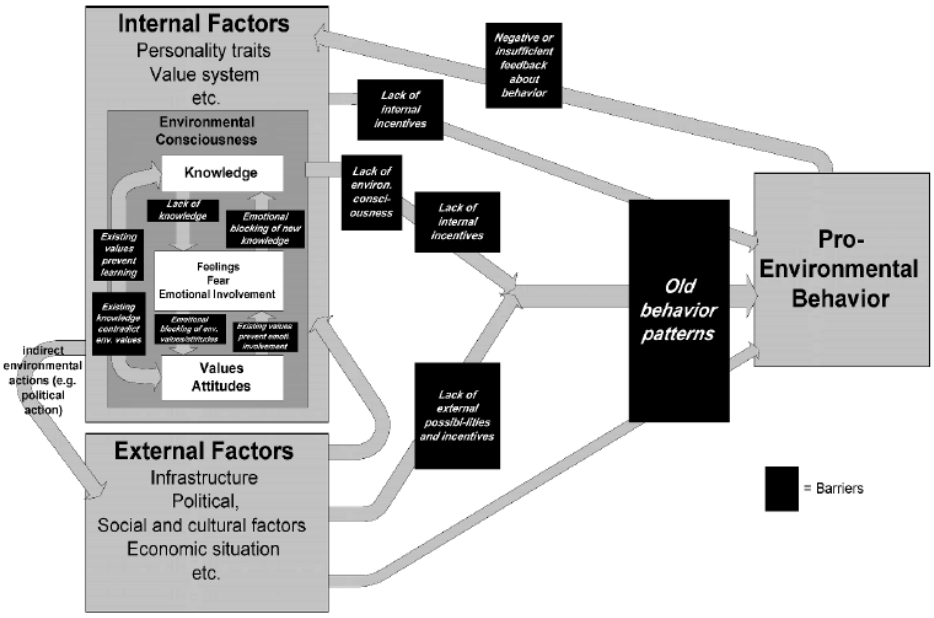

Figure 3: Kollmuss and Agyeman (2002) Model of Pro-Environmental Behaviour

Courtenay-Hall and Rogers (2002) suggest that despite Kollmuss and Agyeman's (2002) assertion that the intention of their model is to help environmental educators, there are some problematic education-related omissions in their approach. Kollmuss and Agyeman's use of the term "pro-environmental behaviours" as the main aim of environmental education is suggestive of a behaviourist approach to education which does not consider or reflect upon the critical thinking or action competences that are referenced elsewhere in the environmental education literature (Jensen and Schnack (2006) for example). Coupled with the lack of reference to teachers and teacher-led research in their paper, Courtenay-Hall and Rogers (2002) suggest that this diminishes the importance of practical knowledge that could be used to more deeply understand the ways in which environmental education is experienced. Kollmuss and Agyeman (2002) define pro-environmental behaviours in two categories; direct, for example, driving less or recycling; and indirect, for example, political activities or environmental writing. The distinction between these categories, and the importance placed by the authors on the direct form of behaviour as the desired outcome of environmental education is felt to limit the potential to develop students' citizenship opportunities. Encouraging them to be involved in the resolution of environmental issues on a national and international scale as well as the local and personal level may change the nature of their relationship with the environment and society (Courtenay-Hall and Rogers, 2002).

Citizen science represents an approach that has the potential to address the challenges raised by Courtenay-Hall and Rogers (2002) as Turrini et al (2018) suggest citizen science

has the potential to “generate new knowledge, enhance awareness raising and facilitate in-depth learning as well as enable civic participation”. Tommey and Domroese (2013) combine the ideas proposed by Kollmuss and Agyeman (2002) with a behavioural feedback model to propose a way that citizen science can become the entry point to a “virtuous cycle of attitudes, intentions to act, and behaviors working together for conservation outcomes”. This thinking echoes the ideas of Schusler et al (2009) positive feedback loop, suggesting that the small positive experiences that are facilitated by citizen science projects may contribute to engaging in positive conservation actions (Tommey and Domroese, 2013). Tommey and Domroese (2013) acknowledge that the impacts their model is based on are the perceived impacts from the perspective of participants, rather than objectively measured impacts, and as such there is room for research to more deeply understand the extent of the difference between these two positions and the implication of this for understanding the impact of citizen science.

Measuring impact in citizen science

Understanding the experience of engaging (or not) in an environmental citizen science project as part of formal secondary school experience involves not only the reflective consideration and discussion offered by the evaluation tools utilised by many existing studies (Philips et al, 2018; Aristeidou and Herodotou, 2020), but also a relational, situational approach as exemplified by Dunkley (2018) in which narrative interviews were undertaken with participants, however those participants were adult volunteers. As pupils engaged in environmental citizen science in secondary schools undertake the experience in a different way to the majority of (older, voluntary) participants (Harlin et al, 2018), it is important that research adequately reflects that experience to more fully articulate any learner or learning impacts that may be made. In order to do this direct observation of the young people as they go through the experience is crucial. The observations in this research attend not only to the content and structure of the activity, but also to the emotional and sensory experiences that the pupils can be observed to have in outdoor spaces away from the classroom.

Suave (2009) suggests that environmental education is forged in our relation to the environment, and that it is at this interface of social and ecological relations that environmental citizenship can be developed. This research looks to notice and identify those relational experiences that pupils have and explore the potential of them to lead to environmental citizenship related capabilities. As Keleman-Finan (2019) suggest, while there is an increase in the demand for evaluation tools such as Phillips et al (2018) that enable evaluation of a range of learning-based indicators, actual evaluation of the experiences of

young people engaged in citizen science remains low. They also noted that in their study, citizen science projects with primary schools were more effective than those with secondary schools, suggesting a greater degree of autonomy over subject choice as a possible explanation for this. The participants in my research are all from within the secondary sector, this is in an attempt to more fully illuminate the unique opportunities and challenges for this educational stage in implementing citizen science experiences with and for pupils.

Bela et al (2016) highlight that there is an emphasis within the existing literature on citizen science and learning on the measurement of simple, factual and instrumental knowledge. The assessment of more complex learning, both for individuals and communities is less commonly included in project evaluations and research outputs. This echoes reflections from environmental education literature which suggests that more complex and difficult to identify concepts such as affective and attitudinal responses are less well represented in the research literature (e.g., Brossard et al, 2005). My research contributes to this gap, explicitly identifying the sensory and affective responses pupils make to the citizen science experience.

Modelling participant outcomes in citizen science

In attempting to model the participant outcomes of public participation in scientific research projects, Phillips et al (2012) and Shirk et al (2012) describe the outcomes in the form of a project-based logic model (fig. 4 and 5). Phillips et al's (2012) model describes the linear stages of the project from inputs to outcomes and impact, outlining the elements that contribute to these, for example, participant time as an input, increased engagement as an outcome and enhanced scientific and civic literacy, along with improved environmental conditions as impacts.

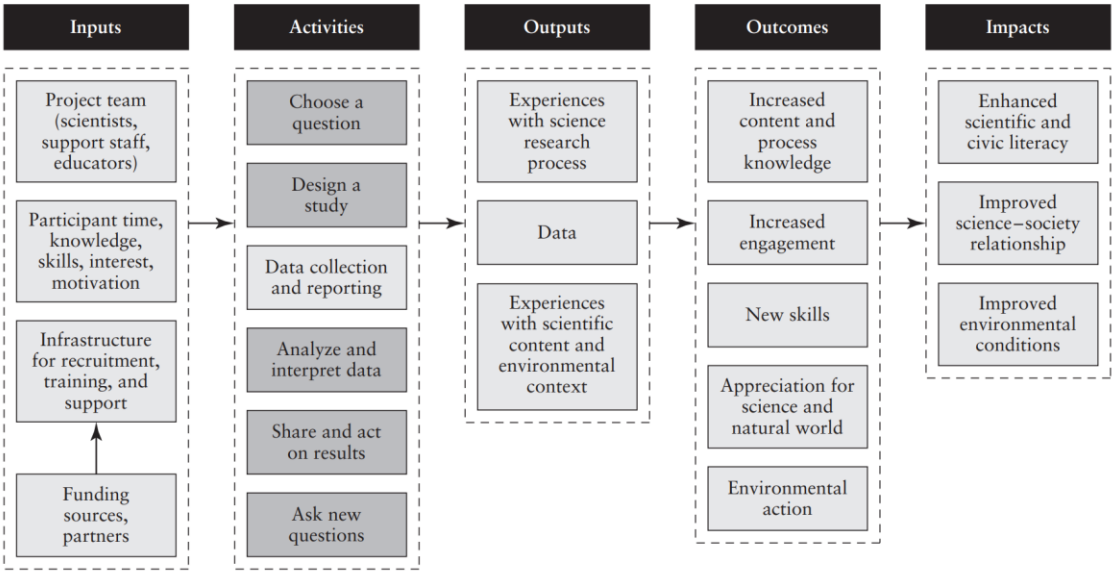

Figure 4: Phillips et al (2012) Model of Participant Outcomes in PPSR

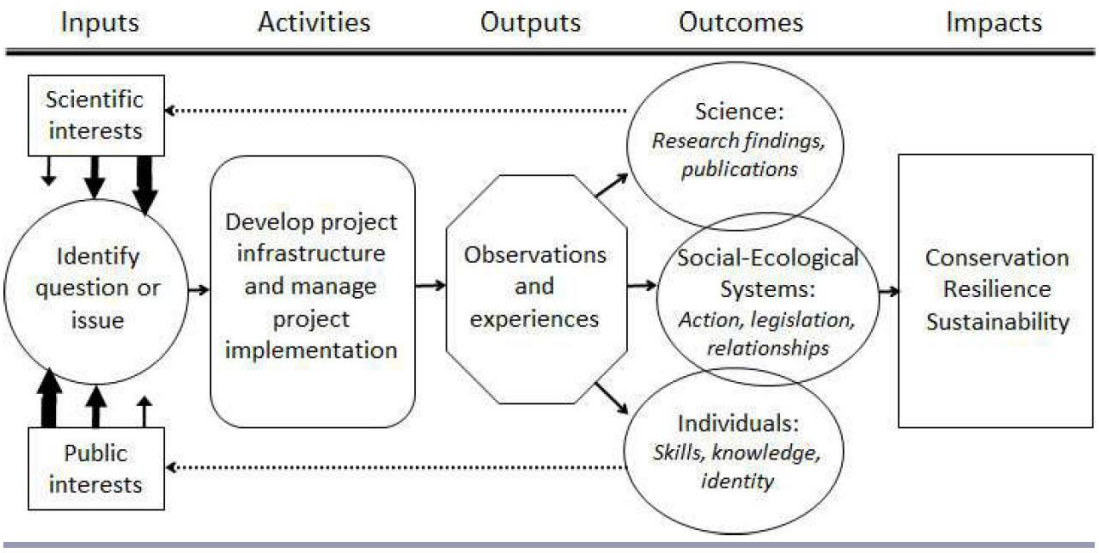

Figure 5: Shirk et al (2012) Model of Participant Outcomes in PPSR

Shirk et al (2012) bring some of these project specific elements together to develop a more generic model, where the public and scientific interests input to identify the issue in question, the outcomes categorised in terms of science, social-ecological systems and individuals, and the impacts as conservation, reliance and sustainability. The differences in emphasis between these two very similar models are an example of the different ways in which citizen science is viewed, with Philips et al's (2012) model showing a very science centric perspective on citizen science, with the project flowing in a consistent positive direction from inputs to impact, while Shirk et al (2012) emphasises the potential for a wider impact on society and the environment and recognises the feedback opportunities of outcomes feeding

into further questions. Both of these models assume that the act of participating in the study will result in identifiable citizenship-related outcomes. However, the activities and outputs identified in both models are predominantly scientific, with the emphasis on data collection and experiences with the science research process (Phillips et al, 2012) and project management, observations and experiences (Shirk et al, 2012). Only in Phillips et al (2012) is there mention of sharing and acting upon results and experiences in an environmental context which provide some insight into how these citizenship outcomes may be enabled.

Philips et al (2018) conducted an extensive literature review and survey of citizen science projects to understand the learning outcomes measured in citizen science projects, they compared these to the ISE framework and reconceptualised and clarified some of the categories, creating a new more citizen science specific set of outcomes. These include;

- Interest in Science and the Environment
- Self-efficacy for Science and the Environment
- Motivation for Science and the Environment
- Knowledge of the Nature of Science
- Skills of Science Inquiry
- Behavior and Stewardship

(Philips et al, 2018, p. 7)

The intention of this framework is to assist citizen science projects in identifying the desired learning outcomes of their project and to develop resources and evaluation materials appropriately. The authors note that the mechanisms of understanding how the learning happens in citizen science projects is an area that is missing from current research and they suggest that social theories of learning may be appropriate as they emphasise the influence of participation in social activities on learning (Roth and Lee, 2002). Philips et al (2018) suggest that “Behavior change and development of environmental stewardship” (ibid. p. 10) are among the most sought-after outcomes in science and environmental education programs, both in and out of school. As Drissner et al (2010) discuss however, in any short-term environmental experience, the opportunities to impact upon or change behaviour are limited. The curricular context of the citizen science activity imposes a restriction on the length, regularity and repeatability of the experience for the pupils. As such, understanding the nature of the citizen science experience, in particular in relation to the restrictions imposed by the formal school setting, is crucial in evidencing any potential impact of the experience on pupils’ eco-citizenship related dispositions.

In summary, the growing body of literature on learners and learning in environmental citizen science suggests that while outcome measures and impact assessment approaches predominate, there is a need for research that more deeply understands the processes and experiences for the pupils involved. My emphasis on the sensory, affective and relational experiences of pupils, their teachers and the scientists involved contributes to this important area of research need.

Section 2: Education and environmental citizenship

The concept of the citizen is fundamental in Curriculum for Excellence, the Scottish curricular framework (Scottish Executive, 2004). One of the four capacities that are the cornerstone of the curriculum is for pupils to become 'responsible citizens.' This capacity largely falls into what Kiwan (2007) would describe as the participatory model of citizenship, where there is an expectation of active participation in community and democratic decision making. Biesta (2008) makes the point that citizenship when defined as a competence, suggests that it is something that people can achieve, rather than citizenship as a practice, or a thing that people do. This capacity is explicitly identified in the Scottish curriculum as the ability to 'evaluate environmental, scientific and technological issues' (Scottish Executive, 2004). Vesterinen et al (2016) suggest that "science education is now often seen as part of wider citizenship and sustainability education" (ibid. p.30) and that there is a research gap considering the perspective of pupils in relation to the contribution of science learning to citizenship education.

There are a range of terms within environmental education that express ways of knowing about and responding to the environment. Environmental literacy for example is defined by Disinger and Roth (1992) as the ability to assess the health of the environment and take action to resolve any problems within it. However, Stables and Bishop (2001) argue that this functional approach to literacy represents a narrow or weak conception of environmental literacy which does not account for the different interpretations of environmental challenges. Sustainability literacy is described by Stibbe and Luna (2009) as the ability to act on sustainability knowledge, echoing a functional approach but broadening the conception to include social and economic aspects alongside the environment. Barry (2006) suggests that environmental citizenship should be superseded by the term sustainability citizenship, also reflecting that the narrow perspective that focusing solely on the environment may have rather than considering the social, cultural and economic elements that come together with environment to facilitate a more sustainable relationship with the planet and its resources. An alternative conception described by Olsson et al (2016) is sustainability consciousness

where the relationship between knowledge, attitudes and behaviours are considered as interrelated rather than as separate conceptions in the complexity of sustainability issues.

I have chosen to use environmental or eco-citizenship as a key component of the terminology in this research to reflect firstly, the environmental or ecological focus of the citizen science activities that the pupils will be involved in, and secondly the nature of the 'citizen' as an active participant in environmental education. Pallett (2017) suggests that "In the case of environmental citizenship, the primary focus is on regulating and reducing the environmental impacts of individual actions" (Pallett, 2017, p. 2). However, Schindel Dimick (2015) cautions against taking an individualistic approach to environmental citizenship. She suggests that young people must be encouraged to develop both critical and caring dispositions in order to successfully participate in the global political communities that will be crucial in attaining a common global perspective on environmental concerns. Hobson (2013) suggests that environmental citizenship is a commitment rather than an established state and one which the contextual factors surrounding the individual strongly influence that level of commitment. Dobson (2007) goes so far as to say;

> There is no determinate thing called 'environmental citizenship', but in the broadest possible compass such citizenship will/can/may surely have something to do with the relationship between individuals and the common good.
>
> (Dobson, 2007, p. 280)

Dedeoglru and Ekmekcioglu (2020) "argue that citizenship must have, first and foremost, an eco-centric value basis" (ibid. p. 5). Engaging young people in citizenship actions, through their experience of citizen science in school, as I explore in this research, has the potential to position the environment as a part of citizenship education in a way that is a little different from the democracy or rights-based programmes that young people more commonly experience in school.

Adamou et al (2021) conducted a systematic literature review which sought to ask if citizen science participation could lead to environmental citizenship outcomes, in particular, competencies and actions. The authors found that there was a positive association between citizen science experiences and environmental citizenship knowledge and skills, however, that the relationship with decision-making and argumentation skills and action-based competencies, was less secure. They suggest that designing citizen science with explicit 'action-orientations' will provide a way to use citizen science as a mechanism for environmental citizenship more effectively. My research contributes to an understanding of

when and how citizen science can be effective in developing environmental citizenship in young people.

Dobson's (2007) description of environmental or ecological citizenship is one which is "both international and intergenerational" (ibid. p. 282). Huttunen et al (2020) also suggest that much contemporary theorisation of environmental citizenship rejects the notion of national borders and boundaries. They suggest that this is because "the causes and impacts of ecological degradation are global" (Huttunen et al, 2020, p. 200). For young people, the scale of environmental citizenship in these conceptions has the potential to be intimidating and overwhelming. Huttunen et al (2020) describe environmental citizenship as experienced in what the authors term 'relational space' or the "networks and relations that evolve beyond the actual local qualities of the place" (ibid. p. 202). They suggest that in these spaces, it is possible to identify environmental citizenship through emerging and diverse actions, rather than the rights and responsibilities evoked in the more socio-legal framings. This description echoes the features of the feminist perspective (Lister, 1997) and the lived (green) citizenship dimensions of Kallio, Wood and Halki (2020). My research explores the local and situated experience that the pupils have and their potential to connect to wider, global environmental concerns.

Huttunen et al (2020) describe the conflicting perspectives of including non-human nature in theories of citizenship. The lack of clear, undisputed boundary between humans and the materiality of nature and environment as expressed in post-human and assemblage ontologies (for example, Delueze and Guattari, 2004, Ingold, 2000, Haraway, 2016) brings with it questions of agency and responsibility in relation to citizenship 'status'. When responsibility is considered a core component of citizenship, the entanglements of human-non-human entities that are 'responsible' for environmental issues and ecological damage become problematic in proposing solutions and reparations. My research employs new-materialist orientations to contribute to this growing debate.

Children's environmental citizenship

Children have a different perspective to adults in relation to 'citizenship' and 'environment'. The consideration of citizenship from a legal, rights-based approach does not account for the ways in which children act within and belong to communities and their environment. Hayward (2012) suggests that while children experience ecology and environment in a fluid and complex series of experiences, the adult framing and language used to describe environment and ecology is contrary to this and emphasises the distinction between the

human and non-human world. Lister (2007) describes a relational understanding of citizenship, which is defined by a ‘sense of belonging’. She suggests that this is particularly relevant in exploring how children experience citizenship. Feeling respected and able to participate in a community such as a school or local community are a key part of this conception. Larkins (2014) suggests that home, school and local areas are typically the ‘relational spaces’ in which children’s citizenship is enacted. It is in these spaces that it is important to look for ways of understanding how children enact their citizenship. Hayward (2012) suggests that “citizenship and environmental education too often fails to meet the needs of a new generation” (ibid. p. 4) as a result of failing to consider the everyday ecology of young people and does not give them the tools to understand and effect change in a complex world. My research explores citizen science as one of these ‘tools’. Lister suggests that “participation can promote responsibility” (Lister, 2007, p. 708). Participation in citizen science experiences as an example of environmental action can give pupils a real experience of participation as a citizen. However, given the constraints of the formal school system within which the experience is nested, there is a need to more fully describe the perspective of the pupils and understand the meanings that they make in the process.

Kallio, Wood and Hakli (2020) describe lived citizenship in a way that considers the effect of citizenship in real life situations rather than the formal legal status of citizenship. This conception is drawn from critical and feminist approaches (e.g., Lister, 2007) and places the embodied experience and acts of citizenship in daily life at its core. It exposes the experiences of traditionally excluded groups and is a particularly useful way of making visible the challenges around young people and their role as citizens, in particular in relation to the environment and environmental action.

Echoing Dobson’s (2007) description of environmental citizenship as international, Kallio, Wood and Hakli (2020) suggest that a “lived citizenship approach enriches and deepens our understandings of citizenship as experienced beyond the nation-state or territorial boundaries.” (ibid. p. 3). Lived citizenship as a conception aligns broadly with phenomenology, interactionism, existentialism and pragmatism, in particular the way in which each of these ideas attempt to draw attention to the everyday, mundane, experiences of people (Jacobsen, 2009). In bringing this consideration of alternative citizenships into my research, it offers a way of accessing and describing citizenship in the mundane, informal and domestic arenas, which are of particular relevance to young people in schools and domestic settings.

Rethinking citizenship and environmental education is as essential as one part of supporting future generations, “we cannot achieve sustainable human well-being and the flourishing of

a non-human world without citizens who care about sustainability and who are supported and able to act on their concerns" (Hayward, 2012, p. 5). Demonstrating understandable cynicism about effective democracy in the current neo-liberal approach, Hayward (2012) advocates that a political solution to the complex environmental challenge we are faced with goes against the neo-liberal approach of encouraging market forces and individual responsibility. Suggestions by William Ophlus (1977) that "we need less open democracy and more green managerialism", are given as evidence of frustration with existing democratic pace. However, Hayward (2012) suggests that any success of authoritarian approaches will not make up for the loss of freedom that is a core value of many (young) people. Therefore, it is important to equate meaning and action, to empower young people but also support them in the challenges that this power might bring. Feldman (2020) describes the press responses to youth climate activists. Dismissed and diminished, young people are described in deficit terms, as overly-emotional and unfamiliar with political process. There is a need to provide young people with ways to demonstrate and effectively participate in eco-citizenship actions without fear. Adamou et al (2021) suggests that citizen science might provide a 'springboard' to eco-citizenship, strengthening ties between society, nature and science. My research considers the extent to which involvement in a citizen science project might provide that 'springboard' towards more public facing eco-citizenship actions.

Citizenship, eco-citizenship and science learning

In secondary science, attending to issues of environmental concern are an important part of learning and teaching. Gray and Bryce (2006) describe the challenges of a science curriculum that must simultaneously attend to the needs of both future scientists and future citizens. These challenges are particularly evident in relation to complex and conflicting issues of environmental concern. The authors describe a traditional vision of science which is objective, formulaic and dependent on isolating 'variables'. This positions alternative perspectives on scientific and worldly knowledge as 'unscientific' and in deficit. However, the need to attend to complex socio-scientific issues requires a different approach. Drawing on Funtowicz and Ravetz (1993) idea of post-normal science, Gray and Bryce (2006) suggest that "there is a need to invite insights and suggestions from people with different sort of scientific expertise or even none at all" (ibid. p. 178). My research considers authentic participation in scientific research from the perspective of novice scientists in school settings.

Davies (2004) suggests that there are many connections between science and citizenship education, and that, as such, potential for collaboration between educators of both. Bryce

(2010) argues that '*real* science' is a way of bringing together scientific enquiry with social, political and ethical concerns, enabling pupils to explore and consider the nature of science more meaningfully. Citizen science is one way in which these wider concerns can be accessed within science learning, Jørgensen and Jørgensen (2020) suggest that "citizen science projects should help their participants make connections between the data they collect and larger environmental problems" (ibid. p. 3). My research looks to more fully understand if indeed the experience of participating in a citizen science project does connect learners to wider, global environmental issues, and if so, how is this experienced by the pupils themselves.

Pedagogical approaches which look to align science and citizenship learning are found within the humanistic and the environmental/sustainability spheres (Vesterinen et al, 2016). These include socio-scientific enquiry, place-based approaches, and eco-justice actions. The authors suggest that there is an expectation that a 'scientifically literate' citizen will be able to contribute to personal or political decision making about scientifically related issues. However, they also suggest that there is a research gap considering the perspective of pupils in relation to the contribution of science learning to citizenship education (Vesterinen et al, 2016). Jenkins (2011) suggests that for the many science students who will not go on to be professional scientists, an inquiry-based approach to science learning in schools would engage pupils in the humanistic aspects of science and enhance their appreciation and understanding of scientific issues. She goes on to suggest that Citizen Science could be a powerful way of integrating these humanistic elements into the traditional science curriculum.

Yacoubian (2018) attempts to "elucidate a vision of scientific literacy for democratic decision making" (ibid. p. 308), highlighting that whilst science literacy is a common goal of many science curricula and assessment, it is a contested term that is open to interpretation. Norris and Phillips (2003) defined the components of scientific literacy as:

> (1) knowing what counts as science and how science differs from nonscience,
>
> (2) knowledge needed for participating in science-related social issues,
>
> (3) knowing the risks and benefits of science, and
>
> (4) being able to think critically about science.
>
> Yacoubian 2018, pp 309

Norris and Phillips (2003) discuss the differences between scientific literacy as defined above and a functional literacy that has its emphasis on reading and writing as tools to

facilitate science. They suggest that educational attempts to increase science literacy focus on the scientific knowledge in the form of facts or theories and do not attempt to address the fundamental literacy that would encourage individuals to make interpretive connections to scientific information. This is suggested as a crucial component of the ability to apply scientific literacy to the scientific encounters of non-scientists in life beyond school. Mirowski (2018) asserts that “science suffers a democracy deficit” (ibid. p. 175) suggesting that citizen science has the potential to contribute to a restructuring of political power, “The more outsiders are somehow folded into the scientific process in whatever capacity, the more that the public will come to appreciate and support science and the better off democracy will flourish” (Mirowski, 2018, p.177). This is supported by the findings of Queiruga-Dios et al (2020) who report that a citizen science project in Spain (n=83) was observed to improve that participants understanding of scientific processes and to contribute to attainment of the Sustainable Development Goals (SDGs).

Levinson et al (2020) suggest that education for environmental citizenship in schools and other educational settings can support young people acting for a sustainable environment. They highlight the importance of young people, as citizens, building awareness of and confidence in their ability to influence change at a range of scales. Hadjichambis and Paraskeva-Hadjichambi (2020) present a model of Education for Environmental Citizenship (EEC) (fig.6)

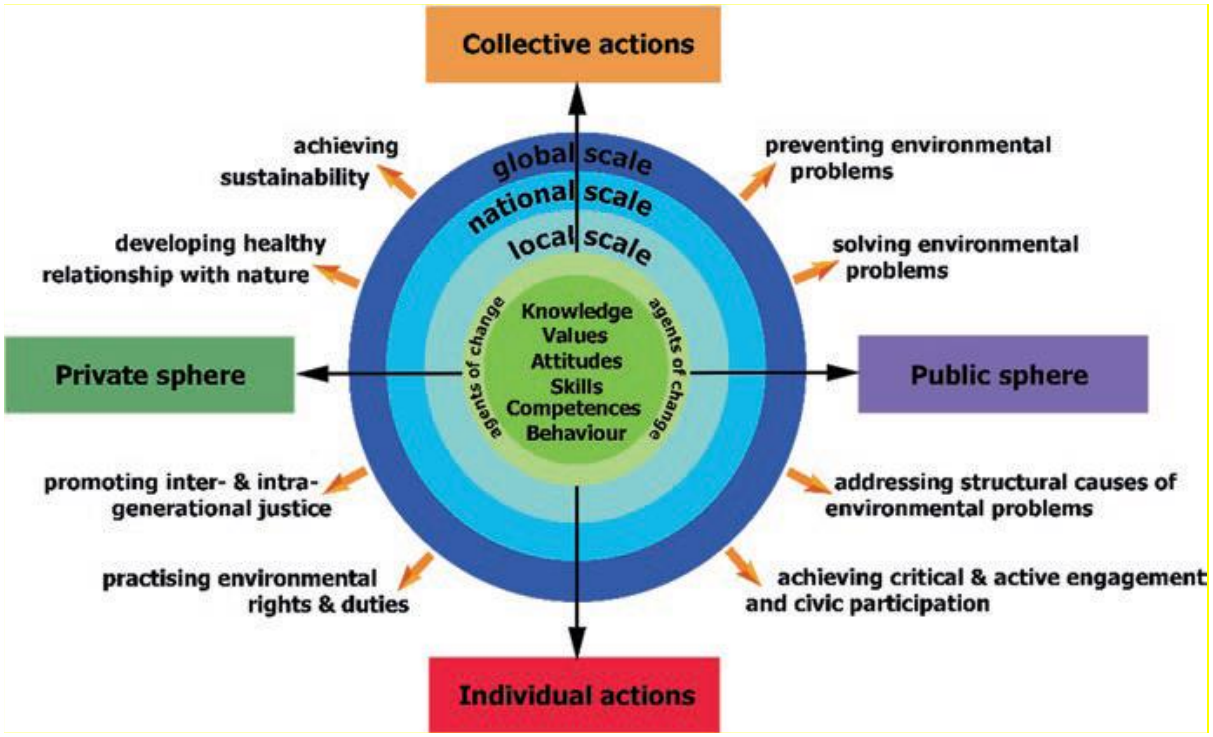

Figure 6: Hadjichambis and Paraskeva-Hadjichambi, 2020, p. 240

At the centre of the model lies the personal components that are needed to develop an environmental citizen. Surrounding this is the need for environmental citizens to act as 'agents of change'. This includes public participation and political actions, in addition to educating peers and acting to promote change in society. The model describes environmental citizenship as experienced at different scales, local, national, and global, and also in different spheres, public, private, individual and collective. The combination of these components leads to the outcomes of the model, achieving sustainability or solving environmental problems, for example. The authors suggest that while 'developing a healthy relationship with nature' is an outcome that is a major challenge for current generations, they suggest that "empowering youth to develop healthy relationships with nature can function as a treatment for the global environmental crisis" (Hadjichambis and Paraskeva-Hadjichambi, 2020, p. 244). The authors go on to suggest pedagogical approaches that they propose could promote education for environmental citizenship which includes six stages; Inquiry, Planning actions, Critical and active engagement and Civic participation, Networking and Sharing in Scales (local, national, global), Sustain Environmental and Social Change, and finally Evaluation and Reflection (Hadjichambis and Paraskeva-Hadjichambi, 2020, p. 250). Used within this framework, environmental citizen science is a tool that could be effective in achieving the outcomes set out in the EEC model.

Frameworks like that described by Hadjichambis and Paraskeva-Hadjichambi (2020) emphasis the outcomes of environmental education without fully explicating *how* those outcomes are materialised in practice. Edwards et al (2018) suggest that while the scientific content acquisition of volunteers has been measured in many citizen science projects, there has been less attention given to the understanding of wider outcomes. There is a need to move to a measure that identifies and values the processes involved for young people during their citizen science experiences. Environment citizenship involves not only mastery of the scientific content of an issue, but also an analysis of the complex social and economic challenges around the issue, alongside a critical thinking consideration of appropriate forms of action. Acknowledging the lived experience of children and young people in relation to the environment is a crucial step towards a deeper understanding of the *how* emerging capabilities can be noticed. The decision-making capacities and individual power are less in young people, in particular in formal education settings, however, citizen science as a citizenship experience can be meaningful, enabling young people to act as citizens in the now, not citizens of the future. As such this represents a much more complex outcome of a citizen science project. Citizen science project involvement may offer pupils the opportunity

to apply skills and knowledge from many aspects of their learning to a particular issue in a way that classroom-based approaches are not able to achieve.

Hadjichambis and Reis (2020) suggest that environmental citizenship is rarely positioned at the heart of many educational approaches that could benefit, including sustainability, science and environmental education. Many authors choose to consider 'environmental', 'ecological' and 'green' citizenship to be interchangeable terms (e.g., Huttunen et al, 2020, Latta 2007), Dobson (2003) however, argues that ecological citizenship offers a more holistic and interconnected vision than environmental citizenship. Agreeing with Dobson (2003), my research contributes to the field by positioning eco-citizenship at the heart of my investigation into pupils' experiences of citizen science. This leads me to the conclusion that there is a need to explore citizen science as a lived eco-citizenship experience for young people in formal schooling. What are the opportunities afforded by citizen science and how is the curriculum refracted through the experience?

Conclusion to the literature review

In summary, the growing body of literature on learners and learning in environmental citizen science suggests that while outcome measures and impact assessment approaches predominate, there is a need for research that more deeply understands the processes and experiences for the pupils involved. My emphasis on the cognitive, affective, sensory, and relational experiences of pupils involved contributes to this important area of research need. Drawing on the literature considered here on children's environmental and ecological citizenship, this study will explore citizen science as a lived eco-citizenship experience for young people in formal schooling. By identifying eco-citizenship capabilities and the conversion factors that may be stimulated by participating in citizen science project, I am able to contribute to the need to understand how young people can act in a meaning-focused way to the challenges of the Anthropocene. This literature review supports the need for this study on the following grounds:

- A need to understand how to better engage and support young people, as citizens in addressing environmental issues.
- A need to understand the role that environmental citizen science experiences, in school settings, can play in supporting young people to address environmental issues.
- A need to use different theoretical and empirical approaches to understand the lived experiences of young people in the development of eco-citizenship capabilities.

Following on from both sections of the literature review, the following research questions have been identified to describe the processes involved for pupils in experiencing citizen science activities in relation to eco-citizenship capabilities.

RQ1: What contribution is made by fieldwork experiences in curriculum-based environmental citizen science that supports eco-citizenship capabilities?

RQ2: What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities in young people?

RQ3: What conversion factors contribute to the development of eco-citizenship capabilities in young people's experience of environmental citizen science in schools?

Chapter 3: Methodology and Method

This chapter outlines the methods used and theoretical lenses applied in my research. Firstly, an overview of the research process outlines the substantive components as they were implemented across my project. Each component is then separated out, highlighted on the process flow diagram (e.g., fig 7) and described in detail. It should be noted that while this is presented in a broadly chronological order, there was significant flow between the stages.

Research overview

MICCI was the project which sparked my interest in environmental citizen science as a phenomenon. As such, MICCI was identified as the first of the cases in my study. Initially conceived as a comparative case study, OPAL was identified as a suitable comparison case. I had experience of both cases and as a teacher felt that they offered different experiences for the pupils involved. A third case was identified in association with one of my supervisors, he was involved in a citizen science project that was sufficiently different from both MICCI and OPAL to bring a relevant, third perspective to my investigation.

An initial sensitising concept, environmental or eco-citizenship was identified. I was interested in the citizenship-related actions that were enabled in pupils as participants in the citizen science projects. Time was of the essence as the annual nature of the MICCI project, scheduled to coincide with National Science week, would only take place once or at most twice during my data collection window. A pilot study was developed in which a series of data collection approaches were tested alongside my understanding of eco-citizenship as a concept. Reflections and revisions followed and a final set of four data collection approaches were selected. The Capability Approach was introduced as an alternative theoretical consideration to the concept of environmental action.

Situational Analysis was identified as the overall analytical approach for my research as its attention to the complexity of a situation involving multiple stakeholders was particularly relevant for considering the different components of citizen science projects. Additionally, its explicit inclusion of the more-than-human was particularly appropriate in attending to pupil experiences in fieldwork locations beyond the classroom. Situational Analysis involves four types of maps; messy, relational, social worlds and positional. In my research, each type of map was created in response to the data collected in relation to all three cases, however, messy and relational maps were the most important to me throughout.

Following the first stage of relational maps, which predominantly, though not solely, reflected the participant observations and selected survey responses, I identified findings relating to fieldwork learning and more-than-human encounters. However, while there were some differences between the cases, the palpable, emerging eco-citizenship capabilities across all cases became more important for me to understand, as such a return to theory and the data was required. A second stage of relational maps re-turned (Barad, 2014) to these findings in the light of a component of the Capability Approach, that of conversion factors, and the conception of Lived (eco) Citizenship. This led to the final eco-citizenship capabilities findings that mark the end point of this research project.

The following diagram (fig. 7) describes how these stages informed and reflected each other. The remainder of this chapter will take each of these stages in turn and describe its role in the progression of my research.

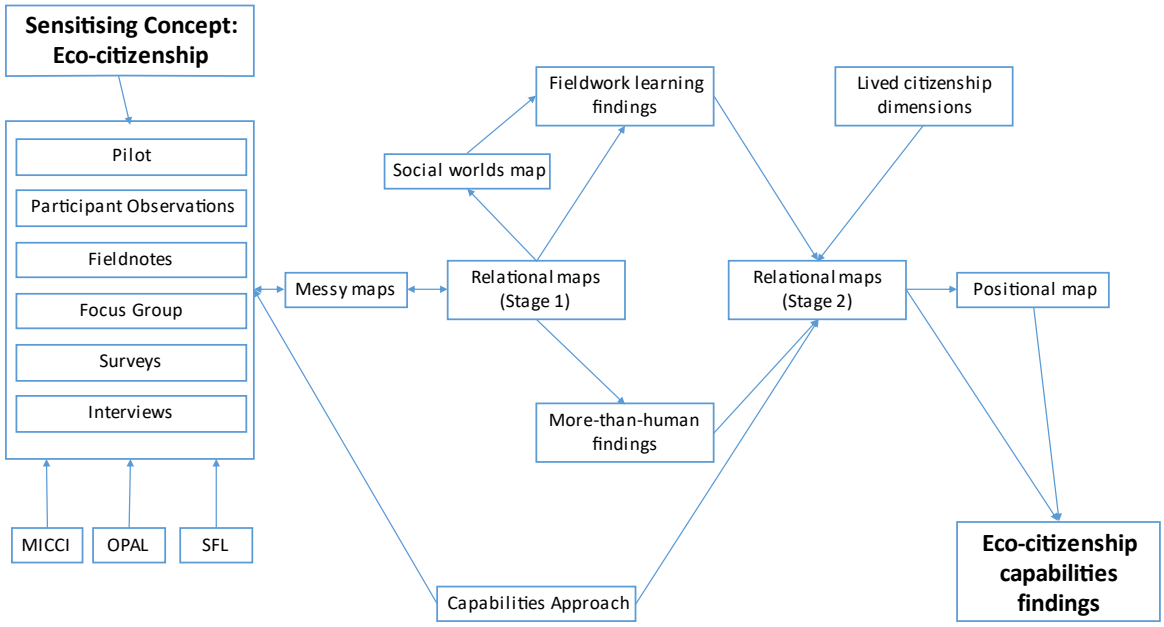

Figure 7: Overview of my research process

The cases

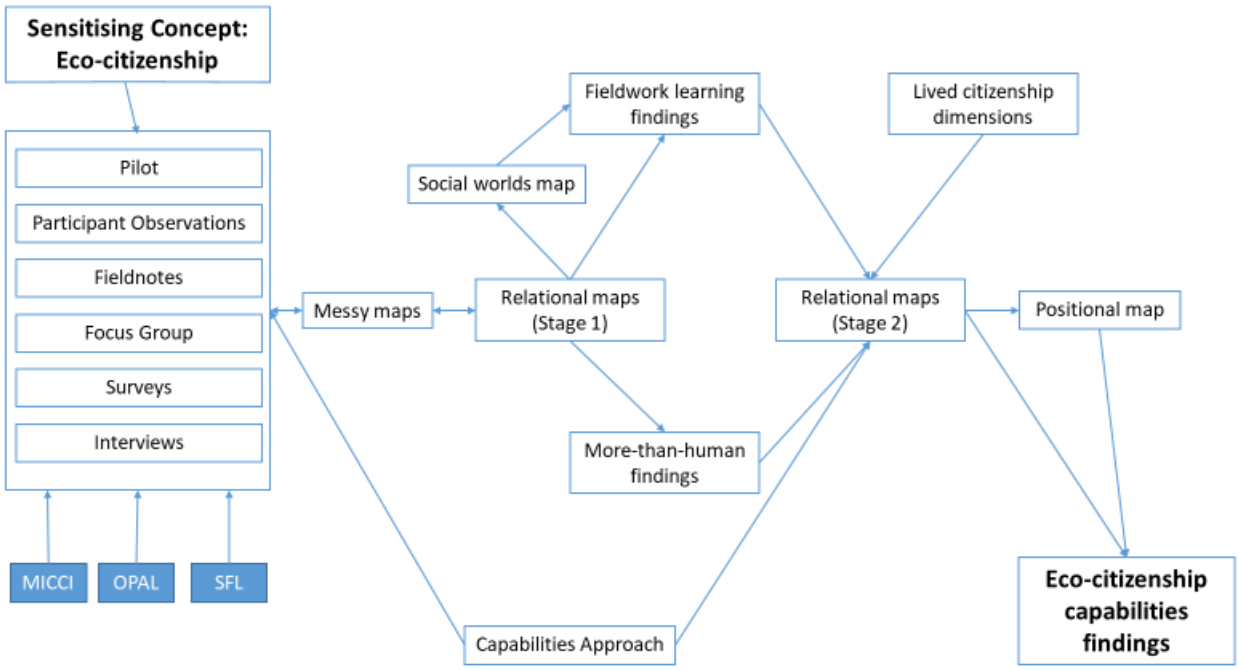

Figure 8: Overview of my research process with the research cases emphasised

Case study research background

My research took a mixed methods case study approach to the phenomenon of environmental citizenship outcomes as experienced in citizen science projects. Case study research "has gained credibility as a research methodology in exploring complex phenomenon based on the real context." (Bhatta, 2018) I felt that as the environmental citizenship outcomes and dispositions experienced by young people in formal education are complex and context dependent, a case study approach would allow the complexities and contexts to be attended to in a rigorous and reflective manner.

Stake (1995) suggests that there are three types of case study, the intrinsic case, where the case in itself is the focus of interest. Secondly, the instrumental case, where a particular element of the case is the focus of interest. Finally, a collective case study, where multiple cases are studied to bring the area of interest into focus across a range of circumstances. My study is representative of the final category, the collective case study. Comparison across and between citizen science typologies was intended to enable the experiences for pupils to be understood in relation to how and when they have been encountered.

Stake (1995) suggest two main data collection approaches, observation and interview. He suggests that the observations should be directed by the area of interest, eco-citizenship

capabilities in this case. Observations can be quantitative and qualitative in nature. In this research, the orientation is predominantly qualitative, there are however a small number of quantitative components included. These, in general, facilitate comparison between cases in a clear and concise way. Stake (1995) asserts that while the case in question will not be seen the same way by all involved, using interviews is a method of uncovering and representing the multiple realities of the case. Interviews will be used in this study with both the adults and the young people, however the manner of conducting the interviews will be different in order to acknowledge the different understandings and articulations possible between the different actors in each case.

The selection of the cases is critical to the success of a case study approach (Thomas, 2016). The cases in my research (fig. 8) were selected for their exemplification of specifically different approaches to Citizen Science as defined by Riesch (2015), contributory and collaborative. The cases also exemplify the opportunity of locally experienced environmental citizen science projects to connect with global environmental issues, allowing me to investigate the potential links that pupils are able to make during their experiences.

The first case took a broadly ‘collaborative’ approach, where the data collection location and methods are developed with the assistance of a local scientist. This case, Moorland Indicators of Climate Change (MICCI), included data collection and experimental analysis techniques relating to the health of Heather Moorland. Pupils conducted research in the field and worked with a scientist to process and analyse the data. The connection to global climate change issues was explored throughout this particular case.

The second case, the use of an Open-Air Laboratories (OPAL) framework, fell into the ‘contributory’ model of citizen science, where participants gather data in a research programme designed by scientists. Using OPAL tools, pupils collected and submitted data on a range of environmental issues, including tree health and air quality. This case was selected as the model is the most common form of environmental citizen science and the high levels of variable control make it a popular approach for the scientific community.

The ‘Understanding Soil Fertility Legacies in Coigach-Assynt’ project is a further example of a contributory citizen science project operating on a smaller scale than OPAL. The impact of local relationships was a key aspect of this project. The project connected to wider global issues around soil fertility and food production.

Case study methodology and SA are compatible in that they both look to understand the depth and complexity of a particular ‘thing’. Thomas (2016) describes the definition of a ‘case’ in terms of a container, or as a ‘bounded’ unit of investigation in which everything

within the case is considered part of the research. Alternatively, Thomas (2016) also suggests that a 'case' can be considered a situation or an event and include "the set of circumstances that surround this" (ibid. p. 13). Clarke et al (2018) draw on interactionist and pragmatist theory (Mead and Dewey, for example) to suggest that a 'situation' is "both an object and an ongoing process" (ibid. p. 71). The authors emphasise the ecological and relational interactions that embody a 'situation', suggesting that a situation has a momentum of its own which is "greater than the sum of its parts" (ibid. p. 71). There is a tension, however, between the methodological stances taken between the comparative/exploratory case study approach and the more post-qualitative position explored through situational analysis. As Clarke et al suggests, situational analysis is not particularly compatible with narrative or descriptive case studies, as SA intentionally pulls "narratives apart analytically" (Clarke et al, 2018, p. 366). This tension was helpful throughout the analysis as it prompted me to consider not only what was visible and important to me (as researcher) in the experiences, but how and why they might matter to the participants and to the conception on eco-citizenship more broadly.

The school demographics

The following table provides some background information on the school groups involved.

Table 1: Sample school demographics

School	MICCI School 1: March 2019	MICCI School 2: October 2019	MICCI School 3: October 2019	OPAL School 1: September 2019	OPAL School 2: October 2019	Soil Fertility Project: October 2019
Description	Scottish Semi-rural comprehensive secondary school	Scottish semi-rural comprehensive secondary school	English Academy Trust School, urban location	British Independent school in Spain, urban setting	Scottish urban comprehensive secondary school	Scottish rural comprehensive secondary school
Curricular area	S2 science class	Advanced higher geography	Eco-group mixed year groups	A-Level Biology	S1 Green Gym Nurture Group	Higher and Advanced Higher Geography class
Number of Pupils Gender ratio	17 8M:9F	10 0M:10F	4 0M:4F	19 7M:12F	3 1M:2F	8 2M:6F
Adult Interviews	1 teacher (early career) 1 scientist	1 teacher (experienced) 1 scientist	1 teacher (survey) 1 scientists		1 teacher (mid-career)	1 teacher (mid-career) 1 scientist

Ethical considerations

Consent

Recruitment of the participating schools was initiated via the scientists involved. Schools that were already participating in citizen science (or related environmental education) projects were invited to participate in the research component. Participant information was sent to the teachers, a follow-up conversation was held if needed. This gave the teachers the chance to address any concerns that they may have in relation to the research and associated consent procedures. Participant information sheets (including parental information for those participating pupils under 16), were issued ahead of the participant observation data collection days. Most groups had an information session prior to the fieldwork day and a part of this was allocated to revisit the participant information sheets and discuss the pupils' consent to participate. Where an introduction in advance was not possible, time was allocated at the outset of the participant observation to do this. Participants, both pupils and adults, were assured that their participation was entirely voluntary, and that it could be withdrawn without consequence at any time during the data collection days (and for a short time afterwards). Following each data collection activity, I spent time explaining to the participants what I had noted or recorded, asked them to confirm the accuracy of this and that they were comfortable with its ongoing use. Written consent was then requested of the participants (independently if 16+, including parents if under 16) at the end of all data collection sessions.

I was able to attend additional MICCI fieldwork days during the autumn of 2019. The data from these additional participant observation fieldwork days and focus group sessions were not included in the research as parental consent was not able to be obtained via the schools. There had been a particularly short lead in time for my attendance and it wasn't possible to hold an information session ahead of the fieldwork day. These sessions undoubtedly informed my research, however, I felt that the pupils did not have the same opportunity to fully understand their involvement in the research and as such should not be reported on at this time. In one of these cases, four participants were included as written parental consent was received, however, only their survey responses were used so as not to include any of the other pupil's contributions.

Anonymity

Video (in the pilot study only), photographs and audio recordings were used throughout the research. All identifiable contributions were anonymised (or pseudonymised where

appropriate) and the source material deleted. Images of the fieldwork days, some of which contained identifiable images of the pupils, were used as reflective tools in the focus groups. The pupils were asked for permission for me to use these in the analysis stages and in the research outputs, they were all happy for me to do so.

Positionality of the researcher

In this research I was acutely aware of my position as both insider and outsider in my relationship with the participants. As none of the pupil participants were known to me, from their perspective, I was an outsider. However, I am demonstrably a teacher, it is a part of my identity that I hold strongly and choose to value. I have considerable knowledge of both the fieldwork sites and topic-related content that was involved in the tasks. I engaged with the pupils via their own class teachers, who were present in most, though not all, of the data collection events, and I was introduced alongside the scientists working with them on the activities, many of whom I share a professional history with. As such, I recognise that it would have been difficult for the pupils to 'opt out' of participating in the activities or the research components, even though I made sure to emphasise this possibility regularly throughout the sessions. In my relationship with the adult participants, I felt that my perspective as someone known to many of them, with a shared interest in the topics in question positioned me in a positive light. I felt this enabled the participants to be honest and open in our discussions in a manner that may not have been the case with a stranger. I was, however, careful to revisit the provided responses with the participants, where appropriate, to ensure they were comfortable with their responses being included in the research and that any personal, non-pertinent content was omitted.

Theoretical lenses

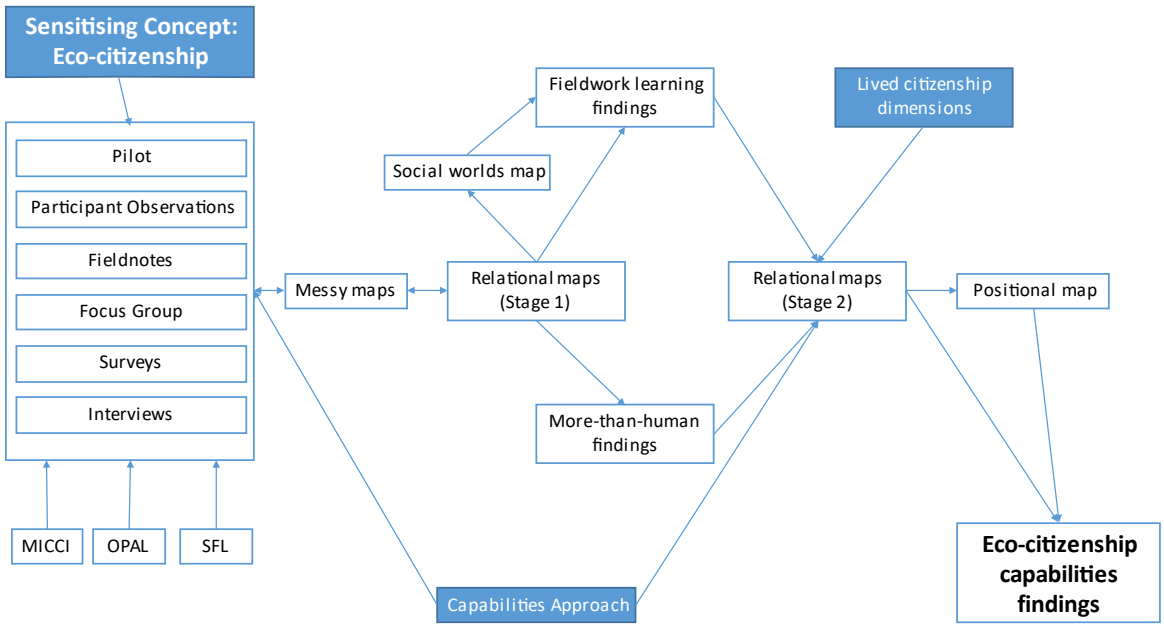

Figure 9: Overview of my research process with the theoretical lenses emphasised

Three theoretical lenses were applied at different stages of my research (see fig. 9), this section provides some background and definitions on each and illustrates how they were applied in my research.

Eco-citizenship

Environmental or eco-citizenship reflects not only knowledge and awareness of environmental issues, but the capacity to actively participate in decisions about the environment (Dobson, 2007). Barry (2006) suggests that citizenship can be a continuum from passive to active participation, an individual's position on that continuum can be affected by many factors internal and external to their own value system and relationship to an environmental issue. Hoskins et al (2012) suggest that two main competencies contribute to active citizenship; "knowledge and skills, and positive attitudes towards participation" (Hoskins et al, 2012, p. 423). This echoes the sentiments of Jensen (2002), who suggests that although knowledge cannot be shown to directly influence behaviour, the types of knowledge and the methods of acquiring that knowledge cannot be disregarded entirely in attempting to understand the imperative to act. Hobson (2013) suggests that a responsive environmental citizen may be someone who is prepared to "take personal and positive action" (Hobson, 2013, p. 66) on a particular issue as they experience or become aware of it.

Action can also be found in the outcomes identified by Haywood et al (2016), the collective and individual actions that are the product of the citizen science experience in their view. While Hawthorne and Alabaster (1999) outline nine different components of environmental citizenship, including environmental information, awareness and concern, they suggest that is the combination of the ability to understand, evaluate and act for the environment that make up environmental citizenship. How might 'action' be conceptualised in environmental education and how could this could be identified in the experiences of the young people involved in citizen science activities? While Hobson (2013) attempts to conceptualise environmental citizenship, she also suggests that a priori definitions, such as environmentally aware purchasing or talking about environmental issues with friends or family, might limit the identification of 'faint traces of environmental citizenship' (Hobson, 2013) that have the potential to be identified in the conversations and everyday experiences of people.

Jensen (2002) defines action as that which is "directed at solving a problem and it should be decided upon by those preparing to carry out the action" (Jensen, 2002, p. 326, emphasis in original). Jensen and Schnack (2006) go on to describe the action competence approach which brings together an analytical approach to environmental problems and the ability to participate in action for environmental objectives. Actions can be direct, contributing directly to the resolution of the issue, or indirect, influencing others to contribute to a resolution. Action competence as a concept includes the capacity to act in the present and in the future, Jensen and Schnack (2006) suggest that while action competence cannot be described in terms of the actions performed, that the actions performed can be identified in developing action competence. It is suggested that while experiences and actions are always particular to the individual, common experiences are found throughout society, in schools as a particular example. Jensen and Schnack (2006) go on to suggest that the collective understanding of these common experiences has the potential to lead to collective action which defines a functional democracy.

Competencies are defined by Rieckmann (2012) as "interplay of knowledge, capacities and skills, motives and affective dispositions" which enable self-directed action (Rieckmann, 2012, p. 129), and by Jensen and Schnack (2006) "being able, and willing, to be a qualified participant" (Jensen and Schnack, 2006, p. 473). Sterling et al (2017) suggests that a competencies-based approach can go some way to bridging the knowledge-action gap in sustainability education. However, the authors acknowledge that literature on sustainability education outcomes uses the terms competencies, skills and capabilities synonymously to

reflect the idea of understanding a concept and acting in response to the context of the challenge, despite the differences in their true meaning.

Following the pilot study, I became increasingly conscious of the limitations of using an action competence approach in my research. The eco-citizenship 'outcomes' that I was looking for could be considered to be tentative, palpable and emerging, rather than strongly articulated in the pupils' responses or behaviours. Reflecting on findings by Stern et al (2014) that a focus on knowledge gain and behaviour change provides only a superficial understanding of the "*why* and *how* it works" (ibid. p. 603), I was prompted to explore alternative approaches to understanding the experiences of the pupils. The next two sections describe these approaches and my application of them in my research.

The capability approach

An alternative conception to the action competencies approach is the capability approach (CA)' (Robeyns, 2017). The conception of capabilities as described in the CA enables a more nuanced understanding of action. In this approach it asks "what people can do and be (their capabilities) and what they are actually achieving in terms of beings and doings (their functionings)" (Robeyns, 2017, p. 9). In the first analytical stage, I utilised the eighth of Nussbaum's (2011) central capabilities, the 'other species' capability to inform my data collection. In doing so, I was interested in how, if at all, the citizen science experience had changed, or encouraged the pupils to reflect on their relationship with animals, plants and the world of nature.

The CA includes a series of evaluative 'conversion factors' which allow the degree to which an individual can convert a resource (a citizen science experience, in this case) into a functioning (an environmental citizenship 'action') be understood. The first of these is 'individual' conversion factors, or things which affect the participants own person or body, the second is 'social' conversion factor which relate to the social structures affecting the individual, and finally, 'environmental' conversion factors, which engage with the physical landscape within which the experience occurs. These conversion factors offer a unique perspective that is missing from the competencies/outcomes approaches commonly used in evaluating environmental experiences and will be used in this case to more deeply understand the transition that pupils undergo between the citizen science experience and the potential of undertaking environmental citizenship actions.

The conversion factors component was brought in in the second stage of my analysis. These were included in the relational maps with the intention of identifying the elements, if any, of the citizen science experience that could be considered personal, social or environmental

conversion factors. These were also reflected in the second survey questions, to find out how young people related to eco-citizenship more widely.

Lived citizenship dimensions

Kallio, Wood and Hakli (2020) describe lived citizenship in a way that considers the effect of citizenship in real life situations rather than the formal legal status of citizenship. This research strand draws upon that conception, placing the embodied experience and acts of citizenship in daily life at its core. Lived citizenship exposes the experiences of traditionally excluded groups and is a useful way of making visible the challenges surrounding young people and their role as citizens, in particular in relation to the environment and environmental action. This is particularly relevant in considering the experiences of young people who, through formal schooling, will be exploring their role as citizens and considering what that means for them and their relationship with the ecological world.

Four dimensions of lived citizenship, described by Kallio, Wood and Hakli (2020) were applied in my analysis of the second stage of relational maps, these were:

Spatial

Drawing on Lister et al (2007) the context and circumstances of life cannot be separated from the experience of citizenship. The spatial dimension highlights the relationship between the global and local citizenship realms and looks to draw out connections between public and private worlds.

Intersubjectivity

The intergenerational and interpersonal experiences that locate citizenship related experiences within and across communities. This dimension highlights the relational experiences of citizenship, working with others, peer pressure, family relationships and communication.

Performed

This refers to the actions and practices associated with citizenship, related to “Acts of citizenship” by Isin and Nielsen (2008) and describes the constitution of subjects as citizens in respect to their own actions or behaviours. These actions are those which assert the individual as a citizen at a range of different scales and positions, not just individual-group or formal-informal.

Affective

This dimension looks to illuminate the feelings associated with being a citizen, this can relate to belonging, in relation to a nation or a community, but it can also be expressed as attributes of care and responsibility.

Applying these four dimensions to my research enabled me to "recognise the embodied, relational and lived experiences of *being* a citizen in everyday life" (Kallio, Wood and Hakli, 2020, p. 1). This enabled me to notice and define the actions and behaviours of the pupils *within* their experience of the citizen science project. In drawing particular attention to their responses to the more-than-human encounters of their fieldwork experience, I was able to reflect on the meanings that the pupils are moved to make from these.

Alternative theoretical approaches

Alternative theoretical approaches could have been used in this study, for example, an 'ecological conception of agency' (Priestley et al, 2015, Biesta and Tedder, 2007) could have been appropriate in place of the capability approach. The practical-evaluative component of this model offers a relevant way of considering the dimensions that may influence the actions of pupils in engaging with a citizen science activity. There are, however, important temporal considerations in that articulation of agency (e.g., life histories and future orientations) that are somewhat less visible in the single event experience of citizen science in formal schooling. To explore the citizen science experience further, Biesta's 'pedagogy of the event' (2015) offers an alternative to situational analysis in looking deeply at what happens *in* as well as *to* the learner during the activity. It is "a pedagogy that is oriented positively towards the weakness of education. This is a pedagogy, in short, that is indeed willing to take up the beautiful risk of education" (Biesta, 2015, pp. 140). The methodological clarity of this approach is more open to interpretation however, and as a newcomer to the field, situational analysis offered a clear structure to use (and challenge) in coming to a rigorous interpretation of my data. As such, the application of situational analysis and the capability approach to the three citizen science cases was felt to be the most appropriate theory-methods package for this study.

Data collection

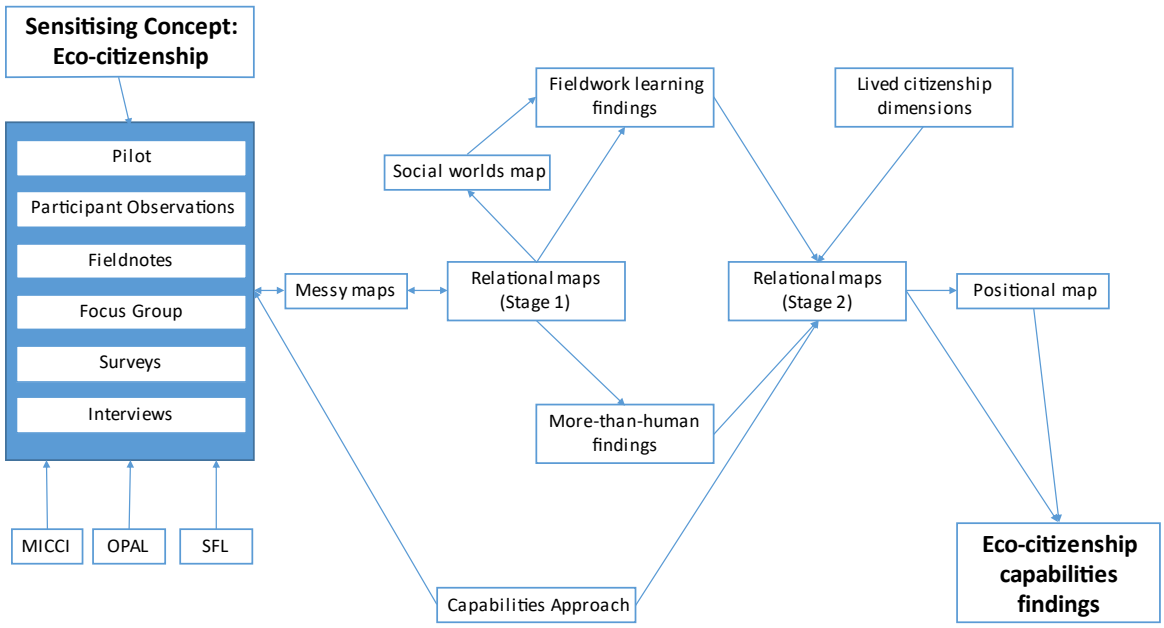

Figure 10: Overview of my research process with the data collection approaches emphasised

Pilot study

The data collection approaches taken in this study are identified in fig. 10. The following sections will describe each of these in turn. The pilot study involved MICCI school 1. There were three components to the activity, a pre-visit session with the class hosted by myself and the NP ranger, a full day fieldwork session in which I tested a range of options for recording fieldnotes, and finally a follow-up classroom session in which survey instruments, focus group discussions with pupils and semi-structured interviews with the adults involved were conducted. The responses and reflections on these informed the main data collection stage that took place later in my research.

Participant observation

"Observational studies have been fundamental to much qualitative research."

Silverman, 2017, p. 193

While observational data can be collected and analysed in both quantitative and qualitative ways (Simpson and Tuson, 1995), this study has taken a 'naturalistic' approach to observation. This involved observing the pupils throughout the fieldwork day without assigning pre-determined categories or counting examples of behaviour. While I hoped to observe discussions or behaviours that suggested environmental citizenship dispositions, I

felt it was important to determine if these could be seen in the natural behaviour and discussions of the pupils or if more targeted elicitation would be required to identify such dispositions. I recorded the data in a number of ways to maximise the quantity of data and to ascertain the most effective means of recording the experiences of the day, whilst also participating in the fieldwork experience with the pupils. Whilst participant observation can lead to some blurring of the boundaries for the researcher, it can result in a greater depth of data as the researcher is fully immersed in the activities rather than an outsider (Simpson and Tuson, 1995). I included three approaches to assembling fieldnotes on the pilot study day; firstly, I took pencil notes throughout the day, recording examples of conversations, the responses and behaviours of the pupils to the environment and the interactions they had with the human and non-human actors in the space. Secondly, I made verbal audio recordings immediately after the pupils departed the field study site in which I described any further interactions or details of the day that seemed pertinent. Finally, I used a body camera to capture a video recording of the day, I switched this on and off throughout the day in an attempt to capture what I felt were the more relevant components. I also considered this in effect a cross checking tool, I referred back to the video after I had drafted the first fieldnotes to ensure accuracy of the recorded conversations and to revisit the scene. Phillipi and Lauderdale (2018) suggest that effective fieldnotes can not only enhance the depth and rigour of qualitative research, but can also help to situate the research in its wider context. As my analysis of my fieldnotes was intended to lead to social and positional maps, it was important to me that the wider contextual elements, such as references to curriculum or social media influences, were recorded during the fieldwork day for incorporation into the later analysis. Images were also taken on the day to contribute to the photo-elicitation task in the focus group session.

Focus groups

The focus group session was undertaken exactly one week after the fieldwork day, and was delivered as a workshop style session including a series of activities that allowed different aspects of the fieldwork to come to the fore. In order to enable the pupils to effectively share their experiences with me, I devised a range of elicitation tasks. Barton (2015) suggests that elicitation techniques are “research tasks that use visual, verbal, or written stimuli to encourage people to share their ideas” (Barton, 2015, p. 180). Barton (2015) suggests that when research topics are complex; climate change, environmental citizenship, for example, or tacit; relating to teaching and learning approaches, elicitation techniques can be a valuable way of enabling more engaged responses from participants than may be achieved by asking straightforward questions. Furthermore, the nature of the elicitation tasks can be

more familiar to the participants than a formal interview or survey and as such put them at ease and encourage greater articulation of their ideas and experiences (Catterall and Ibbotson, 2000). In this research, I designed the elicitation tasks to reflect tasks that pupils may participate in during normal lessons, and as such provide a sense of familiarity for them. Only the recorded focus group discussions, which took place out with the classroom in small groups deviated from what could be considered normal classroom activities.

The tasks that pupils were involved in during the pilot phase included a recorded discussion, photo elicitation task, a sentence completion task and a free-writing task. Each of these tasks will be described and the analytic approach to the data collected outlined in this next section.

Recorded discussion

This involved a series of questions, including open and closed questions, asking pupils to recall their experience and explain the impact and importance of that experience. Three groups of between 4 and 6 pupils were extracted from their classroom and they spent around 10 minutes with the researcher discussing their experience of citizen science. The recorded discussion has the advantage of flexibility, the researcher can respond to the pupils' recollections and prompt them towards relevant areas of research interest as needed. Furthermore, the social nature of the discussion can stimulate memories, thoughts and corrections relating to how each individual experienced the topic or event in question (Delamont, 2012). On reflection, the pupils in the pilot groups appeared somewhat self-conscious in the discussions, though this varied between groups and pupils. As such, some individual pupils may have felt less confident in contributing to the discussion and their experiences are therefore less represented in the final results. This reflects the challenges outlined by Delamont (2012) suggesting that social relationships may be inhibitory to some participants and that the researcher must ensure that dominant individuals are not able to command the attention of the group.

Photo-elicitation

Four images of different elements of the fieldwork day were presented to the pupils and they were asked to give each a title and annotate them with any memories or words that they could think of in association with the image. This is an example of an 'associative technique' (Catterall and Ibbotson, 2000), where the participants are stimulated to contribute a wide range of responses using, in this case, a visual prompt. Using images, I was able to direct the pupils to consider elements of the fieldwork day that may have been forgotten or held low importance to them at the time (Barton, 2015). Banks (2001) suggests that the use of the

same images with different participants allows the range of perspectives and reflections on the same experience to be expressed. However, my selection of the images may be considered a restriction of the pupils' ability to reflect the elements that they found important (Elden, 2013).

Sentence completion

I issued the pupils with six sentence stems and asked them to complete the sentence in their own words. For example, the pupils were given 'Moorlands are important because….' they were then asked to complete the sentence as they felt most appropriately reflected their experience. The pupils worked individually but were allowed to discuss the responses in table groups. The stems varied in length and complexity to give pupils both simplicity in completing the task with long stems and the opportunity to provide longer, more elaborate responses when stems were shorter (Barton, 2015). Sentence completion is a simple and practical task that was familiar to the pupils, this has the potential to overcome barrier responses and encourage pupils to be less self-conscious than they would be in, for example, the recorded discussion (Catterall and Ibbotson, 2000). However, the simplicity of the task may lead to satisficing behaviours as experienced in survey research (Hamby and Taylor, 2016).

Blog posts

In a final written task, I asked the pupils to write a short (1/2 A4 page) blog post with prompts including 'what the moorland looked, felt and sounded like', and 'what your fieldwork is part of and how your data will contribute to this'. This is an example of an 'expressive technique' (Catterall and Ibbotson, 2000) or as Barton (2015) describes a 'construction task', in which the participants are encouraged to generate a novel construction, which could be, for example, a written piece, role play or dramatic production. I felt that this offered the pupils the opportunity to reflect on their experience in a free and unstructured way, enabling their own reflections to lead the content that they contributed.

Reflections

Reflecting on these experiences, I amended the data collection approaches that I took on into the main stage of my study.

In the participant observations, I omitted the use of video entirely, feeling that it was a distraction for both myself and the pupils. Instead, I focused on targeted note taking at key points of the fieldwork days, this gave me more space to engage and respond to the events as they unfolded. I continued to record verbal fieldnotes following the events, usually on the

journey home. This was particularly effective in attuning my attention to the most memorable and impactful components of the events.

In the written responses, I included a very short Likert scale survey drawn from the Cornell Lab of Ornithology Evaluation Research suite of citizen science evaluation tools. This survey instrument was selected as it was designed specifically for use with citizen science experiences rather than environmental education more broadly.

I retained the sentence-stem task; however, I reduced the number to four and included two cognitively focused stems, and two affectively focused stems, the pupils were asked to reflect on what/how their citizen science experience had made them; think about, feel, was most memorable and most important to them.

The blog post was removed, replaced with a shortened, but still open-ended question that asked the pupils to comment on any change that they felt the citizen science experience had made to their relationship with animals, plants and the world of nature. This served to more explicitly connect the terminology used in the capability approach to my study.

The group discussion was amended to use the photo elicitation task and a written component alongside the recorded discussion, this was intended to reduce the self-consciousness that had been observed in the pilot and give the pupils alternative ways to record their responses. Four questions were included, these were issued one each to small groups of pupils, time given to discussing and making their own notes before discussing their reflections with me. Only the discussion with me was recorded, the pupils were encouraged to make notes on their thoughts before and after our discussion. A targeted 'capability approach' appropriate question was also included. The four questions included were:

- Using this image [image of an organism that the pupils encountered on their fieldwork day] to help you, can you describe any ways that taking part in the [insert MICCI/OPAL/SFL] project has made you think about how you live in relation to plants, animals and the natural world?
- Can you suggest what you think the best possible outcome of the [insert MICCI/OPAL/SFL] project would be;
    - for the environment, and
    - for you?
- Select the [environmental citizenship] term(s) that you think are most relevant to defining an environmental citizen and discuss whether taking part in the [insert MICCI/OPAL/SFL] project has enabled you to experience these.

- Thinking about the planning of your own life, has being involved in the MICCI project led you to consider living in a way that you feel is ‘good’ for the environment? What might this involve and why do you think it might be ‘good’ for the environment?

Semi-structured interviews

The interviews with the adults involved a recorded discussion that was framed around four broad questions;

- Can you tell me about your experience of the (MICCI/OPAL/SFL) project?
- What were the opportunities/benefits?
- What were the constraints/challenges?
- Reflections on ‘an environmental citizen’ in relation to participating in (MICCI/OPAL/SFL)

An opportunity to return to the field

The main data collection phase was completed by the end of October 2019. A small number of activities had been scheduled for Spring 2020, however these were cancelled due to Covid-19. Following the various lockdowns, in the late spring on 2021, I was informed that the MICCI project was able to resume and that one of my data collection schools was returning to the Scottish field-site. Restrictions on the mixing of ‘bubbles’ at that meant that I was unable to participate in the event, however, this gave me an opportunity to return to the school with a follow-up survey. I developed a short survey involving the self-efficacy statements, and some reflections on developing eco-citizenship capabilities and the conversion factors that could be associated with them. This prompted me to return to some of the other schools that had been involved in the main stage of my research and invite them to circulate the survey to AH biology or geography students, regardless of whether they had undertaken citizen science projects or not. They responded positively and I was able to collect 74 pupils’ reflections in this final data collection opportunity.

Participant numbers

The following tables (tables 2 and 3) show the number of pupil and adult participants in the research. Table 4 describes the activities undertaken and data collected in the main body of the research. Table 5 provides the number of respondents to the self-efficacy component of the survey.

Table 2: Pupil participant numbers

Pupil participant observations and follow-up survey and focus Groups		
Case	**School**	**Participants (Pupils)**
MICCI	School 1	19
	School 2	10
OPAL	School 1	19
	School 2	3
SFL	School 1	8

Table 3: Adult participant numbers

Adult Responses			
Response Type	**Case**	**Adult**	**Number**
Semi-structured Interview	MICCI	Teacher	2
		Scientist	3
Written Survey		Teacher	2
Semi-structured Interview	SFL	Teacher	1
		Scientist	1
	OPAL	Teacher	1

Table 4: Citizen Science Activities and Data Collected

Citizen Science Project	Pupil Description	Citizen Science Activity Description			Data collected			
		Introduction to the citizen science project and PhD research (20 – 50 mins)	**Fieldwork session**	**Follow-up session: Citizen science project data analysis and PhD data collection**	**Participant Observation**	**Group Discussion**	**Survey**	**Interview(s)**
MICCI School 1	S2 Science class	Researcher and scientist present	1 x full day Moorland based environmental data collection	1 x 50-minute period	1 x full day	Pilot questions	Pilot Questions	Teacher 12mins Scientist 20mins
MICCI School 2	AH Geography Class	Researcher and scientist present	1 x short day (10:30 – 13:30) Moorland environmental data collection	1 x 50-minute period	Short day (10.30 – 1.30)	Revised Questions	Revised Questions	Teacher 5mins
OPAL School 1	A-Level pupils on residential fieldtrip from Spain	Researcher and scientist present	½ day Invertebrate Survey in the grounds of the residential centre.	1 hour follow up session in the lab	½ day	N	Revised Questions	N
OPAL School 2	S1 Green Gym Group (extracted from class)	Researcher and scientist present	2 x 50-minute periods Tree health survey (trial survey) and invertebrate survey in the school grounds (main survey)	1 x 50-minute period	1 x 50-minute period	Revised Questions	Revised Questions	Teacher 15mins
Soil Fertility Legacies	H and AH Geography class	Scientist and teacher present	1 x full day Soil sampling and analysis in a local field site	1 x full day	1 x full day	Revised Questions	Revised Questions	Scientist 40mins Teacher 20mins

Table 5: Self-efficacy survey responses

Self-Efficacy Survey	
Case	**Responses**
MICCI	19
OPAL	21
SFL	9
None	25

Situational analysis

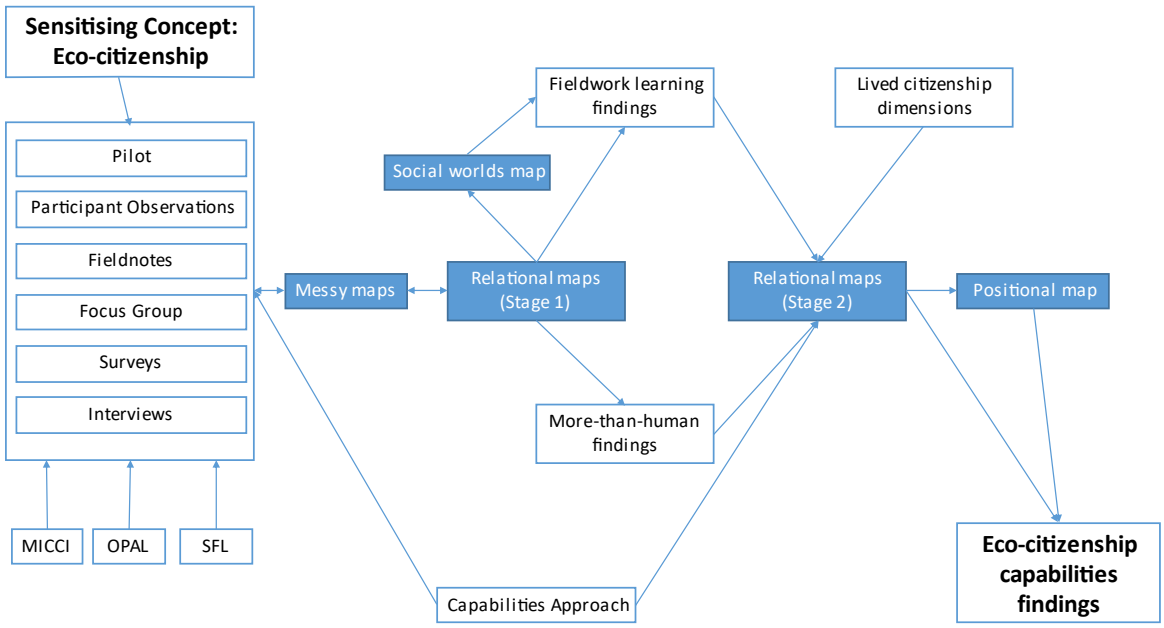

Figure 11: Overview of my research process with situational mapping stages emphasised

Theoretical underpinnings

This research used situational analysis to generate situational maps of the citizen science experience for the participants in my research (see fig. 11). These maps include the human, non-human, material and discursive elements that are found within the cases. The initial analysis included all seemingly pertinent information and assumptions, and this was categorised and ordered throughout the analytical process. In this section I will outline the theories that underpin situational analysis, and consider why this is was a suitable analytical method for use with my particular cases. Following this, I will describe the stages that I went through in bringing together my data using the processes of situational analysis, including some of the challenges that this complex approach involved.

Roots of situational analysis

I will firstly outline the roots of situational analysis in grounded theory, symbolic interactionism and pragmatism (Clarke, 2005). The ontological contradictions that have emerged as these concepts have evolved echo the positivist/interpretivist divide already described in relation to case study perspectives. There are elements of grounded theory that lie naturally within the interpretivist ontologies, for example, its emphasis on perspective and multiple points of view. However, some aspects of grounded theory draw from positivistic

approaches and can be limited by these, for example the risk of oversimplification in the search for a purity of analysis. Situational analysis attempts to account for these limitations by emphasising the 'situation' and the reflexivity of the researcher in relation to and within the research.

Grounded theory, symbolic interactionism and pragmatism

Clarke (2005) argues that traditional grounded theory (Glaser and Strauss, 1967), which seeks to generate formal theory, can be criticised for being reductionist and retains elements of positivism that do not allow the presentation of the contradictions and ambiguities that are present in social situations. Clarke (2005) presents situational analysis as a more relativist, real-world and situation specific approach to research.

Building on constructivist grounded theory, according to Charmaz (2006) focuses on the meaning, action and process in a social context. This position includes the researcher *within* the research and can present the results as a narrative told by the researcher. She suggests that multiple interviews or observations may be needed to fully realise the meaning of an experience to the participant. In the case of this research, there was not the opportunity to interview the pupils more than once, however, using a range of techniques across the data collection attempted to illuminate the different perspectives and viewpoints from the individuals involved.

Situational analysis, as it has emerged from grounded theory, draws heavily from symbolic interactionism and also has roots in pragmatist philosophy (Chamerlain-Salaun and Mills, 2013). Symbolic interactionism suggests that individuals consciously interact with the world and that is within these interactions that the meaning of a situation can become apparent (Serge, 2014). Clarke (2005) asserts that the contradictory positions of symbolic interactionism as a perspectival interpretation of a fixed reality are core to the challenges within grounded theory that situational analysis attempts to overcome.

While situational analysis has its roots in grounded theory, where a systematic approach to analysing qualitative data is taken (Clarke, 2005) it attempts to more satisfactorily attend to the complexities found in a social science inquiry. Clarke et al (2017) asserts that situational analysis should supplement grounded theory-based analysis, rather than replace it altogether. Situational analysis allows the invisible to become visible and encourages the messy nature of the method assemblage to be brought into view (Law, 2004), which when combined with the systematic analytical coding present in traditional grounded theory, offers a way of deeply understanding and potentially unravelling some of the complexities in the research situation.

den Outer et al (2013) make use of situational analysis as an attempt to “know not only more but differently” (den Outer et al, 2013, p. 382). Investigating the reflexive practices of higher education, the authors look to appraise situational analysis as a reflexive method. Finding the approach challenging, the authors concluded that while situational mapping encouraged the researchers to move between interpretive levels and in doing so revealed multiple possible interpretations that may not have become apparent in other approaches. Their main critique, however, was that this approach does not easily allow questions of agency to be addressed, for example the decisions taken when moving between the different maps are ultimately determined by the researcher, but the reflexivity in this process was felt to be lacking.

In practice

Situational analysis uses cartographic techniques to explore and analyse the research situation. Three main mapping approaches are described:

> 1. situational maps that lay out the major human, nonhuman, discursive, and other elements in the research situation of concern and provoke analyses of relations among them;
>
> 2. social worlds/arenas maps that lay out the collective actors, key nonhuman elements, and the arena(s) of commitment within which they are engaged in ongoing negotiations, or meso level interpretations of the situation; and
>
> 3. positional maps that lay out the major positions taken, and not taken, in the data vis-à-vis particular discursive axes of variation and difference, concern, and controversy surrounding complicated issues in the situation.
>
> (Clarke, 2003, p. 554)

The intention of these maps is to bring out the complexities, to subject the research situation to a rich and deep analysis that includes the human and non-human actors present in, and impacting upon, the intention of the research (Clarke, 2003). Clarke (2005) describes the use of this cartographic approach as a break with the traditional researchers’ ways of working, thereby generating unique insights into the situation. den Outer et al (2013) found the process of producing situational and social world maps useful and insightful, however the positional maps proved to be challenging in that positional maps move away from the position of the individual to the related position within the relevant discourse. This raised questions of agency and representation for their particular research area (reflexivity in researchers), which I found useful to consider when moving towards the positional mapping

analysis. The three types of map, but the situational map most clearly, as created by the researcher is a reflection of their specific view at that moment. Changing time or researchers will produce a different map(s), which reflects the changing landscape and alternative journey that might be seen by an alternative perspective. Kitchin and Dodge (2007) suggest that maps are “spatial practices enacted to solve relational problems” (Kitchin and Dodge, 2007, p. 335). The visual representation of the situation opens up the messiness and enables multiple perspectives to be considered. Different elements of the map can be expanded or collapsed as the analysis proceeds, illuminating the visible and invisible relationships between elements.

Following each data collection exercise, I created firstly a messy map and then a relational map of the data. Three key questions are asked of the data in the construction of this map; “Who and what are in this situation? Who and what matters in this situation? What elements “make a difference” in this situation?” (Clarke, 2003). An example can be seen in fig. 12. p. 86, and again in appendix 6. Simultaneous memo-ing should also be carried out in the construction of the map, attending to question of presence and absence, allowing the researcher to ‘wallow in the data’. Following this, the data was interrogated to more fully understand it’s importance in my research, for example, in interrogating the question stem responses, a map was constructed for each sentence stem, in which broad themes or converging concepts were identified, learning about, or physical sensations, for example. The related concepts were brought together and remapped, this time looking across the different cases. This iterative process provoked my ‘analytic imagination’ (James, 2012) and produced what Clarke et al (2018) describe as ‘thick analysis’.

Clarke et al (2018) suggests that in the relational map, each element is compared and related to each other element on the map. As I added to the map for each case with each new data source, this quickly became unwieldy and I opted to group or cluster the maps to meaningfully direct my analytical focus. It is worth noting that this was done consciously and reflectively, another researcher may have selected different relationships of importance to them, which would have been equally as relevant. In creating and re-creating the relational maps, I was able to identify areas of commonality between the cases and discern some differences. I was able to describe some initial findings in relation to the fieldwork learning experiences and more-than-human encounters from these relational maps. However, the differences between cases were less clearly defined than I had expected which led me to further theoretical reflection and a new set of relational maps. Incorporating the dimensions of lived citizenship (Kallio, Wood and Halkli, 2020) and conversion factors (Robeyns, 2017)

into a second set of relational maps allowed me to reconsider my initial findings and incorporate the new conversion factors data set into my analysis.

Clarke et al (2018) suggest that all three map types should be used during the analytical process. I found the process of working with the relational maps intuitive and rigorous, however, the social worlds and positional maps proved to be a little more challenging. Growing out of the Chicago School approaches to *relational ecology*, the social worlds maps are intended to emphasise the relative positions, insecure boundaries and asymmetries that are present in any situation of inquiry (Clarke et al 2018). In practice, I felt that only some of the data that I had collected helped me to build this particular type of map and a return to the field was not possible due to Covid restrictions. I focused particularly on the interviews with the adults in order to build the social world, centring the pupils as impacted by the social worlds that converged to create the citizen science experience that composed my research 'situation'. After a few iterations, the value of this type of map began to become clear, in positioning the 'worlds' of the teachers and the scientists in opposition and attraction to each other, I was able to identify some affordances and challenges for both parties. These contributed to the fieldwork learning findings.

The positional map was the most difficult of all to generate, and I was only able to build this during the second stage of the relational mapping exercises. I identified the conceptions of 'care' and 'contribution' as reflected differently in the data from the adults and the pupils. This became the basis of the positional map, and contributed to the eco-citizenship findings.

My move to post-qualitative approaches evolved through my experience of situational analysis. Initially rooted in pragmatism, my research intention was to clarify what citizen science *did,* or was able to *do* for the pupils involved. The rigorous attention to the experience, the actions and transactions (Dewey, 1938/2015, Biesta and Burbles, 2004) contained within it were, to my mind, a search for the ways in which this experience could matter to environmental education and to the young people involved. In working through the stages of situational analysis, I was exposed to ideas of situated knowledge as described by Haraway (1991). The relational mapping in particular opened up the conceptions of rhizomatic and assemblage approaches such as that of Delueze and Guattari (2004) and Ingold (e.g., 2011). The re-turning of the maps connected me to the refractive processes described by Barad (2014). Most vividly, however, the intention to take the non- or more-than-human into my analysis was driven by the fieldwork experiences themselves. The non-human actors (Clarke et al, 2018) were demonstrably in relation with the pupils in the fieldwork experiences, these entanglements were, and still are, the things that have remained most meaningfully with me from the citizen science activities. I was moved to more

fully explore this and in doing so my relationship with this research has deepened immeasurably.

Breaking down the analytic process

As a result of the various data collection activities, across each of the project a total of 14 data sets were generated, a summary of these can be found in Appendix 4 (p. 258). In order to fully incorporate these different sources of data into the situational mapping approach, I followed the steps outlined here:

Step 1: Inductive open-coding

I undertook a line-by-line or word-by-word analysis of the data, identifying codes where appropriate, it should be noted that Clarke et al (2018) does not advocate a Grounded Theory-type coding approach be taken prior to messy map construction, however, I felt that for some of my data sources, an immersion and coding process was necessary before moving on to the mapping stage.

Step 2: Messy maps were constructed using a mixture of raw data and identified codes, for example fig. 12 shows the transcribed messy map of MICCI school 1's fieldwork day:

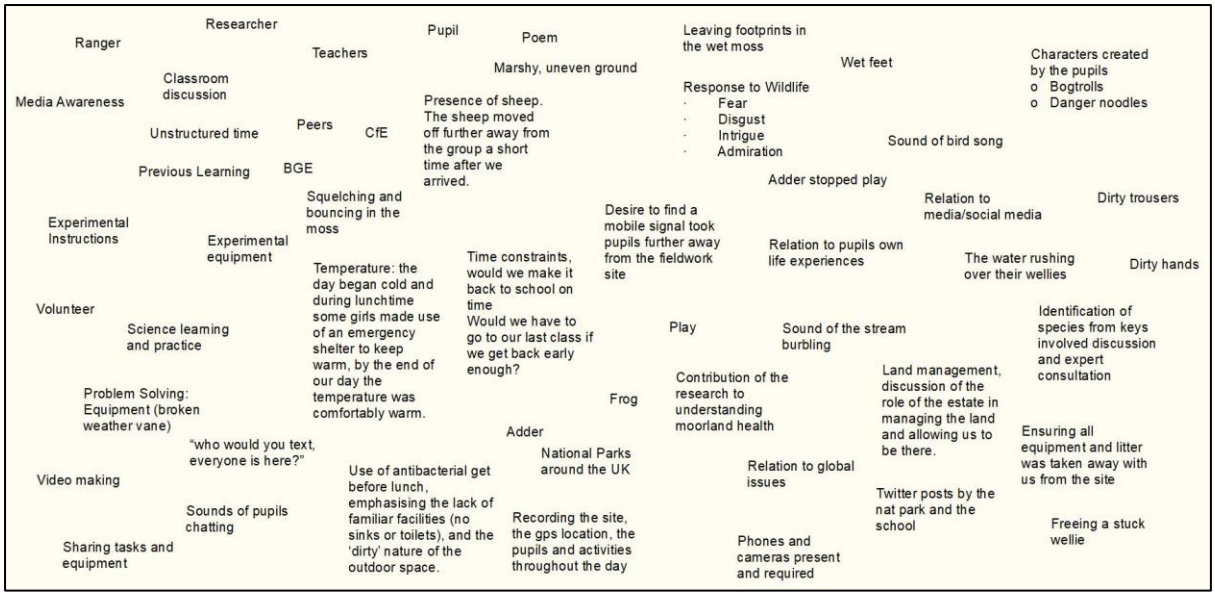

Figure 12: MICCI School 1: Messy Map: 9.5.2019

Step 3: Relational mapping was then used to identify themes

The process of relational mapping as described by Clarke et al (2005) asks that each component of the messy map is considered in relation to each other component in a systematic way, this was a rigorous and intensive process of engaging with the data.

I re-applied the themes that I had identified through the mapping exercise to the original source material (interview transcripts or survey data, for example), and also retained them for use with subsequent data sets.

Step 4: Selected themes and the related raw data were extracted and used to develop the social worlds map

Themes of particular relevance to the research questions were identified and applied to the data across the cases (this resulted in a 'count' of the frequency of occurrence of some themes to facilitate cross-case comparisons).

Step 5: Findings related to fieldwork learning experiences and more-than-human encounters were identified.

Findings and re-turning the data

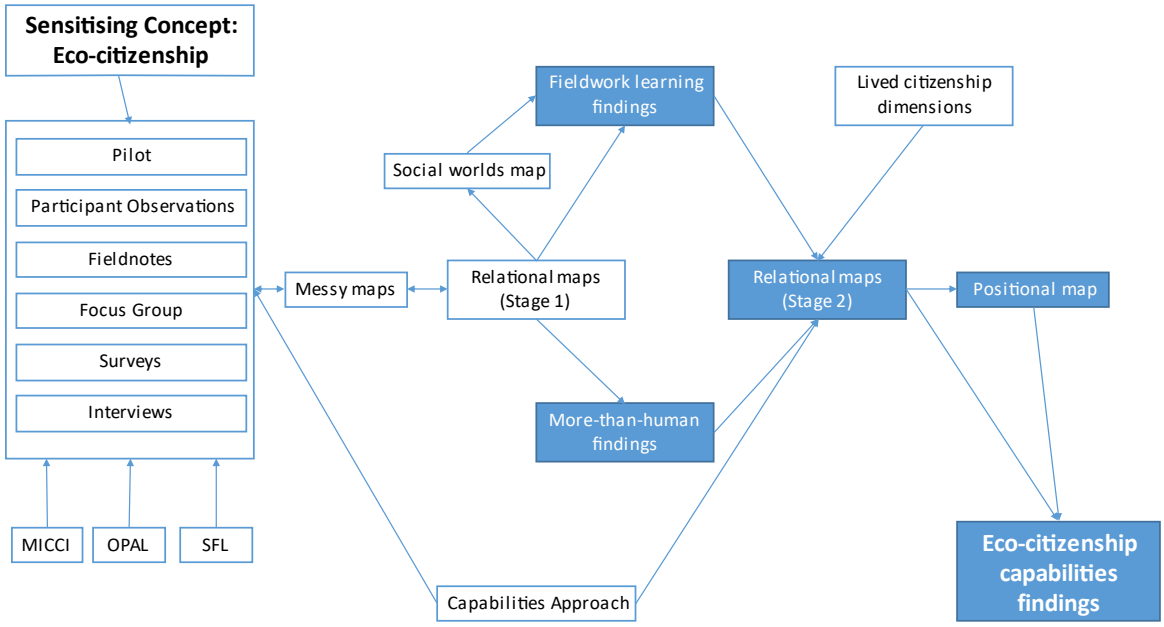

Figure 13: Overview of my research process with the second analytical stage emphasised

I identified the fieldwork learning and more-than-human findings using the relational and social worlds maps as described in the previous section. While these findings were an important first step in my research, they only took me part of the way towards eco-citizenship. The 'actions' for the environment that I had hoped to observe were not strongly demonstrated in the pupils' behaviours or reflections, instead proto- or emerging eco-citizenship capabilities were palpable. In re-turning to the data from the stage 1 findings and bringing the lived citizenship dimensions and conversion factors into the frame (see fig. 13), I

was able to develop a second stage of relational maps considering how these proto-citizenship dispositions could be made more tangible in relation to the wider lives of the pupils. These reflections and re-turning form the basis of my eco-citizenship capabilities findings.

Self-efficacy data analysis

The self-efficacy data was firstly treated as described in the Cornell Institute for Ornithology technical brief (Porticella et al, 2017), where the responses were converted into a numerical value and the average for each participant calculated. I then calculated an average score for each citizen science project (and none). Secondly, each self-efficacy statement was considered separately. The response for each statement were converted into agree and disagree categories. I then calculated the proportions of agreement/disagreement across each of the citizen science cases and the non-citizen science participants. For each self-efficacy statement, this involved breaking the self-efficacy statements up into three components:

- A capability statement (e.g., I can)
- A place identifier (e.g., the planet)
- A solution orientation (e.g., take care of)

The lived citizenship dimensions, conversion factors and self-efficacy components were combined to create a priori codes, see table 6 below:

Table 6: Applied codes

Lived Citizenship Dimension	**Conversion Factor**	**Self-efficacy component**
Spatial Dimension	Environmental conversion factors	Place identifier
Affective Dimension	Personal conversions factors	Capability statement (individual)
Intersubjective Dimension	Social conversion factors	Capability statement (working with others)
Performed dimension		Solution orientation

These codes were then applied to the messy and relational maps from stage 1 in a systematic manner. For example, fig. 14 shows the application of stage 2 codes to the SFL

relational map.

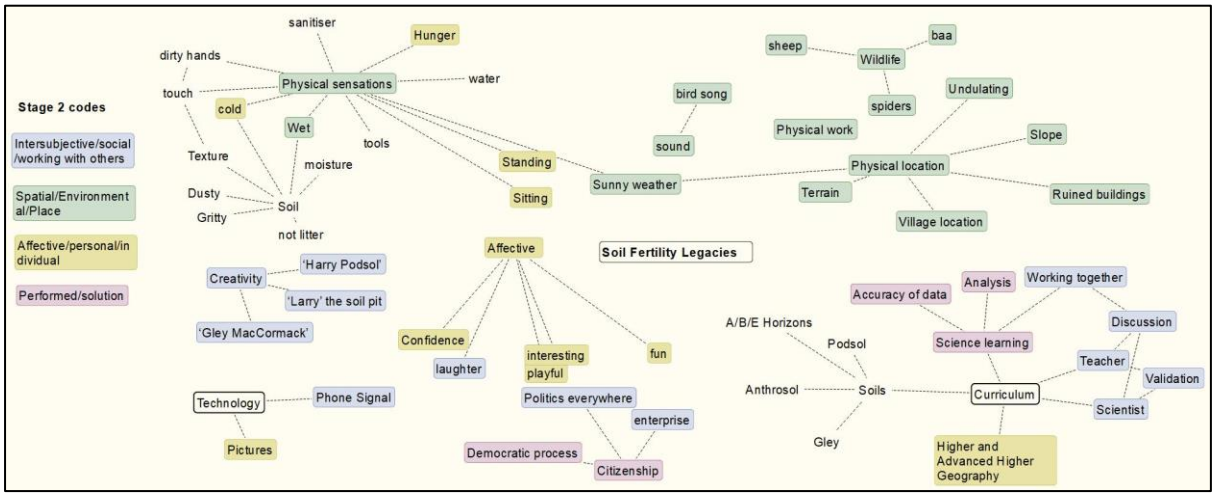

Figure 14: Stage 2 relational map with applied codes example

Themes were identified which were focused on interrogating how the experiences identified as important in the stage 1 findings could be more fully understood as part of the process of developing eco-citizenship capabilities. The map in fig. 15 shows the themes that were identified across all cases in relation to the spatial/environmental/place coding.

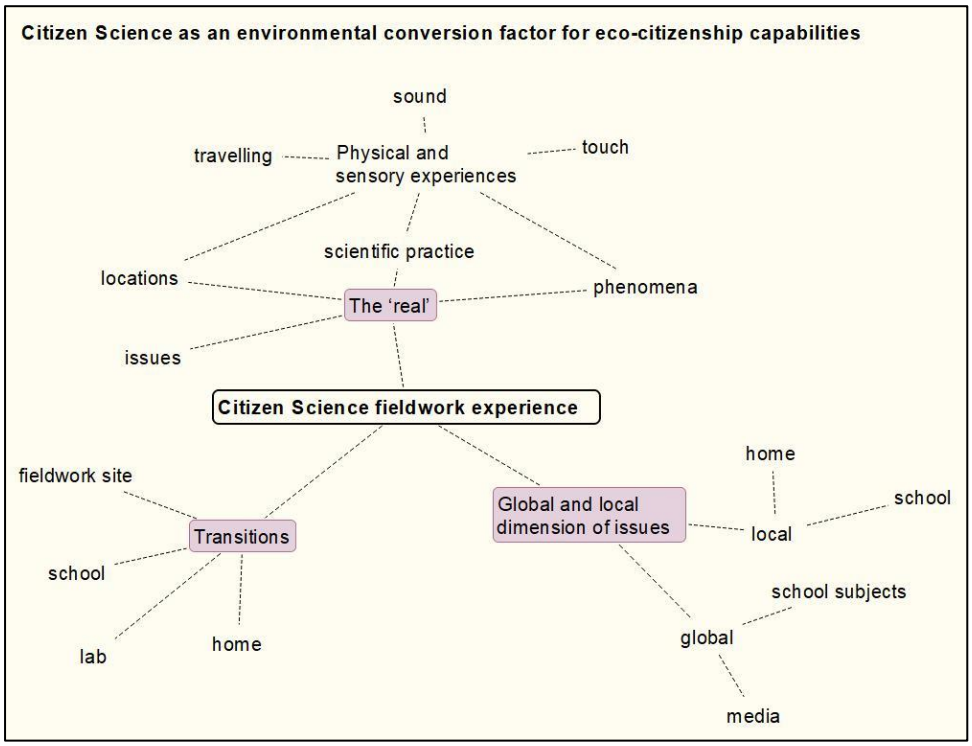

Figure 15: Stage 2 theme identification example

In summary

In this chapter I have outlined the steps taken, observations made and reflections taken that moved my research from a sensitising concept to the final substantive findings. The process of using situational analysis was particularly effective in exploring the complexity of the citizen science experience from a range of perspectives. It was a rigorous and sensitive process which I felt enabled me to dive deeply into this unique situation. It was, however, complex and at times challenging. The application of the capability approach and the conception of lived eco-citizenship provided me with a way of noticing and evidencing the palpable and emerging citizenship actions of the pupils.

Chapter 4: Fieldwork Learning Findings

Introduction

This chapter addresses the following research question;

> *What contribution is made by fieldwork experiences in curriculum-based environmental citizen science that supports eco-citizenship capabilities?*

In this analysis chapter, data is drawn from the participant observations of fieldwork experiences which were converted first into fieldnotes and then messy maps (Clarke et al, 2018). These maps were built to also include the pupil reflections that were provided during a sentence completion task, and individual interviews with teachers and scientists. For a fuller account of these approaches, please see the methodology section 'Data Collection' p. 67.

The data was analysed firstly using inductive coding and messy maps. The contribution of the participants was coded and arranged into themes using the messy maps, the sensitising concept (Clarke et al, 2018) of 'environmental citizenship' was utilised and interrogated within these first stages. The themes and associated terms were then arranged into relational maps, in which the convergences and divergences across the different citizen science experiences were identified. These will be drawn out and discussed in relation to the eco-citizenship capabilities that are implicated in the experience. Finally, the data was brought together into a social worlds map. This map will be used to interrogate the relationships involved in the environmental citizen science experience, drawing out the opportunities and challenges raised by these.

Background

Delors (1996) proposed a model of learning in which a foundation of 'learning to live together', supports the pillars of 'learning to know', 'learning to do' and 'learning to be'. 'Learning to know' involves acquisition of "instruments of understanding" (ibid. p. 23), 'to do' involves the acquisition of competencies and skills, 'to be' involves a greater depth of self-knowledge, contributing to the "all-round development of each individual" (ibid. p. 94). The foundation of 'learning to live together' is proposed "so as to participate and co-operate with other people in all human activities" (ibid. p 23). There is a strong emphasis on a scientific culture throughout the Delors report, with the suggestion of the need to develop scientific thinking in order to promote development, not only in relation to future technologies, but also

embedded within local contexts (Delors, 1996). Hodson (2003) suggests four components that he considers as the major contributions to a science curriculum which is “oriented towards socio-political action” (Hodson, 2003. p. 645). The first three of these components echo Delors (1996) pillars, suggesting that; learning science (the concepts and theories), learning ‘to do’ science (the practical tasks or ‘scientific inquiry and problem solving’) and learning ‘about’ science (understanding the ‘nature of science’) can result in students who are able to engage in Hodson’s fourth component, taking socio-political action.

Environmental citizen science shares the fieldwork component that is commonly (though not exclusively) included within environmental education, particularly through formal education settings. Approaches to environmental education can be classified into different domains, Lucas (1979) considered environmental education to be considered ‘*about, for* and *in’* the environment. These dimensions were adapted by Fien (1993) changing the ‘*in’* for ‘*through*’, and also by Palmer (1998) changing the ‘*in*’ for ‘*in or from’.* This analysis chapter will bring together these approaches to learning science and environmental education and present findings under three headings; Learning *about,* Learning *to do,* and Learning *together.* Learning *about* focuses on the pupils’ topic-related reflections, while learning *to do* focuses on the practical components of the experience. These reflections were identified during the participant observations of the fieldwork experience, and in the post-visit survey tasks. Learning *together* will centre on the interpersonal relationships demonstrated and observed during the fieldwork experience.

Bringing these different but similar learning theories together to consider environmental citizen science within the formal school context is relevant as the situation of the experience sets it apart from the voluntary citizen science experiences that are selected and undertaken in non-formal or informal settings. The situation of this particular type of experience relates as strongly to environmental education and fieldwork as it does to voluntary environmental citizen science. ‘Learning’ as described in relation to citizen science literature focuses predominantly on the learning outcomes that can be demonstrated and identified through, or as a result of the experience. Acknowledging the wide range of factors that can influence the ’outcomes’ (learning or otherwise) of a particular experience, this research seeks to locate the environmental citizen science experience within the formal education setting that it is delivered through. The pupils described in this research generally accessed the citizen science experience through timetabled classes, either science or geography. This brings with it the subject specific learning outcomes as a requirement of these courses. A small section of pupils involved experienced the citizen science activity as part of a less formal nurture group or eco-club. These approaches have less strictly specified learning outcomes

(Lee, 2016), however their situation within the formal setting of the school, often delivered by science/geography teachers, retains some of the characteristics of a school-based experience.

Unlike widely used measures of learning outcome, the capability approach (for example, Nussbaum, 1988, Sen, 1980) offers the opportunity to understand the potential that the citizen science experience has to connect pupils with eco-citizenship dispositions. Sen (1992) argues that a capability set should be context dependent, suggesting that education is a centrally important 'being and doing' (Sen, 1992, p.44). Nussbaum (2011) set out what she feels are her 'Ten Central Capabilities', many of which impact or are impacted upon by a person's experience of education and schooling. In this chapter, the experiences that are observed and reflected upon by the participants will be considered in relation to the identified 'central capabilities' of Nussbaum, while also identifying eco-citizenship capabilities that are specific to this context.

Walker and Unterhalter (2007) describe the ways in which education and learning can be described in the capability approach. Firstly, in the reproduction of existing inequalities, authors in this group suggest that modern schooling contributes to embedding injustices and looks to change the structures impacting this. The second strand of research considers schools and contemporary education as 'transformative spaces' (Walker and Unterhalter, 2007, p.7) in which the activities of pupils can be explored in order to challenge inequality and injustice. The environmental citizen science experience is associated with this second consideration. The experience itself could be considered 'a resource', or something which can be utilised in the development of a capability or a capability set (Robeyns, 2017). Alternatively, it could be considered a 'conversion factor', in which the resources provided by the natural world are converted into eco-citizenship capabilities (a fuller discussion of conversion factors can be found in chapter 6). In the three sections that follow, the learning experiences of the participants involved will be described, suggesting ways in which they support the development of eco-citizenship capabilities.

Section 1: Learning *about*

Pupils' topic related reflections

When asked to reflect on their citizen science experience (generally around a week after the fieldwork day), there were two sentence completion tasks in which there was a strong emphasis on topic-related content over, for example, the more interpersonal or practical

aspects of the day. In these sentences pupils were asked to suggest what they 'thought about' and what they felt was 'most important' about the citizen science experience.

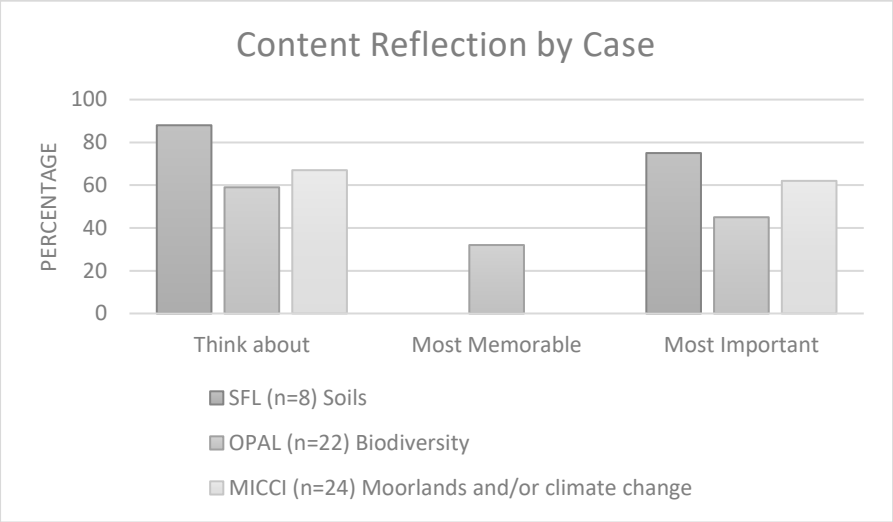

Figure 16: Topic-related content reflections, percentage of pupils by case

Table 7: Topic-related content reflections, percentage of pupils by case

Content Reflections by case	**Percentage of pupils recalling relevant content by category**		
	Think about	Most Memorable	Most Important
SFL (n=8) Soils	88	0	75
OPAL (n=22) Biodiversity	59	32	45
MICCI (n=24) Moorlands and/or climate change	67	0	62 * (n = 13)

* The pilot group were not asked to complete a sentence about the most important to them, they were asked to reflect upon what was most important about the moorland, to which all 11 participants responded with either habitat or carbon storage-related responses (or both).

The results shown in fig. 16 and table 7 suggest that over half of the pupils in all cases were disposed to think about the relevant content of their fieldwork day. Furthermore, over half in two cases and almost half in the OPAL group considered the learning content the most important element. In the pupil's reflections on the 'most memorable' aspect, the OPAL group were the only ones who considered the learning content memorable, with a proportion of these memories relating to the diversity and beauty of the invertebrates. This will be considered in depth in Chapter 5.

Taking a situational analysis approach to this data, a relational map (fig. 17) was generated using the responses to 'the citizen science experience made me think about …', this category was selected for presentation as it contained highest topic-related reflections across the three citizen science experiences.

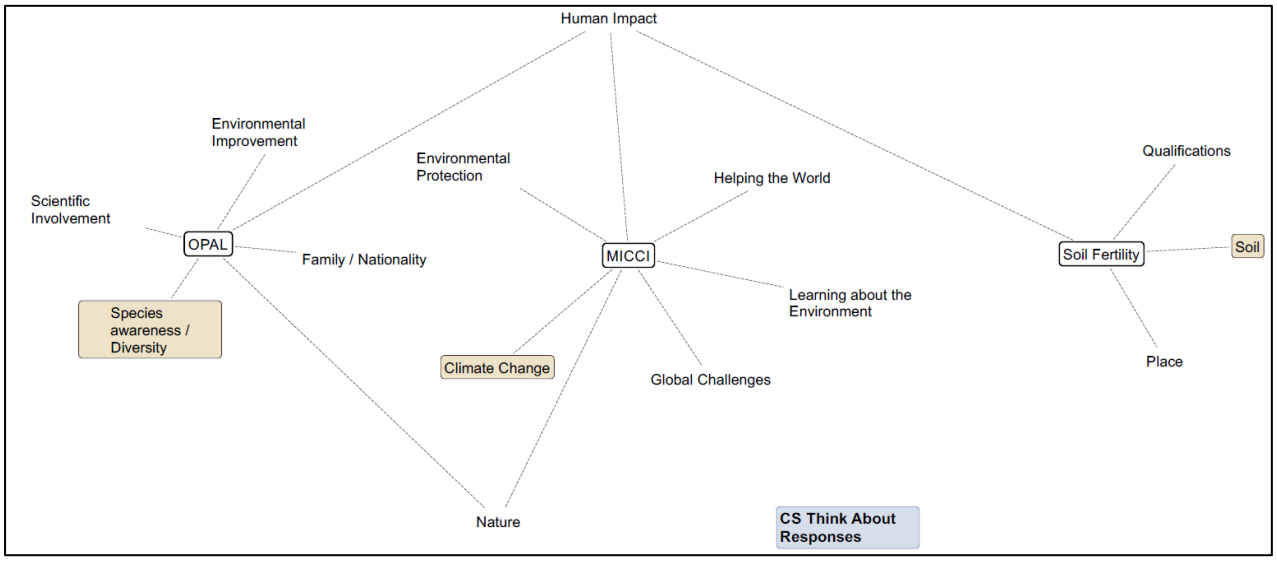

Figure 17: Relational Map of 'Citizen science made me think about ….' Sentence stem responses

It is clear from the wide range of topics that pupils were prompted to recall thinking about, that the core topic-related content of each activity was only a part of the thought process for the pupils. In the OPAL study, which was a survey of invertebrates in different habitats, species awareness/diversity was mentioned directly by 59% of responses. Other responses related to the scientific involvement, improving the environment and relating the experience to their home circumstances. The Soil Fertility Legacies project had 75% of responses include a direct reference to soil in their responses, with an emphasis on school qualifications and the local nature of their experience also described. Finally, in the MICCI project, which has moorland impacts on climate change as its key topic area, 67% of pupils made a direct reference to climate change (or global warming) or moorlands. The MICCI project stimulated the widest range of 'think about' topics, in particular in relation to environmental protection and global challenges. Across all three experiences, the pupils were prompted to 'think about' the impact that humans have had on ecosystems, biodiversity and nature.

The pupils' reflections on human impact were often framed in negative terms, e.g., by decreasing biodiversity, they were also framed in neutral terms, by using 'affect' rather than a positive or negative statement. Where there were references to positive human impact, they were generally in relation to helping or protecting the environment or the planet. The way that the pupils expressed this reflects the level of responsibility that they felt in relation to human impacts on the environment. Sometimes the pupils are present in the statement 'how *we* can', but most often it is a reference to the generic human, as in 'all of us'. This may suggest that the pupils are able to reflect on the role of humans in the various environmental issues that each citizen science activity raises. It could be questioned whether they consider this a personal responsibility or a more collective human responsibility that they have limited control over.

Protection and improvement of the environment or the planet is an idea that is evident in both the OPAL and the MICCI responses but not in those from the Soil Fertility Legacies participants. This was positioned by the pupils in different ways, from very individual expressions of concern asking what they could do to help, to expressions of group responsibility 'things that *we* can do'. There were also a number of abstracted concerns, for example, stating the importance of conservation acts, suggesting that something needs to be done, but not specifically by any one individual or group of people.

In the OPAL survey the pupils made connection to their home lives, with one pupil relating to identifying tree species with her dad, and another making the comparison between the species found in Scotland and their home country (Spain). Again, in the Soil Fertility project, pupils reflected on a personal level with the fieldwork relating to the familiarity of the field study site. However, in the MICCI project, there was no reference to home or family, rather there were exclamations relating to the planet as a whole as 'interesting' or 'messed-up'. The location of the fieldwork is highly likely to have an impact on the individual vs global perspective that pupils are able to take away from the experience, interestingly however the two OPAL activities took place in very different locations, one in school grounds and the other in a residential centre as part of a week-long visit.

Hayward (2012) suggests that children can experience citizenship in ways that can be SMART, resulting in what she terms a "thin environmentalism", or SEEDS, which can result in a "strong ecological citizenship". Environmental education is considered a component of the SEEDS experiences, and the 'think about' responses that pupils have given in relation to their citizen science experience can be used to explore any connection with the "strong ecological citizenship" component, or instead the "thin environmentalism" experiences.

Environmental education, as Hayward positions it, should be relevant, it should reside within a democratic society and help children to develop skills of democratic and collaborative action. In both the OPAL and the MICCI experiences there are responses that suggest that the pupils are beginning to consider the environmental concern,

> *How important nature is and no matter how small it is, it is important*
>
> OPAL School 1: Survey Response: 10.9.2019

and beginning to consider their role in changing or improving the situation. Hayward (2012) suggests that the abstract nature of much classroom-based environmental education can result in the challenges being felt to be "far away" from the pupils' everyday lives, suggesting that there should be "local places with which we identify before we can build empathy with the places of others" (ibid. p. 97). The Soil Fertility project demonstrates that the pupils related the scientific experience to their local setting, however the constraints of the project did not then facilitate a widening of this to more global soil fertility issues.

Hayward (2012) stresses the importance of minimising eco-phobia and eco-trauma whilst also enabling children to see themselves within the situation. There are some clear examples of the overwhelming nature of the environmental challenges, in the MICCI project, pupils were reflecting on the scale of damage to the planet and how 'messed-up' it is. In the OPAL project, however, pupils were able to be more constructive, reflecting on the importance of using resources to help and getting involved themselves in conservation activities. This suggests that there is some difference in the emphasis of the two projects, with MICCI offering a profound experience where the magnitude of the environmental challenge is laid bare for pupils, while the more data focused nature of the OPAL project provides a framework within which to consider the issue but feel that small steps towards a resolution are possible.

Therefore, my analysis in this section suggests that participation in environmental citizen science can contribute to the development of the capability to learn about environmental issues. Across all cases the pupils were able to:

- Offer their own reflections and thoughts about environmental issues
- Demonstrate understanding of environmental knowledge
- Reflect on the impact of human activity on the environment in positive, negative and neutral terms

The formal learning context

The situation of the citizen science activities described here as being experienced through formal schooling is the main aspect that distinguishes them from the more voluntary approaches taken in community and adult citizen science experiences. Drawing predominantly from the participant observations and some survey/interview responses from participants, reflections on the formal learning context were identified in the situational map of all three projects. This section explores the relationship between the citizen science experience for pupils and the formal learning context.

Reference was made throughout all three cases to the formal learning context of the field visit. In the three senior classes, the framing related strongly to Advanced Higher or A-level projects, with an emphasis on collecting data directly for these or utlising the work of the citizen science project to prepare them for undertaking their projects independently.

> *One of the aims of the session for the pupils was to critique the different types of equipment used to collect and identify the invertebrates. The pupils were studying A-level biology and on return to Spain would be undertaking an independent investigation, the experiences gained on their visit were intended to help them prepare for this. The advantages and disadvantages of the different pieces of equipment would be identified and made notes on throughout the session.*
>
> OPAL School 1: Fieldnotes 10.9.2019

> *I had a chat with the AH pupil from the other group about her AH project. She chose soils as her project topic partly as a result of the positive experience of the soils project last year, but also as the school has the equipment that would enable her to complete it. Conversations with the teacher over lunch reveal that she attributes the soils project as a major factor in AH project choice as her confidence in teaching soils has also improved markedly on involvement with the project and as such her enthusiasm for the topic has increased. This has built confidence in the topic for the pupils, who feel a soils project is one that they can 'do well in'.*
>
> SFL Fieldnotes: 3.10.2019

The second quote reflects a tension between the selection of this topic as a result of genuine interest or because it contains the opportunity to 'do well'. Performing well in AH projects was seen as a positive by both the teacher and the pupil in this particular example. Davies

(2004) suggests that this is an important tension that is exposed when science education and citizenship education are approached together. This is also explored by Iversen and Jonsdottir (2019), who identified a tension between environmental citizenship and 'doing schooling', in which the practice of engaging with a local controversial environmental issue within science education enabled pupils to debate and discuss the issue with local decision-makers. However, the school-focused nature of the assignment being a graded group-work project returned the pupils to a performative exercise in which achieving a good grade was prioritised by some. This was also evident in the teacher reflections of their reasons for getting involved in the Soil Fertility Legacies project.

> *I think that the big motivating factor for me was, I could see how it was related to the curriculum.*
>
> *We are gauged on our results and the soil projects assignments have been some of the more high-scoring ones that we've done.*
>
> Participant Interview: SLF Teacher 15.12.2020

This reflects the value that this particular teacher put on the curricular connection and the potential for the project to improve the exam results of the pupils by utilising the experiences gained in the citizen science project. She went on to describe the need for any citizen science project to be directly related to the formal curriculum.

> *Interviewer: It has to be, it HAS to be curricular?*
>
> *Participant: Yeah, it has to be, I mean, as much as I would love to say, let's go and do this you know, unfortunately if it is not related to what they are doing in the exam there is just is no time for it.*
>
> Participant Interview: SLF Teacher 15.12.2020

In arguing for a renewed approach to curriculum, Wals (2022) highlights the need for 'spaces in between', where both teachers and learners can follow alternative pathways than are typically found in contemporary, mainstream approaches. The scientists involved also reflected on the constraints of the formal school curriculum, working to overcome these helped them enable schools to get involved more easily.

> *Not being a teacher and not being in the schools, I'm not there around curricular planning and timetabling and all these things that I know they're trying to deal with, but I know what I can do is put into place that flexible*

> *approach to make things as admin light as possible, to make it as relevant as possible*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020

Embedding citizen science experiences fully within the formal curriculum was seen by one of the scientists as a solution to the challenges faced in implementing the MICCI project.

> *I think if it was in the curriculum that would solve all the problems, like if it was actually in there is something they should do as part of their curriculum. Take part in a citizen science project, you know, it would be something that would help.*
>
> Participant Interview: MICCI Scientist JW: 12.11.2020

While this suggestion may overcome some of the recruitment and operational challenges faced by the scientists, it risks any citizen science experiences becoming another 'tick-box' activity. Rather than opening up the opportunities for pupils involved in environmental citizen science to explore the uncertainty of scientific learning, as Davies (2004) supports, this may reduce the risks that teachers would be willing to take, re-enforcing the need to 'achieve' results, thus diminishing the potential eco-citizenship capabilities invoked in the process.

Learning about environmental issues is an important component of environmental citizenship (Berkowitz et al (2005), Jenkins (1999), Schild (2016), Schusler et al (2009), Short (2009)). The experiences observed and described by participants in this research reflect the importance of this within the environmental citizen science experience. This supports the capability to 'imagine, think and reason' (Nussbaum, 2011) in relation to environmental issues and the impact that humans can have on the environment. This research has found that while topic-related content knowledge is dominant in the reflections of both the pupils and the adults involved, these are only part of the experience. It can therefore be suggested that the environmental citizen science experienced as described here, supports:

> *The capability to learn about environmental issues.*

Section 2: Learning *to do*

Environmental citizen science experiences offer pupils the opportunity to engage in scientific enquiry processes with a particular purpose beyond classroom learning. The common experience of school, lab-based scientific experimentation has been described as a 'cookbook approach' (Trumbull et al, 2000), in which pupils follow step-by-step instructions which present scientific enquiry as ordered and somewhat sterile. Leon-Beck and Dodick

(2012) found that novice researchers in ecological studies struggled with what they term the "dynamic tension between students' idealized research protocols and the reality of the field" (ibid. p. 2475). They suggest that experience in uncertain, complex field environments can help prepare students for the challenges of authentic field research. Hodson (2003) proposes that "engaging in and developing expertise in scientific inquiry and problem solving" (ibid. p. 658) is one of the key components of an effective science curriculum. He suggests that 'real world tasks' should be utilised to develop and build confidence in these components. This section considers two strands of practical learning in science, 'learning to analyse' and 'problem solving' that were observed during the fieldwork day and reflected upon afterwards.

Learning to analyse

The pupil's engagement in the process of analysing and recording results accurately was observed on the fieldwork days, with many questions from pupils across all three projects directed at teachers and scientists around identifying the 'correct' response to complete their record sheets. This prompted detailed discussions between the pupils and the scientists which made the analytic process more visible to the pupils. The following excerpt is an example of a typical discussion;

> *Flattening the soil sample, "Try to roll it into a ball" instructs the scientist, "It won't go." Reports the pupil. "Press for a thumb print?" "No, not really."*
>
> *"This one is a bit different" reports a pupil, "there are always differences from the norm" reassures the scientist.*
>
> *"Does it smear?" "No" "Smearing means there is silt in the sample" explains the scientist.*
>
> *A pupil rubs the sample between their fingers, "I've lost my soil"*
>
> *"If there are grains then it means there is sand present" the scientist explains. "It is dusty." Reports a pupil. "What we have is a sandy clay loam with some gravel" declares the scientist.*
>
> *"This is more sandy than the last one." A pupil compares samples of the same soil horizon.*
>
> *The group are attentive and focussed on the task throughout their analysis. Once they have completed one horizon with the concentrated*

help of the scientist, they become more confident in attending to the next horizons.

"This has more clay in it," suggests a pupil, the scientist counters with "organic material can sometimes behave like clay, but look at the colour."

"Oh, that's pretty powdery."

It's just really cold. You can roll it into a ball"

"Oh, my hands are so mucky."

There is a brief chat about the bus they got to come from the school to the site, which also involves some extended discussion about the buses to and from school breaking down and the poor quality of the roads in the area.

"This sample is silty rather than sandy"

All four pupils are involved in the discussions, there is a co-operative and supportive atmosphere.

SFL School 1: Fieldnotes 3.10.2019

Reiff-Cox (2020) suggests that the traditional 'step-by-step' scientific pathway is a misrepresentation of the complexity and variety of scientific enquiry. Engaging pupils in detailed analysis in the field, supported by experts, enabled them to experience diverse scientific experiences and work through the challenges that this brings. Reflecting on Nussbaum's (2011) central capability to use 'senses, imagination and thought', the pupils, though novices in the field, have the opportunity to use their senses to observe and touch the soil samples. They are then supported to expose their thinking processes and challenged to reconsider without judgement. This process was observed in different ways across the cases, for example.

A discussion took place in relation to counting dead organisms. Some pupils had counted dead organisms and some had not, there ensued a discussion about the importance of agreeing issues in advance of sampling as it would be difficult to recount. The importance of accuracy in the scientific process was emphasised. The group leader suggested that dead organisms would not generally be counted with the exception of organisms trapped in a spider web.

OPAL School 1 Fieldnotes 10.09.2019

The need for accuracy in reporting was emphasised, a reminder to pupils that the data that they were collecting had a destination beyond their own immediate observations. The data collected would be used by the pupils later in the day, and if submitted, by scientists in another organisation, as such the ability of the data to be actually used was important to these pupils. Lab-based analysis was a follow-up to the fieldwork day for two cases, extending and deepening the investigations that could take place. The analysis that took place in the field was limited in all groups, the intention to analyse the results was present for all the groups but whether this was followed up depended upon the teacher.

> *Back in the classroom there was a session where the pupils calculated the biodiversity index of the three habitats in order to compare them. The pupils settled to this task quickly and with confidence, only one group had to start again and were last to contribute their results.*
>
> *The results showed that the soft ground had the highest biodiversity index and the human impact had the least. The natural space, which the pupils hypothesised would have been highest, was in fact in between. This prompted a discussion over ways of managing landscapes for biodiversity and a description of the green roof on the accommodation block as an example of this.*

OPAL School 2 Fieldnotes 10.09.2019

Moss et al (1998) found that a lack of involvement in analytical processes was a frustration for pupils engaged in project-based learning, with this having a negative impact on their perceived value of the experiences. Jorgensen and Jorgensen (2020) suggests that moving participants from thinking about the data collected as a single experience towards understanding the meaning of their data in relation to wider environmental issues is "one pathway for connecting local citizen science to global environmental citizenship" (ibid. p. 3). The central capability to apply 'practical reason' (Nussbaum, 2011) can be drawn upon here. While participation in the citizen science projects described here enabled the pupils to collect, analyse and record data in the field (to varying degrees), there was less emphasis in these cases on engaging critically in experiences that influence their conception of what they feel could be 'good (for the environment)' in their own lives. Thus 'practical reason' was applied to the citizen science practice but only partially applied to the pupil's relation to wider environmental issues.

Problem solving

The (predominantly) remote and isolated nature of the fieldwork experiences meant that when equipment failed there was not another one to hand, or a technician's office around the corner to source a replacement, as there would be in a school classroom-based lesson. This resulted in some challenges for the pupils which they used creativity and alternative materials to overcome;

> *The girls found the weather vane broke as they were attempting to assemble it, one of the girls found a bobble to successfully mend the equipment. There was some uncertainty from them about the tasks, but their success in fixing the weather vane gave them confidence in figuring out how to collect the data that they needed.*
>
> MICCI School 1 Fieldnotes: 9.5.2019

Taylor (2008) found that both scientists and educator agreed on the importance of creativity and critical thinking skills in science education, while Abrahams and Miller (2008) critique the 'recipe' approach to scientific investigations typically conducted in schools as not enabling pupils to make links to the learning content. It is possible that the challenges and 'problems' experienced within the citizen science experience have the potential to be positive learning opportunities for the pupils. One of the scientists described their role in stepping back and enabling the pupils to take the lead in many of the decisions of the day;

> Participant: *there was times when you're just like 'is that the best way to do that?', you know, 'have a wee think here, where are you going to take your sample from if you're standing there and you're taking it downstream, you know, why don't you think about think about taking it upstream?' Just wee things like that, just observations, and I think giving them, empowering them, so handing over stuff because we weren't going to touch it, that's your GPS for the day, I'm not touching it again,*
>
> *…*
>
> *so, you lead us to the site, oh okay, problem solving, you know, not just expecting us to take them from a to b and get on with it.*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020

This suggests that some of the criticisms of the 'data sensing' approach to citizen science may be mediated by creative input of the scientists, emphasising the importance of scientists, teachers and pupils working together to develop citizen science projects that meet the needs of all involved.

It was recognised that learning in unfamiliar settings had the potential to be challenging for the pupils, as such the scientists reflected on the importance they placed on 'getting it right'. Two of the projects in this study were relatively new to all involved and as such the evaluation and subsequent evolution of the projects were described.

> *I think it is quite a difficult thing to get right, to do it properly and get right and if we can help in any way, shape or form then we can do that. I think in also in the first year, we also did not exactly a lecture, we did a class session, is what I'm trying to get at, a class session explaining what soils were and what they were about. We didn't do that in years two and three because we kind of decided let's keep it more practical and we can pick up those things as we talk about, potentially in the field.*
>
> Participant Interview: SFL Scientist 5.12.2019

Balancing the in-class and fieldwork experiences of the pupils was felt to be important to the adult respondents. Research into fieldwork and environmental education (Cook, 2010; Rickinson, 2001; Glackin, 2016, among others) suggests that situating the environmental component within a series of learning activities involving both classroom-based and repeated field visits, is more effective than a one-off, novel event. This will be revisited in the 'Learning *together'* section (p. 109).

Saunders et al (2018) suggest that implementing environmental citizen science experiences can provide opportunities for pupils to engage in 'real' scientific enquiry. Contributing to scientific research is one aspect of this. In this research, authenticity was mentioned by both teachers and scientists in relation to the learning experience,

> *They* (citizen science projects) *provide very good case study examples and 'ready-made projects' that apply to real world situations*
>
> Participant Survey Response (why choose citizen science projects with class): MICCI Teacher RY: 7.11.2020
>
> *Because it makes them realise actually the practical applications, the real-life applications of what they are learning and you know what, this has*

been great at saying right, yes we have our textbook soil profiles, like here's what a podsol is supposed to look like, here is what a gley is supposed to look like, but actually in real life, things are a bit messier than that. So, for them being able to see that and it not just be like, okay this is what it has got to be like, is really useful for them

Participant Interview: SFL Teacher: 15.11.2019

The students love the opportunity to have a "hands-on" chance to take part in such projects.

Participant survey response (any further comments): MICCI Teacher LR: 8.11.2019

It's an it's an opportunity for them to experience real, hands-on, scientific work that that that realistically, you know, people are doing out on the moors in the Peak District, in the South Pennines, you know they're out measuring dip wells and they're doing that.

Participant Interview: MICCI Scientist JW 12.11.2020

Glackin (2016) found that the 'success' (based on observed programme enactment) of outdoor learning experiences was associated with teachers who valued a level of authenticity in science learning. This meant that the outdoors was treated as a learning environment and actively engaged with as such rather than 'treat' or a 'day out'. Paige et al (2010) described the impact of a citizen science project focused on magpies on primary school pupils, they found that the connection between the scientific content and their experiences in the local area, gardens and parks engaged pupils in a meaningful way. It also enabled a wider range of curricular connections to be explored which embedded science in 'real-life' rather than as an abstract concept. The process of replicating an authentic scientific experience for the pupils was described by the SFL scientist.

We kind of do most of that background preparation in terms of looking at the map and see what we've got and all the rest of it but once we get out in the field, the sampling approach based on some transects which we've done, or a sampling approach based on knowledge of particular locations, based on that kind of background which could explain a little in the field, that is pretty much what we do, the, we dig the holes the same way, we endeavour to describe the profiles in the same way, we use the Munford charts, we use the standard texture classes, we look at structure. We

sample systematically all of that we would do normally, when I say normally that's what we would do in the field.

Participant Interview: SFL Scientist: 5.12.2019

Whilst the authenticity of the experience and the contribution to scientific enquiry were less prominent in the reflections of the pupils than the adults, there were some examples of reflections which suggest there was a value to actually experiencing phenomena over the classroom experience.

Soils aren't so clearly defined as we learn in the textbooks (we couldn't figure out the gley soils)

Participant survey response (most memorable): SFL Pupil SR: 5.12.2009

I didn't even know what a moorland was until we got introduced to the project and I thought it was going to be a lot wetter than it actually was.

Participant Focus Group Response (changed understanding of moorlands): MICCI Pupil C: 05.2019

Some reflections on the challenges of identifying 'real' examples using textbook information was also identified in the participant observations.

The group return to their analysis, identifying the A1/A2 and B horizons. There was a little discussion over the absence of an A0 horizon which is the organic element that the pupils would see in a textbook soil profile.

"Oh, so it is a podsol!" There was a positive response to the recognition of the soil.

SLF School 1: Fieldnotes 3.10.2019

Anker-Hansen and Andree (2017) suggest that authenticity in science learning occurs when it becomes meaningful to the pupils, and as such the pupils and teachers may have different understandings and appreciations for the 'authentic' nature of the citizen science experience. That this type of reflection was much more common coming from the teacher and scientist interviews than the pupils suggests that they are more aware of the potential impact of the authentic nature of using outdoor learning, and of the challenges of doing so. Participation in truly collaborative, or co-produced projects may increase the visibility of the authenticity of the experience to pupils, and provide opportunities to engage in projects important to themselves and their local communities. In their reflections on what had been 'most

important' about their citizen science experience, some pupils described an increased awareness of projects tackling environmental issues. Some authors suggest that environmental citizens are those who are able to 'analyse the reasons for, and the solutions to environmental issues (Schindel Dimick, 2015; Berkowitz et al, 2005; Hobson, 2013; Schusler et al, 2009; Short, 2009). Furthermore, Duggan and Gott (2002) argue that anchoring ideas such as uncertainty and reliability in scientific enquiry within local or topical issues allows science education to move away from an emphasis on content towards a consideration of how a 'citizen' could act in response to findings. This research found that pupils were able to experience scientific enquiry in an authentic manner, supporting:

> *The capability to sense, analyse and reflect on environmental issues using scientific enquiry skills (and tools).*

Section 3: Learning *together*

In building the messy and situational maps of the different projects and fieldwork experiences, the importance of relationships was consistently evident. This area was selected to more deeply consider, and as such, I generated a number of social-worlds maps which reflected the intersection of the teachers and environmental scientists/educators WITHIN the environmental citizen science arena. Building (and re-building) these maps enabled me to identify and arrange competing priorities of the social worlds and arenas. This prompted them to be considered in relation to my research questions and the different challenges to be identified. As Sousanis (2015) suggests, arenas can be considered sites of battle, or alternatively as a 'dance floor' with a shared purpose but different approaches, opportunities and constraints. Drawing on Nussbaum's (2011) central capability to apply 'practical reason' to decisions about the future, the participants involved described conflicting priorities. Despite a shared intention to act positively for the environment, in an eco-citizenship context, these challenges threaten the viability and sustainability of citizen science projects in schools. The segment of the map that I have included here (fig. 18) extracts the four key arenas and two social worlds that have been explored in this research.

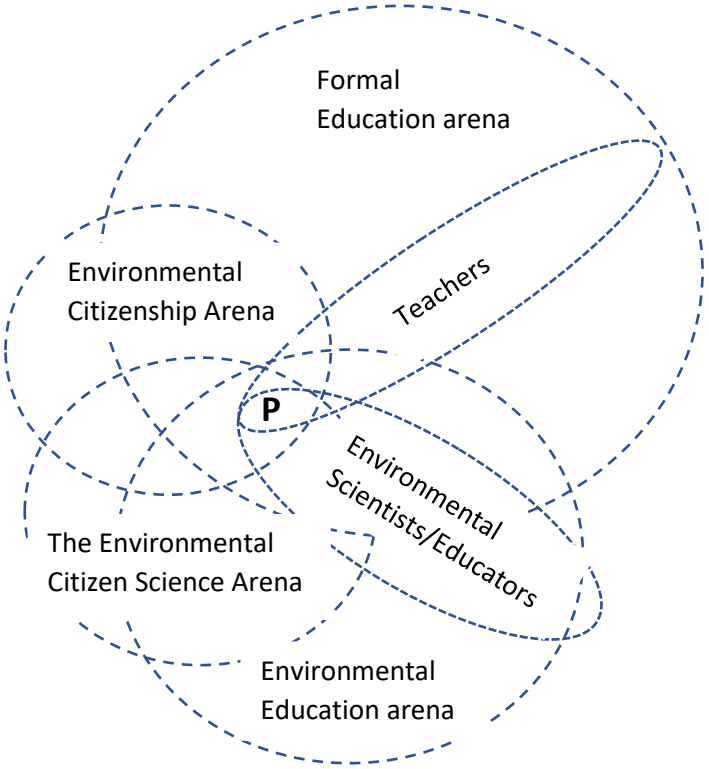

Figure 18: Social worlds map of the citizen science experience across all cases

At the confluence of these four arenas, the social-worlds of the teachers and the environmental scientists overlap with pupils (P) positioned in the centre of this map. In the participant interviews, both the scientists and teachers were asked to describe how their involvement in the citizen science project had come about and to reflect on the challenges and opportunities that they experienced. The relational experiences of the pupils observed during the fieldwork days and reflected upon in the survey responses will be drawn upon here also. These findings will be presented in two sections, firstly, those relating to the relationships between the pupils, the scientists and the teachers, and secondly, the organisational priorities of the social worlds of formal education and environmental education which can both support and inhibit their involvement in citizen science.

Relationships

The seventh of Nussbaum's (2011) central capabilities is 'affiliation', or the capability to "live with and towards others" (ibid. p. 34). Participating in the environmental citizen science experience offered many opportunities for the pupils, teachers and scientists to relate to one

another in a manner that appeared somewhat different to formal school-based relationships. The relationship that the scientists have with the teachers involved was reflected strongly in the interviews as important. In one of the interviews a reciprocal relationship was described, with each recognising and valuing the contribution and experiences of the other.

> *Knowing that you have got a professional relationship with the teachers in the schools, you know that's valued, that's so important, because when new things do come up or opportunities or projects or partnerships, you know, we know we can, we can go to those and say, you know 'there's an opportunity here'.*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020

This was described as particularly important in relation to the MICCI project, which was perceived as new and different, and as such the school groups involved would need to be prepared to be flexible and learn with the project. This is in contrast to the typical school visit, which was felt to be more characteristic of the approach that OPAL enabled, in which the citizen science experience could be adapted to the particular needs of the school.

> *30 (pupils) running about with tape measures, or you know, and that's fine, both of those are of equal importance, but you know, but MICCI is the, OPAL can't do what MICCI does*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020

This suggests that when projects (like OPAL) can be run by schools with little input from the science/ranger teams, there is a perceived difference in the schools that may be able to get involved in a more complex project (like MICCI). This may serve to inadvertently limit school involvement in these projects, but may also limit disappointment or disaffection if the project is not experienced 'fully formed'. However, one of the teachers involved in the MICCI project suggested that the ease of involvement was a key factor in their involvement;

> *Things that are already planned and easy to partake in as the MICCI project was.*
>
> Participant Survey response (what would encourage you to engage with CS?): MICCI Teacher 1: 7.11.2020

Suggesting that, in this case at least, the teacher saw a more 'polished' experience than the ranger team involved perceived.

The wider school ethos was also important to the teachers and is reflected in the awareness of the scientists, for example, the perception of the project to the senior leadership was considered of value in the Soil Fertility Legacies project.

> *It hasn't just been (the teacher), we've had conversations and discussions with the headteacher, so he's been very, indeed he's been out in the field with us in the first year, he has been very, very supportive as well, so that's very, very positive.*
>
> Participant Interview: SFL Scientist: 5.12.2019

While the relationships with individual teachers were described as important, one of the participants suggested that there is a risk to the school involvement in the project when key teachers change role or move on.

> *There's personal investment from the teacher, then that can be a challenge and if that teacher then leaves the school that relationship I've had. I've tried to get in touch with the school and that teacher's gone. Nobody really knows or really cares very much about that project and that relationship then ends, so that's quite a challenge.*
>
> Participant Interview: MICCI Scientist: JW: 12.11.2020

This reflects a challenge relating to the sustainability of environmental citizen science, as part of a formal curriculum in which it remains an add-on, rather than an integrated component. In Scotland, the policy context of Learning for Sustainability (LfS) provides pupils with the entitlement to 'high quality outdoor learning' throughout their school experience. However, in practice this is challenging as the cross-curricular nature of LfS is complex and ambitious, and as a result can be intimidating and confusing to those attempting to implement it. Christie et al (2019) suggest that competing curricular priorities, and financial and time constraints contribute to a lack of awareness and impact of LfS in schools. Sustainable relationships between scientific and environmental organisations and schools are one part of addressing this challenge.

The relationship between the scientists and the pupils was also felt to be important to the adults involved, the ability to connect with young people and help them to make connections with the natural world was discussed by all of the scientists.

> *Participant: there's a bit of an imperative to kind of pass it on you know, so (laughs)*

Interviewer: To get some of that enthusiasm into the next generations

Participant: Yes, yes, absolutely, so it's passing it on is one of the key things, so that's an undoubted benefit.

Participant Interview: SFL Scientist: 5.12.2019

The citizen science experience was described in the sense that it provided a vehicle, an opportunity (an excuse) to do this. The relationship between the ranger/scientist and the pupils was felt to offer an opportunity to engage and inspire the young people, but to also give them room to explore and discover for themselves. Relationship building, to those involved here was therefore important in achieving not only content related learning goals, but also in building confidence and enjoyment into the citizen science experience. The pupils also reflected on the importance of working together and solving problems as a team. In their reflections on what had been 'most memorable' about the fieldwork day, a small proportion of the MICCI and OPAL groups (21% and 9% respectively) reflected on interactions with peers, while in the SLF group peers were involved in half of their 'most memorable' reflections.

Keeping my friend's moral up when it got cold and working as a team to solve problems, putting the string into a square.

Participant survey response (most memorable): MICCI school 2: 31.10.2019

In the participant observations, the interaction between the pupils and the adults involved demonstrates how the scientist supports the pupils to make decisions about their data collection;

"That was a good bit of discussion" the scientist complimented the group.

"Is that loamy sand?" asked a pupil, "I'm not against that" responded the scientist, "that's a yes then", "you need to make your own decisions."

[…]

"Does something feel blocky, or look blocky?" "looks blocky" The group return their focus to the task.

"Everyone grab a chunk", one pupil suggests, and a soil sample is passed around to the group to decide the nature of the sample.

“This is democracy”, “see bringing politics in again”. The group took a vote to establish their consensus on the structure of the soil sample.

SLF School 1: Fieldnotes 3.10.2019

A component of environmental citizenship proposed by some is ‘working with others to reduce the human impact on the environment’ (Schindel Dimick, 2015; Schild, 2016; Chawla and Cushing, 2007). The intergenerational learning opportunities and the inter-action between the different peer groups increased affiliation and social cohesion. The pupils had the opportunity to interact with teachers in a different context to school and with scientists and volunteers’ who brought a new perspective to their learning experience. In working together to determine the outcome of their investigations, guided and prompted by the scientists and teachers involved, the pupils were supported to develop eco-citizenship capabilities of collaboration and affiliation.

The role of adults in guiding and prompting such discussion was visible across all the fieldwork days. The scientists and volunteers were different to the teacher, ‘new’ to the pupils and provided a novel perspective. Hoskins et al (2012) found that talking with peers and adults (teachers and parents) significantly influenced the participatory attitudes to active citizenship across five survey cohorts in Europe. Their research found that this effect was greater even than actual practices of citizenship, volunteering or school council participation, for example. Where scientific concepts were engaged with by pupils in my research, the developing understanding was frequently supported by the discussions between pupils and the teachers/scientists and volunteers. Regular prompts from the adults brought the pupils to consider the data that they were collecting and it’s meaning in relation to the topic.

They (the pupils) showed good retention of the chat we had had the previous day. Remembering why the moorlands were important, what they were made from, what the impact upon climate change and what their role in that was.

MICCI School 1 Fieldnotes 9.5.19

The pupils responded well to questions about climate change and the impact of the moors in mitigating flooding.

MICCI School 2: Fieldnotes 31.10.2019

When the meaning of the different ratings on the soil guide were explained, the teacher also related this to the information that would be

needed in their Higher exam. The AH pupil couldn't remember having done that in the exam, but did remember referring to it in his project.

SFL Fieldnotes: 3.10.2019

The teachers also recognised the value of having 'experts' contribute to the pupils learning on the day, but suggested that all experts are not equal when it comes to working with pupils, with one complimenting the ranger team involved in their particular activity.

I felt like having the […] ranger team were brilliant, really, really good, they knew what they were doing, they knew how to interact with the kids in a really positive way, which was brilliant yeah, and that's not always the case sometimes you get people in from different organisations and they're brilliant at what they're doing and what they're saying, but they don't know how to portray the information very well to the kids, so actually this whole experience has been really brilliant for that and they were really good at like, they were like the experts, you know, usually the kids will say to me 'miss what's this', I'm like I'm not sure, so having them there was really, really useful and they were able to tell us this is this species, and, really, really useful, couldn't have done it without them I don't think.

Participant Interview: MICCI Teacher 1: 15.5.2019

The role of the scientists in building the confidence of the teacher was identified as a key strength of the Soil Fertility Legacies project, particularly noting that the teacher in question was not experienced in this area of the curriculum.

I have zero knowledge about soil, it was not anything I ever did at Uni, it was nothing I ever did as a higher pupil myself and it was my least favourite part of the course …

It has been a complete learning experience for me, I mean, I've learned so much more about this and what's great has been kind of, learning along with the kids. You know, I am quite open about the fact that, they know that I'm not the expert on this and that I'm learning as they are learning, which is great in some ways.

Participant Interview: SFL Teacher: 15.11.2019

The scientists also reflected on the limitations of some aspects of the school experience of the citizen science projects and the need for scientists to provide support to meet this need;

What we'd like to see is the schools taking more of an involvement in doing that analysis and ownership of the data and putting the data in and understanding a bit more about the project as a whole.

Participant Interview: MICCI Scientist LW: 22.5.2019

It's not something you could do self-led and that you need, you need that package and that's expert and the equipment to have the, the whole experience.

Participant Interview: MICCI Scientist JW: 12.11.2020

The opportunity to engage in pre-and/or post-activity learning was considered to enhance the experience by both teachers and scientists.

Actually, speaking to them about that beforehand I think, was really good and really useful, and then it kind of put it into context.

Participant Interview: MICCI Teacher 1: 15.05.2019

You're trying to get them to understand the how peat forms and why that's important and how this a whole lot environment is working and I think that is all dependent on the teacher and whether they've had some prior understanding, so I think you know that could be a negative that there's a bit too much information to take in as well as learning the approach with the equipment. So, I think some prior, some post coming out engagement would probably remedy that.

Participant Interview: MICCI Scientist JW: 12.11.2020

The importance of teachers and citizen science practitioners working together and taking pedagogical approaches into consideration was reflected upon by both the teachers and the scientists. The suggestion that positioning the citizen science experience in a wider educational and global context may result in a fuller, deeper learning experience was explored, one which allows space and time for both the conceptual and the practical learning components of the experience to be fully realised. Peacock and Pratt (2011) suggest that the use of structured worksheets in non-school based learning settings can narrow the focus of the pupils and not encourage them to actually see and consider the wider experiences that the unique learning setting affords. Utilising a scientific protocol as a 'worksheet' may have a similar impact on the citizen science participants. From the scientist perspectives, the practical experiences were considered a structure to hang important messages or key

concepts on, however there was an acknowledgement of the challenges that pupils may find within the experience.

> *It's a really good scaffold, as a framework to hang the key messages on that we want to get across to people, and I think that works really well. So as a practical experience for people, that that's very engaging. Whereas if you just actually just trying to speak to them about those issues, it just loses context slightly.*
>
> *It's hard to differentiate. So, if you've got a pupil that is going to struggle to take on some of these concepts … That's hard to differentiate, and I think that's another thing that some pupils might find a bit challenging.*
>
> Participant Interview: MICCI Scientist JW 12.11.2020

This reflects the challenge that teachers face in building opportunities for pupils to experience engagement in scientific processes in an authentic manner within the performative environment of the school setting, as described by Jeronen et al (2016). Highlighting some contradictions between the learning experiences of the pupils and the needs of the courses within which the citizen science experience took place.

In summary, the interactions and purposeful, positive relationships between the pupils, teachers and scientists involved was a significant and memorable part of the environmental citizen science experience for the participants in my study.

Competing and converging organisational priorities

The situation of the scientists and teachers within their respective organisations was reflected upon in many of the discussions. The contribution of the citizen science project to the organisational priorities was key to all participants, meeting and connecting with organisational priorities offered an opportunity to raise that value of working with schools to the wider conservation teams.

> *Participant: some of the projects in our biodiversity action plan 'Wild Park' wouldn't happen if it wasn't for the volunteers contributing that data*
>
> *…*
>
> *Participant: we obviously have our priorities that we want these projects to fit in with as well, so it's trying to get a bit of …*

Interviewer: a balance?

Participant: a balance.

Participant Interview: MICCI scientist LW: 22.5.2019

For example, for one of the scientists, there was a feeling that the findings of the project would be useful to the peatland restoration teams and therefore would enhance the standing of the project across the organisation.

> *We've got four key biodiversity threats in our new Biodiversity Action Plan and one of those is climate change, and doing the MICCI project is going to give not only results in terms of how the climate is affecting the peatlands, but also the other way around, it will give us information on what's happening with the peatlands particularly on sites in the future that are being restored and how that is changing in terms of vegetation and the carbon.*

Participant Interview: MICCI scientist LW: 22.5.2019

However, the risk that a project fails to meet evolving organisational priorities makes adoption and continuation a challenge. The resource implications facing the organisations and individuals involved mean that capacity to develop meaningful citizen science projects alongside schools is considered a dream rather than a reality.

> *Obviously, we have to think about, everything that we do and making it relevant to our work and to the place, and so that's where I have to sort of get my hat on, the direction the park is taking obviously around climate change work and so on*
>
> *We have to work with those partners (landowners), what are they doing, you know, where are they taking their, what's their organisational priorities, what are they looking at for their site, is there ways that we can help with that? So, all those things have to get you know, sort of, aligned.*

Participant Interview: MICCI Scientist AC: 2.11.2020

Acknowledging and working with the structures of the school were important to the scientists. They recognised that the schools had needs and challenges in relation to timetables, transport, the resources and time available and were keen to support the teachers in overcoming these challenges. Teachers quoted time constraints as their biggest

barrier. The reflection that it is essential to make things as easy as possible for schools to be able to get involved in a project of this nature illustrates the challenges that environmental scientists face in working with young people through formal education settings. The benefit, as explained by two of the participants, is that the school pupils represent a more diverse population than they are typically able to engage with, and as such offers the scientists the chance to make connections with people for whom the environment, and environmental issues are seen as 'not for them'.

> *I think that you know school engagement's really important because, it's not, it's non-biased, so it's literally everybody who is in that class will do that activity, whereas if you engage with scouts or guides or you're only getting that specific type of young person, whereas if you deal with the school, you getting all types of young people so, in terms of diversity and reaching diverse audiences, it's the best way to go.*
>
> Participant Interview: MICCI Scientist JW 12.11.2020

Competing organisational priorities were also a concern:

> *Generally, engagement, it does struggle at times to come into its own and to be valued as how important it is as part of the whole conservation progress, and that is, it's getting better, but you know it is, it is a challenge for people to justify engagement at times, and I think that in my opinion every project should have built in engagement as part of that project and that is, it's becoming better, but you know, it still is still a you know, still a difficult situation.*
>
> *…*
>
> *I think it's just kind of one of the challenges people probably faces thinking about the, the logistical side of it, health and safety side of it, you know, health and safety alarms going off for certain reasons might put people off, so if there was an element of you know. Also, not from my perspective, but some of the ecologists might be a bit protective in terms of not encouraging people to go to look for certain species and also not broadcasting the locations of certain species.*
>
> Participant Interview: MICCI Scientist JW 12.11.2020

Resources, including workload and budget was identified as a key challenge to the running and sustainability of the projects. There were also a number of practical challenges, including transport, clothing and experimental equipment which were felt to be barriers to the successful operation of the project.

> *Interviewer: things that would prevent you from actually engaging with a citizen science project, what would they be?*
>
> *Participant: time, resources, capacity, relevance, head-space,*
>
> *Interviewer: Absolutely*
>
> *Participant: em, yeah, it has to be of relevance to the place, you know*
>
> *…*
>
> *Interviewer: absolutely, so if a school had an idea for a citizen science project came to you, would that be something that you would be able to support?*
>
> *Participant: oh yeah, without a doubt, and again just making sure by having a conversation that those types of parameters that we can work within*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020
>
> *I think with a bit more resource devoted to it, I could have expanded it to include more groups and new groups. Unfortunately, that resource isn't there at the moment*
>
> Participant Interview: MICCI Scientist JW 12.11.2020
>
> *The negative is that the time has to come from somewhere, you know so something that used to take, I mean I'm not kidding literally four lessons, now takes you know, it takes those four lessons because obviously we have do the theory, but now we've got the time the fieldwork takes, the time the lab-work takes, so that has to come from somewhere. Which is a downside, but I think the experience they're getting, it more than makes up for that.*
>
> Participant Interview: SFL Teacher: 15.11.2019

It's not necessarily time that they university recognises

…

at the end of the day, will I get my ref 4 paper out of this, almost certainly not, so how do you kind of square that kind of rubric, but that said, if part of your job in the university is about doing research which you then translate into education programmes, I think that's essentially what we're doing*

…

We've got responsibilities here yeah, so I can kind of pitch up, but I kind of need that in place I think, there has to be something there to be able to say we can continue. So, the sustainability thing is a big question, how you make it work with expectations and longer term?

Participant Interview: SFL Scientist: 5.12.2019

The resource-based barriers to participation in citizen science projects echo those described in relation to schools engaging in outdoor fieldwork and environmental education more generally (Kollmuss and Agyeman, 2002; Fiennes et al, 2015; Christie et al, 2019 and others). However, the strongly relational nature of the citizen science experience has the potential to enable pupils to engage with elements of environmental citizenship, namely 'contribute to debates and discussions about environmental issues' (Dobson, 2007; Hobson, 2013; Schusler et al, 2009). Davies (2004) also reflects on the importance of debate and discussion in science education for citizenship. This research found that, despite resource related challenges and the competing priorities of conservation and engagement, the environmental citizen science experiences described here provided opportunities for the pupils to work collectively to support;

> *The capability to learn together, sharing experiences and understandings of the environment, and environmental issues with peers and adults.*

Chapter 4 Conclusions

Through analysing the environmental citizen science activities experienced by the participants in these cases, I can say that participation offered the opportunity to develop the following eco citizenship capabilities.

- **The capability to learn about environmental issues and consider the impact humans can have on the environment.** This was supported by opportunities for pupils to demonstrate their understanding of environmental concepts and issues. The pupils were encouraged by teachers, scientists and peers, to reflect on human activity on the environment during their fieldwork encounters. Offering their own thoughts and reflections on environmental issues demonstrated the important role of citizen science experiences in making space for these important conversations and reflections.
- **The capability to sense, analyse and reflect on environmental issues using scientific enquiry skills.** This was supported by opportunities for pupils to engage in authentic scientific enquiry. The importance of collecting, analysing and recording data accurately was emphasised throughout the citizen science activities.
- **The capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.** This was supported by opportunities for pupils to work together to solve problems in an authentic situation. Teacher and scientists were able to collaborate and support each other to enhance the learning experience for pupils.

Chapter 4: Findings summary

In my analysis, I have shown that participation in environmental citizen science can contribute to the development of the capability to learn about environmental issues, and consider the impact humans can have on the environment. Across all cases the pupils were able to:

- Offer their own reflections and thoughts about environmental issues
- Demonstrate understanding of environmental knowledge
- Reflect on the impact of human activity on the environment in positive, negative and neutral terms

The formal curriculum was observed to be a consistent frame of reference for the fieldwork experiences.

In my analysis, I have shown that participation in environmental citizen science contributed to the development of the capability to sense, analyse and reflect on environmental issues using scientific enquiry skills. Across all cases, the pupils in my study:

- Were observed engaging in data collection, analysis, and accurate recording of results.
- Reported that they were able to experience scientific enquiry in an authentic manner.
- However, the role of authenticity in the experience and its contribution to scientific enquiry was less highly valued in the reflections of the pupils than those of the adults.

Observations and participant reflections showed me that participation in environmental citizen science can contribute to the development of the capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

The descriptions of converging and diverging organisational priorities by the adults involved reflect opportunities and challenges to the implementation and operational sustainability of school-based citizen science projects.

- Resource issues such as workload and funding challenges are shared by the citizen science providers and schools.
- The priorities of conservation practice and research can be at odds with engagement and participation activities for citizen science providers.

Chapter 5: More-than-human Encounters

Introduction

This chapter will look to draw out those more-than-human elements and respond to the following research question;

> *What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities in young people?*

In the following analysis, data is drawn from the participant observations of fieldwork experiences which were converted first into fieldnotes and then messy maps. It will also use the pupil reflections that were provided during the sentence completion task, and their response to the question of whether the citizen science experience changed their relationship with plants, animals and the world of nature. Finally, focus group interviews with pupils asked them to reflect on their relationship with plants, animals and the world of nature using an image taken during the fieldwork day as a prompt. For a fuller account of these approaches, please see methodology p. 73.

The data was analysed firstly using messy and relational maps. The contribution of the participants was coded and arranged into themes using the messy maps, the sensitising concepts (Clarke et al, 2012) of 'physical/sensory encounters' and 'encounter with other living things' were utilised and interrogated within this process. The themes and associated terms then arranged into relational maps, in which the convergences and divergences between the citizen science experiences were identified. These will be drawn out and discussed in relation to the eco-citizenship capabilities that are implicated in the experience.

As described in detail in my methodology, situational analysis is an approach that builds on symbolic interactionist and assemblage principles to consider all the aspects of a situation. It asks that the researcher pay attention to the material and more-than-human components of the situation under consideration. This is of particular relevance to the experience of citizen science as a formal learning activity that takes place outside the traditional classroom setting. Environmental citizen science experiences take place in settings that are 'beyond the classroom'. As with environmental education experienced in formal education settings, there may be parts of the experience located within the classroom, background information or data analysis for example, however, a field-based data collection component is an essential characteristic of environmental citizen science. The 'field' may be the school grounds or a more remote location, close to home or in a new country, and as such the

participants are encouraged by the scientists and the processes involved, to ‘look’ at the location of concern through a ‘scientist’ lens. The choice of location may be influenced by the pupils, however, often this is dictated by the requirements of the chosen project and the intentions of the teacher/scientist involved. In all cases described here, the location was determined by the teacher and the scientist either individually or collaboratively, the pupils had no involvement in that decision.

Reflecting on Nussbaum’s (2011) suggestion that the eighth of her ten central capabilities is to be able to “live with concern for and in relation to animals, plants and the world of nature”. Considering that ‘capabilities’ for Nussbaum includes “the capabilities of non-human animals as well as human beings” (Nussbaum, 2011, p. 18), this is a particularly relevant ‘capability’ to reflect upon in response to the citizen science experience. The pupils were asked if and in what ways the citizen science experience had changed the way that they feel about plants, animals and the natural world, in a written survey response. Following this, a smaller number of pupils were also asked to reflect on their experiences with ‘plants, animals and the natural world’ in a focus group discussion centred around an image of an organism that they had encountered on their fieldwork day, such as a caterpillar or a dragonfly. The responses to these questions will explore the connection between the citizen science experience and this capability.

This chapter will firstly outline some of the concepts that underpin the subsequent analysis. It will go on to draw out the more-than-human encounters made visible on the fieldwork day and discuss the ways in which the pupils and adults involved reflected upon these. Two examples of the pupils connecting or ‘becoming with’ the fieldwork site will then be described and their importance in illustrating the ways in which pupils are able to “live … in relation to animals, plants and the world of nature” (Nussbaum, 2011, p. 18) will be identified. Finally, the pupils’ responses to whether or not they felt that the citizen science experience had changed the way they feel about plants, animals, and the world of nature, through their survey and focus group responses will be presented.

Background

Firstly, I will provide a brief revision of some of the key principles that underpin the analysis in this chapter.

Drawing on a growing body of research that considers environmental education as a situated experience of ‘becoming-with’ the world around us (Jukes, Stewart and Morse, 2019; Mannion, 2019; Clark and Mcphie, 2020). This chapter draws upon the new-materialist

framing that employing situational analysis provides an entry point into within this research project. Drawing on new materialist theories of attunement and relational assemblages, the situational maps produced in response to the fieldwork experience attempt to not only identify, but to deeply consider the impact of the landscape/human/animal/plant interactions on the eco-citizenship capabilities of the young people involved.

Suave (2009) suggests that environmental education is forged in our relation to the environment, and that it is at this interface of social and ecological relations that environmental citizenship can be developed. This research looks to notice and identify those relational experiences that pupils have and explore the potential of them to lead to eco-citizenship related capabilities. Place-responsive pedagogies (Lynch and Mannion, 2021) can support an improvement in the relationship between people and their environment by encouraging learning in a manner that attunes to the place. Wattchow and Brown (2011) suggest that 'being present in and with a place' (ibid. p. 182) is a characteristic of place-responsive practice, which has the opportunity to help young people attend to the wider, wicked challenges facing them in contemporary environmental education.

Worster and Whitten (2020), suggest that children grow up within a 'Kaleidoscope of Places' (ibid. p. 8) in which traditional expressions of 'nature' can be dynamic and shifting. Moving away from dominance and stewardship approaches within environmental education towards relational ways of being and knowing is relevant when considering the experience of pupils in these particular places is framed by the contributory nature of the citizen science project. While the data collection protocols are echoed across the projects, the 'places' in which the pupils become entangled with varies. For some looking at their own familiar school grounds in a new way, for others visiting a new and unfamiliar landscape. Drawing out these entanglements and the pupil responses to them offers an insight into the connections that pupils are able to make which may be facilitated or constrained by their participation in the citizen science experience.

Section 1: Encounters and reflections

Spiders, snakes and other living things

Noticing

Across all three projects, during the fieldwork days the pupils' attention was attracted by a variety of animals, including reptiles, birds and invertebrates. OPAL and MICCI involved intentional encounters with other living things, with identification of wildlife (MICCI) and

invertebrates (OPAL) as a key focus of both projects. The protocols for these projects both explicitly ask the pupils to look for, and at the invertebrates, birds and other organisms that can be found in their pre-defined locations. SFL was not focused on living things specifically, instead, chance encounters were dominant in this project. The interactions with these animals, whether by intention or by chance, afforded the pupils the opportunity to consider and reflect on the life of that particular organisms, this sparked some interesting conversations between the pupils and the scientists/teachers, for example;

> *"That is cool." The girl, on finding a bright yellow caterpillar under some grass at the edge of the path.*
>
> *"Can I touch it?" she asks, "Let's move it somewhere safer," Suggests 'A' (the scientist leading the experience). "It might be dead" she suggests, "No, they sometimes pretend, roll onto their sides." One of the boys explains, he then goes on to show his knowledge of the structure of an earthworm as 'A' shows the caterpillar to the rest of the group.*
>
> *"I know someone who is terrified of caterpillars." One pupil contributes.*
>
> *'A' suggest that the caterpillar might be responsible for the missing broccoli (from the raised beds). "What do they eat?" asks a pupil. "Leaves" is the response. "Let's put him on a leafy thing."*
>
> OPAL School 2 Fieldnotes 9.10.19

This conversation reflects this pupil's journey from the wonder of initially finding the caterpillar to considering the safety of the organism, relating this to other species and then ultimately intervening to protect it. The pupils are being response-able, as Haraway (2016) suggests, to the intricacies of our relationship with other species as a messy, complicated affair in which these pupils are open to engaging in. Care is taken over the individual, despite the recognition that it may generate fear. The pupil involved is quick to suggest that others may experience fear, though not themselves in this case. The pupils' reflections on fear and overcoming the discomfort experienced when faced with invertebrates will be discussed in more depth in chapter 4. Through engaging in the citizen science experience, the pupils are supported to relate to these other species. Haraway (2016) describes a relationship between the pigeon racing community and the Cornell Institute of Ornithology, engaging in a citizen science project utilising the pigeons. In response to this project, Haraway describes the changed relationship between the human and avian participants, with a new 'knowing' the result.

The intention of the teacher in the OPAL (school 2) particular experience, beyond the citizen science component, was to improve a wildlife garden area in the school grounds, thereby increasing the biodiversity that was able to be found there. Undertaking the citizen science project enabled them to establish a base-line understanding of the species present at that time, with the view that they would be able to plant and design the space to encourage a greater diversity of species going forward. This longer-term thinking facilitated the exploration of what might at first seem like quite a disappointing, 'not fantastic' area. The findings of the enquiry showed that there were in fact a great deal of other living things within the space that these pupils may not have given any consideration at all prior to this experience. Using the citizen science protocol to draw the pupil's attention to the other living things that they share the school grounds with afforded an opportunity to more deeply connect them with their own surroundings.

> *Participant: I haven't really seen a caterpillar before.*
>
> *Interviewer: No, had you not seen one before?*
>
> *Participant: Not really, I think I've seen a couple but like, but seeing one and actually looking at it was cool.*
>
> OPAL School 2: Focus Group Response: Plants, animals and the world of nature: 23.10.19

This notion of actually looking at the caterpillar as opposed to simply knowing that they exist reflects an increased sense of coming-to-know for this particular pupil. The act of taking time to look at the caterpillar is identified as an 'extra', as something unusual, something 'cool'.

> *The main finds were woodlice and an exciting find was identified by the scientist as a slow worm.*
>
> *The pupils noticed the blackberries around them, discussed this as food for birds.*
>
> OPAL School 1 Fieldnotes 10.9.19
>
> *There are various birds that fly over the group and the sounds of the birds can be heard in the space, however the pupils do not take notice or discuss this, they are predominantly focused on the report and ensuring they are completing it fully and correctly.*
>
> SFL Fieldnotes 3.10.19

The ‘noticing’ that the pupils did in their respective landscapes was, in part at least, directed by the instructions of the task and by the adults facilitating. The OPAL project protocol instructs the pupils to look under, around, up and into, the surrounding environment. In doing so, they expanded on this and noticed other components of this particular ecosystem that were not part of the citizen science project, the blackberries as food for birds, for example. Neither blackberries nor birds are explicitly identified in the invertebrate survey. In the SFL project however, the scientists and teachers directed the pupils’ attention down and into the soil, focusing on detailed looking at this one particular component of the ecosystem, as a result this served to somewhat reduce outward looking. There were fewer references in the fieldnotes or messy maps to other living things, excepting sheep, which were present in the landscape in the SFL project.

Reflecting on the role of the ’project’ as an actor in the experience, the adults used the project protocols to direct the ‘looking’ of the pupils, connecting them to different components of fieldwork location, both living and non-living. This served to emphasise some parts of the fieldwork experience over others, and in doing so direct the pupil’s attention in particular directions. This alludes to a conflict present in school-based citizen science experiences between the desire to collect ‘good data’, therefore attending to isolated components of the experience, and exploiting the opportunity to ‘be’ in the outdoors, to provide the pupils with the freedom to make their own connections and relations with that place.

Joy and fear

Excitement and delight in the discovery of the various invertebrates was apparent in both MICCI and OPAL projects. However, in particular in the OPAL project, the use of a pooter enabled them to collect the organisms without touching them directly, resulting in the described pupil-pooter-snail entanglement. To use a pooter, you effectively inhale the organism into the collecting tub, which is a slightly more sensory experience than might have been expected by the pupils, ensuring the correct tube is inhaled through caused some chatter when using it for the first time. The nature of the clear plastic collecting tub enabled the pupils to closely observe their invertebrate finds, and show them to the rest of the group. This built their confidence around the organisms and in both OPAL groups, eventually some of the pupils became confident enough to directly handle spiders and other invertebrates. The example discussion and debate shown here describes how the pupils draw on their existing knowledge and experience of invertebrates, which they were keen to share with each other.

"We found a snail" the boys collected the small snail in a pooter and showed it to me proudly.

"Let's get down around the base" suggests A (scientist), the boys are intently investigating the branching trunk of the tree. "Oh, there's a beetle." "That's a woodlouse."

One of the boys collects a spider in his hand and presents it to everyone, the group are all excited and keen to look at it.

"What kind is that?" "It could be a baby daddy long-legs? No, they have wings."

A short discussion ensues about the difference between the centipedes and millipedes.

OPAL School 2 Fieldnotes 9.10.19

Sharing their different finds exemplified the collective nature of the experience. Within MICCI and OPAL in particular, the pairs or groups shared any findings of interest with the rest of the group. The adults involved also did this. Asah et al (2012) found that while childhood nature exposure with friends was positively associated with adult environmental citizenship, exposure through school programmes was not. By opening up opportunities for peer, inter-generational and inter-species interactions, the citizen science fieldwork experience has the potential to positively influence eco-citizenship capabilities in young people.

Overcoming their fears and discomfort in the face of snakes and certain invertebrates was reflected upon in both the OPAL and MICCI groups. Exposure to, and the chance to spend time with and actually look at, these organisms were all identified as playing a role in reducing the fear and discomfort that they felt. This then made the impact of encountering these species more meaningful and memorable for the pupils. Randler et al (2013) found that there was a relationship between high levels of disgust and low levels of motivation in biology classrooms, reducing disgust and fear of the organisms in question through exposure and awareness raising may go some way to mitigate for this reduction in motivation.

The spotting of an adder in the long grass created a significant drama for the group. One of the girls had sat down close to the snake and got a fright as it moved away from her. Many of the group gathered to take a photo of the snake.

MICCI School 1 Fieldnotes 9.05.19

In noticing, finding joy in, and overcoming fears of other species, in particular invertebrates and reptiles, the pupils were able to engage with these species in a way that is not possible within the traditional classroom experience. As such, engaging in outdoor fieldwork as part of the citizen science experiences served to support the pupils' connection to plants, animals and the world of nature. The following section describes the reflections of the pupils following their encounters with other living things. It will consider the potential impact that these experiences had on their ongoing relationship with plants, animals and the world of nature.

Pupil reflections

The sentence completion task (described in methodology and method: data collection, p. 75) was used to identify any connections to the other living things that the pupils were compelled to make. As described, these sentences were completed around a week after the event, as such exploring the components that persisted in the pupils' attention. The number of comments relating to living things for each case, across the four sentences, was counted and presented below.

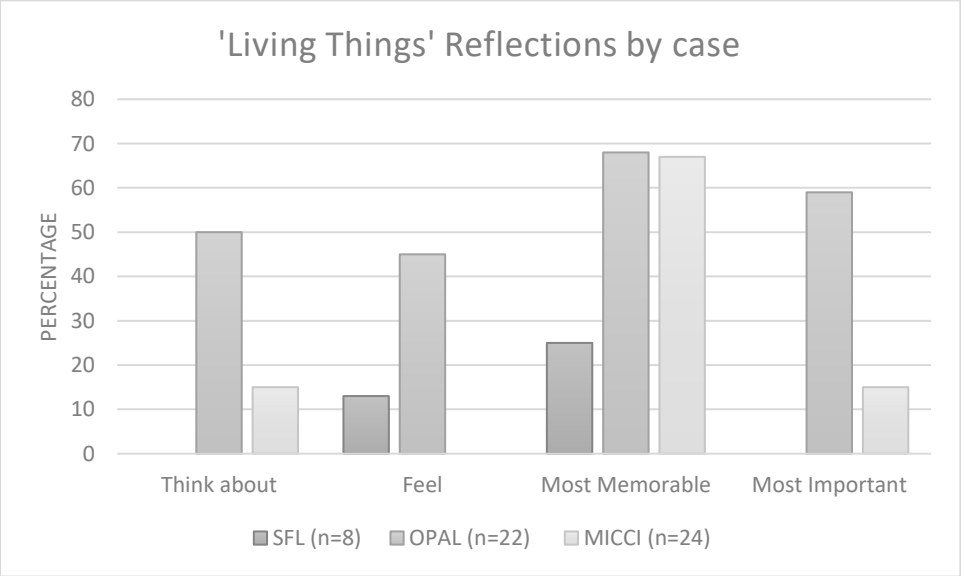

Figure 19: Pupil reflections on 'living things' percentage across all cases

The reflections of living things in the 'most memorable' category are highest in all cases, although significantly lower for the SFL pupils than the other two. The memorable reflections for MICCI and OPAL relate to the specific species that we saw on the day; snakes, spiders, dragonfly, and lizards were all given as examples.

Catching spiders because they are beautiful

OPAL School 1: Survey response: Most Memorable

The OPAL pupils reflected particularly strongly on the living things in the ‘most important’ and in the ‘think about’ categories, this includes reflections such as;

> *The amount of wildlife there is and how much species richness there’s around us without us even noticing*
>
> OPAL School 1: Survey Response: Think About ….
>
> *Nature is filled with loads of hidden species, and it is important not to disrupt them*
>
> OPAL School 1: Survey Response: Most Important …

Revealing the ‘hidden’ component of nature connects back to the enhanced ‘noticing’ that took place on the fieldwork day. Not only spending time in nature, but being encouraged to look, to observe and record served to increase the ‘amount’ of nature that they were able to see. ‘Sensitivity to the environment’ is identified in Hungerford and Volk’s (1990) adaptation of Hines (1987) model of Responsible Environmental Behaviour. While the relationship between awareness of environmental issues and direct action to attend to these is repeatedly challenged in modelling pro-environmental behaviour, such factors remain important in providing a basis on which to build towards individual or collective action (Haywood et al, 2016; Goldman et al, 2020).

While living things were generally less often reflected upon in response to ‘the citizen science project made me feel …’ than in the other sentences, common reflections from the OPAL pupils were that the experience made them feel ‘more comfortable’ and ‘more confident’ around the invertebrate species that they encountered. The dominance of the OPAL project experience in engaging the pupils with living things across all four sentence stems reflects the nature of the enquiry driven by the content of that particular project. In contrast, living things were not considered ‘most important’ by any of the pupils in the SFL project. It can be suggested that the emphasis of this project on soil characteristics engaged the pupils with a different component of the fieldwork location.

Targeted reflections

In the focus group sessions, the pupils involved were asked to reflect on a particular species that they had encountered on the fieldwork day and consider how they related to plants, animals and the world of nature, using the identified species as an example. In one of the MICCI groups, a particularly large dragonfly had been seen on the walk out to the site:

Figure 20: Image of a dragonfly taken on fieldwork day (MICCI School 2)

We passed a dragonfly resting on a heather bush which was absolutely beautiful, covered in dew, it was clearly coming to the end of its life so late in the season, but it was absolutely sparkling in the sunshine, the pupils mentioned that it looked like a broach, that it had sequins on it, it was absolutely sparkling in the sunshine, really lovely.

MICCI School 2 Fieldnotes 31.10.19

The ensuing focus group discussion gave an insight into how these particular pupils reacted to this experience.

> *Interviewer: So, we saw the dragonfly on the walk out, tell me what it was doing?*
>
> *Participant 1: Well, we didn't know if it was dead or not, like we thought it might have been dead, it was like, very still, or it could of just been really cold.*
>
> *(…)*
>
> *Participant 2: I mean it doesn't really, it's much harsher environment like, for them than it is for us, but em, I don't know if it really, like, animals like that doesn't really affect us and like, on a wide scale, I don't know.*
>
> *Participant 3: I guess you wouldn't really think about it until you saw it, like I wouldn't, it's not something I would think about until we were out there and saw it*
>
> *Participant 1: yeah*
>
> *Interviewer: so, actually being there in that moment*
>
> *Participant 1: yeah, it is obviously just seeing that it was quite a lot harder for them to survive than it would be for us, we don't live in the same conditions they do.*

Interviewer What about you, what did you think?

Participant 4: yeah, it doesn't really play a part in our lives that much unless you're out there.

Participant 2: yeah, it's not like we would notice, that you know if all the dragonflies were dying in that area, or whatever, it doesn't actually, we wouldn't hear about something like that. it doesn't actually, it doesn't affect our everyday life but yeah.

MICCI School 2: Focus Group Response: 7.11.19

Comparing the life of the dragonfly with their own, the pupils reflected that it would be harder for them to survive the harsh conditions, however, they reported that they would have found it difficult to relate to the organism had they not been faced with it. They noticeably felt separate from the organism and unable to see how it's life may impact upon theirs. The effect of participating in the citizen science project in enabling these pupils to reflect on the contrasting life of this and other species offers a place to start wider discussions about the conditions of life and how interlinked and interdependent we are within our environment. The entangled and enmeshed perspective of Haraway (2016) and others only becomes apparent to these young people when they are faced with the reality of it. Developing a sense of empathy and increased understanding of the species that they were interacting with was identified by one of the focus groups.

Em well, you know how we were saying that em it's like if you were outside and it's good to be cold for a little while sometimes if you are outside and you're cold sometimes it's like showing you how the environment feels and how bugs feel cause some bugs are more used to warm weather rather than cold weather.

OPAL School 2: Focus Group Response: 23.10.19

Connection to nature is described as a component of environmental citizenship by Chawla and Cushing (2007), and Hadjichambis and Reis (2020) suggest that a 'healthy relationship with nature' is important as a foundation to challenging global environmental issues. The importance placed by the pupils on their connections with other species during the fieldwork experiences are also demonstrated in their reflections after the event. It can be suggested, therefore, that the citizen science experiences support the eco-citizenship capability to connect with plants, animals and the world of nature.

Physical and sensory encounters

Physical and sensory encounters were a significant component of the fieldwork days across all three projects. The locations of the different projects range from the extreme isolation of moorlands in the MICCI project experiences, to the school grounds and the outdoor centre car park of the OPAL project. Drawing on the fieldnotes from the participant observation days, a series of relational maps of these physical and sensory encounters were generated, for example (fig. 21):

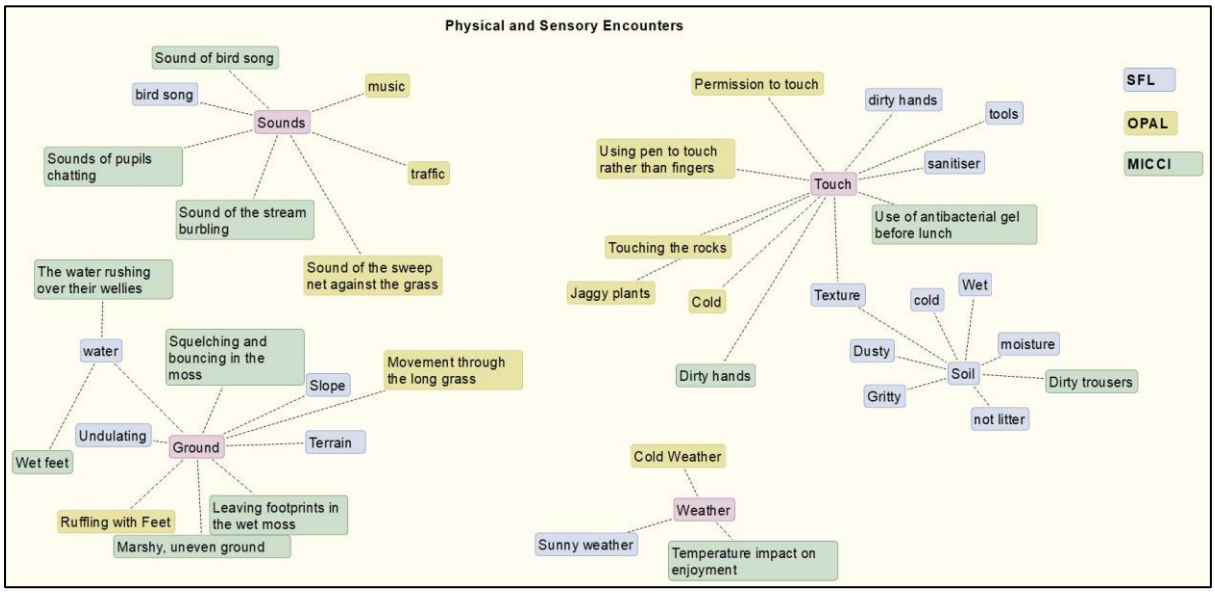

Figure 21: Relational map by project: physical and sensory encounters

In all three projects, the pupils were exposed to sensory stimulus that was unique to each fieldwork location. The sounds of traffic and music were particular to the urban and semi-urban locations of the OPAL project fieldwork days, while the squelching and bouncing on the moss was experienced only in the MICCI project. There were a number of shared sensory experiences between the projects, the experience of touching the landscape with their hands was identified in all three projects. Touching the rocks, soil and plants are all described in the fieldnotes, with reflections on dirty hands and hand sanitiser present. The pupils' experience of the ground beneath their feet was also present in all three project experiences. The undulating, uneven ground described in the MICCI and SFL experiences, and their movement of the leaf litter with their feet ('ruffling') present for the OPAL pupils. Drawing on place-responsive pedagogies (Lynch and Mannion, 2021), the relational nature of this interaction with the fieldwork location was considered. The pupils were moved to react and respond to the nature of the place in quite different ways, for example;

On waiting to climb a fence, some of the pupils began to bounce in the boggy ground, noticing that the ground surrounding them for quite some distance also moved when they bounced. There was a distinct sense of play in this activity, delight was taken in the affect they were having on the ground below them. This was only stopped when cautioned by the teacher that they might get stuck.

MICCI School 1: Fieldnotes 9.05.19

On swapping activities, one of the girls expressed apprehension about the next task, "Do we have to get in the ditch? I don't want to get in the ditch." Within moments of starting the data collection task, all but 3 of the girls were standing in the stream.

MICCI School 1: Fieldnotes 9.05.19

These two examples suggest that rather than being 'in' or 'on' the landscape, that the pupils can be described in relation 'with' the landscape. The nature of the 'place' invites them to behave in ways that are unique to it and the 'place' responds, bouncing back, entangling the pupils 'within' the landscape. The exchange provides a connection between the pupil and the place that they may not be aware of it. Lynch and Mannion (2021) describe the importance of attunement, "a response making process at work *with* the material" (ibid. p 866), as key to place responsive pedagogies. These encounters were fleeting, moments of relation with the places which were not a pre-determined part of any of the projects' intended learning outcomes. Ma and Green (2021) emphasise the importance of embodied learning in the science curriculum, finding that different places constituted different 'bodily-place engagement' amongst primary aged science students. Similarly, Cooke (2022) explore the challenges of using a sensory learning approach with music and science student teachers. The challenge of balancing the need to achieve traditional 'outcomes' such as data collection or content knowledge alongside a desire to make visible the relational and sensory entanglements of pupil-environment is abundantly clear in the cases described here.

Movement within place

'Movement within place' was identified as a theme evident in the fieldwork day experiences and in the pupils' reflections during the focus group discussions. In particular in the case of the MICCI project, the isolated and remote nature of the landscape was dominant in the pupils' descriptions.

> *“This really is the middle of nowhere” exclaimed one of the pupils as we continued across the moorland.*
>
> MICCI School 2 Fieldnotes 31.10.19

> *The moorland was really big and it was full of grass, moss and heather, the ground was soft and there was a bit that was like a trampoline. There was a big hill and it was really cold.*
>
> MICCI School 1 Blog post response 15.05.19

The expectations of the pupils were at times confounded by their experience in the space.

> *Participant: it was like, more the em, like, how small it was and how it was like, you weren’t expecting to be so flowing, small, very shallow, really slow running, disgusting like, slither of water but it turned out to be a nice little stream that you could paddle in when you got a bit hot.*
>
> MICCI School 1 Focus group response (most memorable) 15.05.19

In both the SFL and MICCI projects, the ground was bumpy, boggy and difficult to walk in. This meant that the pupils had to change the way they moved in the space, they went in single file at times, supported each other over bumps and boggy sections, they called to let pupils behind them know about grips (drainage ditches) that would need to be jumped over but were hidden by vegetation. This negotiation resulted in lots of chatter and laughter as they slipped or fell, responding to the effort that the shape of the space was making them put in to just move through it.

> *On accessing the site, the teacher and 1 pupil (the same boy as had lagged behind at the beginning) took the drier route and the remainder took the shorter route through hummocky, boggy ground. There was a great deal of stumbling and laughter during the short walk.*
>
> SFL Fieldnotes 3.10.19

In the OPAL project, there was only one example of this, when the group moved through dense shrubbery and had to move in single file, holding overhanging branches to prevent them hitting classmates. Again, the way that they moved changed, the groups became less fragmented and the pace slowed to facilitate looking for invertebrates in the branches. All the groups stopped regularly on their journeys, prompted by the adults to look at something

relevant to the day's data collection, or to answer questions that related to the scientific issue at hand.

An important component of citizen science is its temporal and spatial range. The desire to investigate a phenomenon or collect data on an issue across a range of locations is a key to the power of citizen science. This also opens up a wide range of possibilities for schools engaging with citizen science activities, taking pupils to remote, isolated locations which are unfamiliar to the pupils, but also carrying out the activities in school grounds or local areas which are easier from a logistical and cost basis. The logistical and cost related challenges of taking pupils far from their educational setting are well documented (e.g., Beames et al, 2009). As such, an opportunity to engage in directed or semi-directed fieldwork in a location of the teacher/pupil's choice is particularly appealing in order to minimise the logistical and cost related challenges.

The physical nature of the contact with these particular environments caused some discomfort, but the pupils found ways of negotiating this, changing the way that they moved in the landscape and the tools that they used to investigate it to limit their discomfort.

> *There was some discomfort at moving through the jaggy grasses, but the pupils worked together to hold back the jaggy plants for the next person as they moved through.*
>
> OPAL School 1 Fieldnotes 10.9.19
>
> *The pupils had to move the rocks and wood piles to find the woodlice and slugs, there was the physical sensation and effort of doing this which some pupils enjoyed and others were reluctant to get involved in. Some pupils used their feet to gently ruffle the stones to avoid touching them.*
>
> OPAL School 1 Fieldnotes 10.9.19

Østergaard (2020) explores the importance of sensing and sense-making in scientific based sustainability education, suggesting that evoking an aesthetic sensitivity can reconnect young people with the world around them. While this stands in contrast to the objectivity and detachment experienced in traditional science classrooms, the author suggests that fostering such skills might "broaden students' notion of science and scientific inquiry." (ibid. p. 579). The demonstration of the pupils' sensitivity to the physical sensations of the fieldwork locations is a component of the citizen science experience could be exploited to greater effect in order to more fully support eco-citizenship capabilities.

Touching the soil is another example of the pupils in the SFL project coming-to-know the material in a way that perhaps challenges traditional classroom ways-of-knowing.

> *Soil texture – the pupils have to touch and manipulate the soil, there are amused grimaces from the pupils on the first touches of the soil.*
>
> […]
>
> *On touching the soil to assess the texture of it, "Oh, I can feel the moisture in it."*
>
> SFL Fieldnotes 3.10.19

The texture and moisture content of the soil are vital components in identifying its structure, and subsequent soil type. Colour is also used, one of the pupils who attended the fieldtrip for the second time commented that the light on our visit made the colour matching much easier as it had been dull and therefore a more difficult task the previous year. The entanglement of the human senses and the soil are wound together and as such are a key element of soil sciences.

The data collection priority promoted by the adults during the fieldwork day can serve to provide a 'way-of-looking' that focuses the pupils on the particular details of the place. Examining the quadrats to identify plant species, the pupils looked intently at the ground, looking more closely at the moorland species than they would were they simply walking through the landscape. They worked between the identification keys provided, and the species, matching the broad and narrow grasses, star and sphagnum mosses to name just a few, with their respective images. They looked to their peers and the adults supporting them to help identify each one, to confirm or challenge their assertions and to estimate abundance in their particular pre-selected spaces. This different way of looking at the environment was identified by two of the adults as important in expanding or extending how we consider the world around us.

> *I really enjoy it when you are just looking down and you've just got a quadrat in front of you and you're just sort of analysing, you know? It's almost like mindfulness, you know like, what are we seeing here, how much moss is here?*
>
> Participant Interview: MICCI Scientist AC: 2.11.2020

> *You know, it's just not really common thing to see somebody on the ground looking at something, so that obviously says we're not looking at things.*
>
> Participant Interview: MICCI Scientist JW: 12.11.2020

Chawla and Cushing (2007) discuss the influence of positive framing of experiences in the world of nature in association with influential adults, often family members, but possibly teachers and scientists. These positive associations have the potential to influence pro-environmental dispositions on into adulthood. The citizen science experience puts the pupils into the natural world with a guide in the form of an influential adult and a reason to look at the world around them. Gannon (2017) suggests that teacher planning is important in finding ways to create 'open spaces' for pupils to explore and consider their experiences with animals and nature. The citizen science experience can be used as a framework, an outline within which such open spaces can be exposed.

Pupil reflections

The identified physical and sensory encounters that took place on the fieldwork days were rarely reflected upon by the pupils in the sentence completion task. There were no references to physical or sensory encounters in the 'think about' or the 'most important' sentences. In the 'feel' reflections, a small number of pupils from each project (2 MICCI and SFL, 1 OPAL) reflected on feeling cold. However, in the 'most memorable' responses, some of the MICCI project participants reflected on the 'bouncy' nature of the moorland (5 pupils) and being in the stream (4 pupils). In the OPAL and SFL projects, pupils thought that it was memorable to search under rocks and in soft ground surfaces for invertebrates, and to physically 'be in' the soil pits (2 pupils in each).

Physical and Sensorial knowledge/knowing was evident from the participant observations, with pupils reacting and responding to the unique nature of each fieldwork location. However, the pupils did not articulate this in their reflections suggesting that the pupil did not 'notice' the physical and sensory entanglements in a way that persisted beyond the event itself. This contrasts with the strong persistence of the 'living things' in the pupil reflections.

Encounters and reflections summary

My analysis of the encounters that pupils had with 'other living things' and the 'physical and sensory' experiences has identified the following findings:

- Inter and intra-action with other living things as a part of the citizen science project can provide a starting point to increasing an understanding of and empathy with other species.
- Fear and disgust can be reduced through exposure to invertebrates and other potentially fear-inducing organisms as part of the citizen science project.
- Pupils from two of the three projects found inter and intra-actions with other living things to be important and memorable parts of the citizen science experience.
- Sharing their experiences and knowledge of other species was meaningful for some pupils in the citizen science experience.

These findings suggest that citizen science experiences can support the eco-citizenship capability to live with concern for plants, animals and the world of nature.

Section 2: Connections

Following Barad's (2014) socio-material approach, where 'diffraction' is considered a re-turning, an iterative examination of a moment of matter. Two examples of pupil entanglements with the material and imaginative components of the fieldwork day will be examined. The first, an image of wellies, this image and its associated reflections allow the effects of being *in* the landscape to be traced and the blurred edges made visible. The second is a reflection on creativity inspired by fieldwork days, in particular the creation of 'bog-trolls'. In one of the fieldwork experiences, the pupils created imaginary creatures called 'bog-trolls. The pupils 'became' these creatures and enacted their adventures in the landscape. Taking these examples of pupil-bog entanglement and drawing out the blurred boundaries between science and imagination, between doing and being, the potential of engaging in the citizen science experience to connect pupils in a meaningful way with the natural world is examined. In drawing attention to this opportunity for deep connection, there is the potential to support the eco-citizenship capability to live with concern for plants, animals and the world of nature.

Wellies

In the following example, a pupil was observed engaging with the boggy ground and reflecting upon their impact on it;

> *The sphagnum moss at one section was very waterlogged and the group took great pleasure in squelching around in it, making footprints and enjoying the sound made on release of their feet. "I wonder if we are damaging it by doing this" wondered one pupil, not to anyone in particular.*
>
> MICCI School 1 Fieldnotes 9.05.19

The image below was taken of the pupil in the above extract:

Figure 22: Image of a pupil's wellies sinking into the sphagnum moss, taken on the fieldwork day (MICCI School 1)

> Humans do not always perceive themselves as part of this material flow of dynamically changing landscapes, environments and ecosystems.
>
> Jukes et al, 2019, p. 3

In considering this particular pupil as part of this landscape, bringing the image and text together in a relational map, I was motivated to draw out the entanglements presented in this situation. The following memo was prompted by the image;

> *The image of the boots sinking into the moorland is a clear representation of the foot-boot-earth relationship that exists at this particular moment. Neither the edges of the boots nor the edge of the earth are visible or clearly delineated. Interrupted by the clean line of the dried grass, the waterlogged soil and sphagnum moss mixture has a visibly 'soupy' consistency. This blurs into the bright green of the moss that has not (yet) been trampled. The muted colours of the grasses, fragments of heather and areas of shadow that suggest dips or hollows in the ground contrast sharply with the matt blue/green of the boots. The shadow cast by the pupil blends in, again, blurring the edges between pupil and earth. The sphagnum moss is a major part of the scientific enquiry component of the day, the characteristics of its appearance are discussed, used to identify it and estimate its abundance within a quadrat. The contrast between it and other mosses, e.g., star moss, is made clear, drawn attention to by the*

adults. The water retaining qualities of the moss are described and discussed in relation to the health of the moorland. The musing of the pupil over their impact on the moss connects not only to the learning intentions that are visible throughout the day, but also the presence of the moss in the consciousness of this pupil and in the physical landscape. As Haraway suggests, "not in the world, but of the world" (Haraway 2016, p.14). The time and space provided by being 'out' in the landscape entangled 'with' the moss allows the pupil to play with it, to squelch and squash, to feel the resistance of the mixture. Other senses are also invoked, hearing the sound the boots made in the boggy ground, playing with that sound and reflecting on it, 'tearing paper' or 'milkshakes' were suggested as representative terms. This relational coming-to-know is unique to this particular moment of pupil-moss-earth entanglement, and is fundamentally different from the manner in which learning intentions are attended to within the formal classroom setting. But what of the moss, what role does it play? It is damaged by the encounter, ultimately, this squelching moment will inflict some damage to this sensitive species of moss residing in this isolated and generally non-human location. However, in the process of coming-to-know this particular patch of mossy moorland, a greater affinity for moorlands in their wider sense may be awakened in the pupil, is this an acceptable trade-off? As Clarke et al (2012) state, "in situational analysis, agency is reformulated into something messy, sticky and distributed, varyingly animating all the elements that constitute a particular situation" (ibid. p 362). How does the moor 'respond' to this disruption? It continues to 'hold' the boot, and by connection to the boot, the pupil is held within the situation, the tension created by the soil-moss-moisture mixture resembling a non-Newtonian fluid, thus the harder the pupil pulls, the less likely they are to become free of earth, but possibly instead become free of the boot. This would not be the last wellie to get stuck on our fieldwork days.

Memo: 4.12.2021

When the pupils from this group were asked to reflect on this image, annotating it on their return to school, they used descriptive terms such as 'squishy' and 'stomping'. The following word cloud (fig. 23) was generated using the terms they suggested (the names are pseudonyms);

Figure 23: Annotated image of wellies

This experience offers the pupils a way to relate to the natural world which entangles them in it, not erasing the human but embedding them as part of a more-than-human world (Somerville, 2017). The opportunities afforded to pupils to entangle within the landscape may be fleeting, but offer moments of connection, the emphasis on positive reflections to this image, 'boggy fun' and the extensive use of exclamation marks in their annotations suggests a delight in the relational experience that they had with the 'bog'. While these moments were not directed as part of the intended fieldwork experience, they represent an opportunity for pupils to connect with the world around them, supporting their eco-citizenship capabilities.

Creativity

Throughout many of the fieldwork experiences, the pupils responded to the experience in creative ways. They made up songs and rhymes and in doing so created creatures and developed stories about them. They gave living and non-living things names and other human characteristics, an anthropocentric interpretation of the more-than-human situation that they found themselves within. Three short examples are described next, one from each project which bring this creative component to the fore. Davies et al (2012) suggests that outdoor learning spaces are well documented as environments in which creativity can be enhanced and encouraged.

In one of the MICCI groups, the pupils created characters that they called 'bogtrolls', these characters featured strongly in their 'most memorable' reflections and so in the focus group session I was able to ask them more about them.

Interviewer: What was the most memorable part of the day for you, what did you think?

Participant 1: bogtrolls,

(…)

Interviewer: yeah, tell me more about the bogtrolls?

Participant 1: we were just all squelching about exploring the burn and then we were, I think it was Rosie

Participant 2: no, it was at one point …

Participant 3: we, we, so Rosie just slowly rose to the bog and then, she was like, everyone do that again, and we just all went, ducked down, she filmed us going … (mimed rising up over the river bank)

Interviewer: you were the bogtrolls, ah!

Participant 3: yeah

Participant 2: and then later on Alex handed me a camera, and was like, can you film bogtrolls, like, okay what's this and then we filmed it and it was basically just us repeating bogtrolls, bogtrolls and running around, and then we got to the river and then there was a certain bit that was quite wide and it kind of like, stopped at each side, and at one side it looked like a little tunnel, and it was just like, that was where they were.

Participant 1: and then we did a vibration dance at a different section

Participant 3: we kept on moving down, we got so far down that the river got deeper, faster and wider, it was quite fascinating actually

MICCI School 1: Focus Group 15.05.2019

This creative response is clearly directly related to the nature of the landscape that they were exploring, the positional change between the burn and the moorland gave rise to the feeling of emerging, and the pupils identification with these bog-dwelling characters became very real for them, a source of joy and excitement. They discussed plots of films starring the 'bog-troll' characters on the walk back to the bus, deepening their exploration of the idea. While this process seems quite at odds with the ecological learning and data collection

objectives of the day, it was undoubtedly a meaningful experience for them that sits alongside the scientific, data collection priorities. As Jennet et al (2016) suggests, creative outcomes can be a strong motivating factor in volunteer engagement in citizen science projects.

In one of the OPAL groups, I watched as some pupils commented on the relationship between two crane-flies, one of which had been recently captured by the pupils.

> *One group collected a crane fly in the specimen jar and as another crane fly flew around the jar, a pupil suggested "it is trying to save its partner"*
>
> OPAL School 1 Fieldnotes 10.9.19

This creative projection of a human-type relationship onto the invertebrates under study gave me an insight into the importance of an empathetic connection for these pupils. This fleeting moment, in which the pupils were able to observe the relationship between the two invertebrates, and suggest an interpretation of their behaviour that makes sense from a human perspective. Ingold (2011) cautions that this anthropomorphosis of animals has the effect of 'subjugating' them, however Gannon (2017) observing children in relation with wetland species, suggests that even with some anthropomorphosis, the process of 'becoming with' other species "opened students to new configurations of learning about themselves and others in the world" (ibid. p. 253). The captured specimen was released quickly after they had gathered the data that they needed, in order to 'return it to its mate'. Schonfelder and Bogner (2017) suggest that alongside positive emotions, engagement with living organisms, as opposed to models, can have a positive impact on cognitive outcomes. Combining the data collection objectives with the opportunity to directly interact with individuals of a different species gave these pupils the opportunity to empathetically and creatively connect with these organisms.

In the SFL project, an identifiable creative component of the day was the naming of the soil horizons, each soil pit and soil horizon was given a name that related either to someone in the class, the teacher, or a popular media figure, e.g., 'Harry Podzol'. This throw-away moment of creative word-play was quite at odds with the detail-oriented analysis of the soil profiles that they had just been engaged in, and offered a way of connecting what could be considered quite an abstract seam of 'knowledge' back to relevant components of their lives.

Connections summary

Reciprocal response-making in the more-than-human that was observed in the pupils suggests that the citizen science experience is able to offer a ‘way in’ to explore intra-species encounters. Worster and Whitten (2020) suggest that “children gain a greater sense of agency” when they become attuned to the links between themselves and the “many points in the biosphere” (ibid. p. 8). Allowing space for pupils to be creative and playful can support the development of eco-citizenship capabilities in young people.

Section 3: The 'other species' capability

In order to more deeply consider the impact that the citizen science experience had on the eco-citizenship capabilities of the pupils involved, two final data sources will be drawn upon. Firstly, pupils were asked to respond to the question, did citizen science change the way they felt about plants, animals and the natural world, and to give reasons for their responses. Secondly, in part of the focus group discussions, pupils were asked to reflect directly on their connection to plants, animals and the natural world. These responses will be described and analysed here.

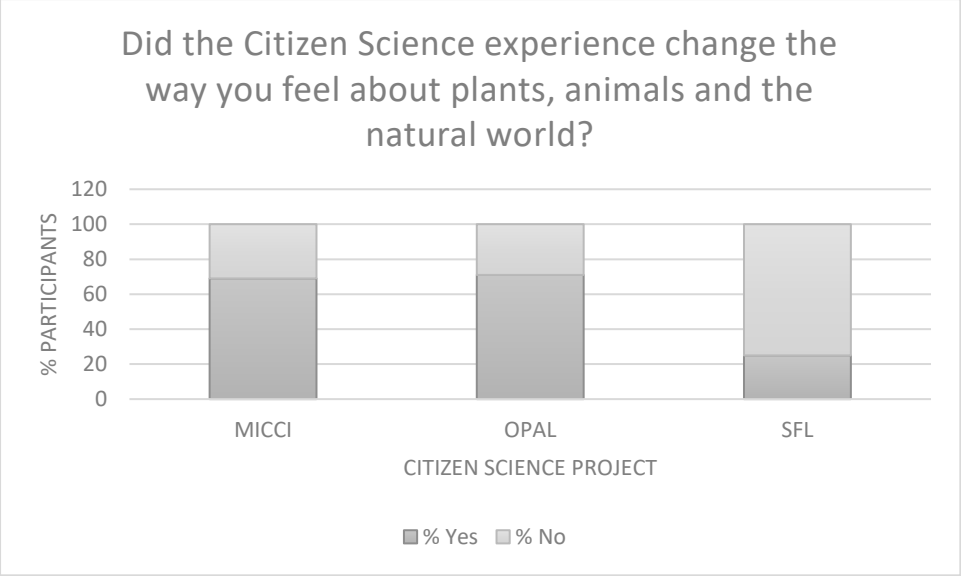

Figure 24: 'Did the citizen science experience change the way you feel about plants, animals and the natural world' pupil responses across all cases

As shown in fig. 24, there is a clear contrast between the generally affirmative response from participants in the MICCI and OPAL projects that involvement in the citizen science experience had changed the way they felt about plants, animals and the world of nature. This is in stark contrast to the SFL participants who generally felt that it did not. This section will explore the reasons that the pupils gave for these responses.

Firstly, for the pupils who responded that the citizen science experience **DID** change their relationship with plants, animals and the natural world, two key reasons were given. These are an increased awareness of living things and the natural world, and an increased level of comfort with living things and the natural world. Secondly, for the pupils who thought that the citizen science experience **DID NOT** change their relationship with plants, animals and the natural world, the most common reason given was that they already felt a strong connection and the limitations of the citizen science experience did not extend this. These three reasons will be explored further here.

Increased awareness of living things and the natural world

Pupils in the OPAL and MICCI projects suggested that the citizen science experience had increased their awareness of other living things. A greater awareness of the diversity of species around them was described by pupils in the OPAL project, this sometimes related specifically to insects, but also made reference to animals occasionally. In the MICCI project, the pupils reported feeling more aware of the importance of the moorland for wildlife, and an increased awareness of nature more generally.

> *Yes, as I now feel more aware of the planet and wildlife. This project has made me feel more connected to the planet and nature.*
>
> Survey Response: MICCI Pupil: Has CS changed …? 15.05.2019
>
> *It has helped me to realise that animals such as spiders aren't bad and we should do more to protect their habitat instead of destroying it.*
>
> Survey Response: OPAL Pupil: Has CS changed …? 10.9.2019

Paying attention to the natural world, whether that be a wild place like the moorland, or the areas surrounding the more urban settings that the pupils are more familiar with, clearly made an impression on these young people. The lasting impact of this is much more difficult to predict, Haywood et al (2016) highlights the importance of repeated visitation in encouraging environmental action, which is not possible for some of these participants. However, the important impacts of even single events like these on the young people involved suggests a possibility to increase awareness and connection with the natural world. This increased awareness was also connected to an increased desire to 'protect' the area;

> *In a way I think it is now very important to preserve these areas and the wildlife within them as they are very beneficial for reducing global issues such as climate change.*
>
> Survey Response: MICCI Pupil: Has CS changed …? 15.05.2019

Making connections between the experience and a desire to see greater protections linked to reducing the impact of climate change is an example of the pupils' desire to see pro-environmental change enacted. The statements include both passive responses, as above, where no specific actor is identified, and also direct references to themselves, for example:

> *It made me feel like I need to start caring more for my environment.*

Survey Response: MICCI Pupil: Has CS changed …? 15.05.2019

Environmental stewardship is an outcome that is considered desirable as a result of participation in citizen science projects (Phillips et al, 2018; Pitt et al, 2019). Environmental stewardship is defined by Pitt et al (2019) as the "conservation-oriented actions that improve features of a particular place in support of ecosystem conservation" (ibid. p. 1387). The achievement of environmental stewardship as an outcome is not well evidenced in relation to citizen science experiences, Phillips et al (2018) suggest that while some example cases provide evidence of a connection (e.g., Pitt et al, 2019), others found less secure connections (Toomey and Domroese, 2013, for example). Taylor (2017) suggests, however, that the emphasis on stewardship can reinforce the position of humans as separate from the environment, able to 'protect' and 'preserve' it as though not intertwined 'with' the environment.

Pupils in the OPAL and MICCI projects also reflected upon the way that their experience of the projects drew their attention to the human impact on plants, animals and the natural world. As with the increased awareness of other living things, this was frequently associated with an increased desire to 'care for' or 'to protect' wildlife or nature.

> *I've grown more conscious about human impact on biodiversity as the Simpson index of biodiversity was lower. I think this project can help contribute to making changes as it shows us which areas we should preserve.*

Survey Response: OPAL School 1 Pupil: Has CS changed …? 10.9.2019

In this example, it is the in-depth analysis that the pupil engages in that draws their attention to the human impact on biodiversity. Their observations in the field and the comparison of different environments contribute to a calculation that they are able to perform, drawing a conclusion about biodiversity in these particular environments. In Hungerford and Volk's (1990) model of environmental citizenship behaviour, the authors identify 'empowerment variables', or the belief in their ability to influence an activity or event, as contributing to pro-environmental behaviours. This has links to Bandura's (1982) conception of self-efficacy, which will be discussed in more depth in chapter 6. Monroe (2003) suggests that activities which give students the opportunity to investigate and suggest/implement ways to solve a local problem can contribute to empowering young people to feel confidence in their ability to overcome challenges. The citizen science experience of using their collected data to direct priority areas for protection or development can give the pupils direct experience of the impact that they can have, supporting their development of eco-citizenship capabilities.

Increased confidence

Within the OPAL project most notably, but also in the responses from the MICCI pupils, a reported increase in the comfort that they felt around insects in particular and animals in general and a reduction in fear and squeamishness around spiders and other insects. This was accompanied by an increased sense of the need to care for these organisms, and also to protect them from harm.

> *It has made me more comfortable being around bugs and insects because I have seen they are just as important as others. I am now more aware that diversity is important for the ecosystem and if there is any human impact it can damage more than we think. This citizen science experience makes you more self-conscious and aware about our surroundings so you can now know how to help the environment, feel more empathetic in a way when it comes to our influence on nature as humans.*
>
> *I don't usually encounter anywhere near as many insects as I have today. To see so many has, I believe, helped me grow more comfortable with them (though not entirely). I acknowledge their importance, and will be more inclined to treat them with more care in the future.*
>
> Survey responses: OPAL School 1 Pupils: 10.9.2019

However, one of the pupils in the MICCI project reported that the encounter with the dragonfly had actually increased her fear of them as she suggested that;

> *I didn't know dragonfly could get that big, so I'm now terrified of them.*
>
> Survey response: MICCI School 2 pupil: 7.11.2020

Studies suggest that fear and disgust can have a negative effect on student motivation (Randler et al, 2013) and on perception of wildlands (Bixler and Floyd, 1997). Exposure to unfamiliar organisms in unfamiliar settings may prove to be overwhelming for some pupils, however, care, excitement and an increase in comfort were the more frequent responses. This experience affords the pupils an opportunity to 'come-to-know' these 'scary' or 'disgusting' organisms in both wild and familiar places. Hicks and Stewart (2020) found that awe and wonder felt in response to wildlife encounters was able to generate learning and intense emotional memories in young people. The participants in the citizen science projects in which the intention to engage with other living things was explicit (OPAL and MICCI) also reported the most positive change in their relationship to plants, animals and the world of

nature. While this relationship cannot be considered causal in this small study, it can be suggested that the explicit nature of the contact with other living things was able to support the development of eco-citizenship capabilities in the pupils.

Some of the pupils reflected on the knowledge that others were also collecting data like this and doing something about the environmental issue in question, suggesting that this was something that gave them hope and comfort.

> *I think I am less worried because everybody is working together to help stop climate change.*
>
> Survey response: MICCI School 2 pupil: 7.11.2020
>
> *I realised there are areas and people who are willing to take care of the world*
>
> Survey response: OPAL School 1 pupil: 10.9.2019

The awareness of citizen science as an activity that a wide range of people can and do get involved in may be something that even if these particular pupils do not get involved again themselves, they can take comfort in the knowledge that it is happening. This emphasis on collective action echoes arguments from Schindel Dimick (2015), Hayward (2012), and Iversen and Jonsdottir (2019) among others, who suggest that environmental citizenship depends on finding solutions to complex problems that are rarely rooted in individual actions. Rather, looking outwards towards democratic and systemic change, whilst more challenging to enact, particularly for young people, may impact more strongly on environmental and sustainability issues.

Existing nature connectedness

The majority (75%) of the pupils from the Soil Fertility Legacies project, and a small proportion of the pupils from the other two projects felt that the experience had had no impact on their relationship with plants, animals and the world of nature. The main reason that was given for this was that they already had an understanding or appreciation and that the event had not changed that for the better or worse.

> *As my mum is a gardener, I have been brought up with respect and knowledge about wildlife and plants so it did not help me with the wildlife part and as taking geography throughout my school years I have been taught this too.*

MICCI School 2 Pupil: 7.11.2020

It hasn't changed the way I feel or think about animals because I have always believed we should protect them

OPAL School 1 Pupil: 10.9.2019

I feel the same because I feel like I am bonded to the environment. If I am sad or angry, I will go outside. I go outside to help feel relaxed when things are stressful.

OPAL School 2 Pupil: 23.10.2019

In adult involvement in citizen science projects, it has been suggested that the participants already have a strong interest in environmental or conservation related issues, and as such positive changes in attitude or connection to the natural world are less easy to make (Turrini et al, 2018; Forrester et al, 2017). The students in most of these cases, but in particular the SFL group, had chosen biology or geography at senior level, and as such could be considered to have an existing interest in environmental issues. The findings here echo that of Turrini et al (2018) and Forrester et al (2017) suggesting that knowledge of the concept (soils, in the case of the SLF pupils) was reported to increase, however the connection to the natural world was less strongly impacted upon.

Interviewer: Was there anything about the project that's made you think about your relationship with plants animals and the natural world?

Participant 2: Not particularly.

Interviewer: Can you think about why not, maybe, what was it about this particular project that you felt maybe didn't connect?

Participant 2: I don't know, I don't think it's something that I'm burning passionate about, so I did it and enjoyed it but I didn't really go like, ah, yes.

Interviewer: This is for me?

Participant 2: Yeah.

SFL Focus Group discussion: 15.11.2019

Schild (2016) suggests that when outdoor experiences feel like ‘leisure’, they do very little to enhance pro-environmental behaviours or dispositions. In this case, the experience was not ‘leisure’ related, but served a particular, school-related function, and as such may be limited in the wider impacts that it might have. Brombal (2020) describes the instrumental use of citizen science in China, suggesting that this serves to strengthen rather than challenge existing anthropocentric viewpoints of environmental issues. The author proposes that adopting a ‘transformative stance’ may improve the impact of citizen science in China, suggesting that an emphasis on generating a sense of caring for, rather than simply measuring components of natural environments might be a way forward. The limitations of the experience were discussed by pupils, firstly in terms or time, and also in the nature of the data collection and analysis.

> *In my opinion 2 hours outside collecting insects and animals (just for a day) has not changed my idea of the natural world.*
>
> OPAL School 1 Pupil: 10.9.2019

Monroe (2003) suggests that adults who become aware of environmental problems might be motivated to act when they believe that they are able to change the nature of the issue. This poses a particular challenge when raising awareness of environmental issues in young people without consideration for the constraints that they face in enacting change. The somewhat instrumental and focused nature of some citizen science project experiences may have limited the wider, place-responsive connections that the pupils were able to make, and as such did not consistently support the development of eco-citizenship related capabilities.

The ‘other species’ capability summary

Citizen science experiences have the potential to change the way the participants relate to animals, plants, and the world of nature by;

- Increasing their awareness of it
- Increasing their awareness of the human impact on it
- Reducing their fear of it

However, for pupils who already have a high level of affinity with plants, animals and the natural world, or those with greater experience, the impact of the projects were limited.

Therefore, the eco-citizenship capability to ‘live with concern for plants, animals and the world of nature (Nussbaum, 2011), is supported by some of the citizen science experiences.

The limitations of single, short-term events that have an instrumental nature serves to limit the depth of this possible connection to the natural world.

Chapter 5 Conclusion

This section will respond to the question set out at the beginning;

> *What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities in young people?*

Place responsive experiences

Being reciprocally responsive through place-based encounters within the environmental citizen science fieldwork experience can afford pupils the opportunity to think about and consider their impact on the environment in a more meaningful way than can be afforded in a traditional classroom setting. Unfamiliar landscapes may be more memorable, however more familiar or local landscapes may prompt deeper thought and hold greater meaning for the participants. The ability of citizen science projects to be adapted to different locations and landscapes affords significant flexibility in their use.

Intra-actions with other species

Raising awareness and reducing fear of other species can contribute to positive experiences for participating pupils. The persistence of this in their affective and memory related responses suggests that this engagement can support the eco-citizenship capability of living with concern for plants, animals and the world of nature (Nussbaum, 2011).

Possibility of change as a result of the CS experience

The entanglements of the pupils 'becoming with' the fieldwork locations and experiencing new ways of looking at plants, animals and the natural world supports the capability to have attachments to things and people outside ourselves (Nussbaum, 2011).

Creative responses to the experiences

Utilising the citizen science projects to encourage the pupils to look at their surroundings in different ways provides them with different viewpoints and perspectives. This experience can give space for pupils to be creative and 'play' in the natural world, with the possibility of increasing the connectedness that they feel towards it.

Chapter 5: Findings summary

Analysis of pupil reflections suggest that interacting with other living things supported their ability to relate to other species.

School based citizen science provides opportunities for fear and discomfort were reported by some pupils to be reduced as a result of interacting with other species, such as spiders and snakes, during their citizen science activities.

Encounters with other living things were reflected on as the most important and memorable for pupils across most cases.

Analysis suggest that physical and sensory encounters were a key part of fieldwork activities.

Reciprocal response-making in the more-than-human was observed in, and important to pupils across all of the fieldwork experiences. Young people's creative, empathetic and playful reactions to the different citizen science experiences demonstrates a significant basis for the emergence of eco-citizenship capabilities.

Changes in their perceived relation to animals, plants and the world of nature were described by some pupils, however, others reflected that their already established affinity was not changed by the citizen science experience.
Pupils with less affinity for the world of nature benefited from citizen science experiences and developed a new capability.

Taken together, my analysis suggests that environmental citizen science experiences have the potential to change the way the participants relate to plants, animals and the world of nature by;

- Increasing their awareness of it
- Increasing their awareness of the human impact on it
- Reducing their fear of it

However, for pupils who already have a high level of affinity with plants, animals and the world of nature, or those with greater experience, the impact of the projects were limited. Therefore, the eco-citizenship capability of 'Being able to live with concern for and in relation to animals, plants, and the world of nature' (Nussbaum, 2011, p. 34), can be

supported by school-based environmental citizen science experiences. This is of particular importance for pupils whose relationship with environmental issues is strongly influenced by their school experiences.

Chapter 6: Delving deeper: Eco-citizenship capabilities

Chapters four and five have shown the contribution made by citizen science in schools to the development of eco-citizenship. Building on these, this chapter takes the analysis to a deeper level. Utilising the 'constant comparison' method that is a key part of the situational analysis approach (Clarke et al, 2012), the situational and relational maps produced and analysed in previous chapters will be re-examined in relation to targeted focus group and survey reflections. By asking;

> *What conversion factors contribute to the development of eco-citizenship capabilities in young people's experience of environmental citizen science in schools?*

This chapter intends to delineate some key dimensions of young people's lived experience of eco-citizenship (Kallio, Wood and Halkli, 2020), the conversion factors (Robeyns, 2017) involved and the substantive capabilities (Nussbaum, 2011) derived.

Lived eco-citizenship dimensions

Hayward (2012) suggests that young people have different experiences of environmental citizenship than adults. Emphasising the everyday experiences that young people may have, at home, in school or with their friends, rather than 'adult' experiences like voting or environmentally conscious consumerism, offers a way of realistically understanding eco-citizenship in young people. Kallio, Wood and Hakli (2020) describe lived citizenship in a way that explores the reality of citizenship in everyday situations rather than relying on the formal, legal status of citizenship. This analysis draws upon that conception, placing the embodied experiences and acts of eco-citizenship in the daily life of young people at its core. As previously discussed, (p. 70), utilising the concept of lived citizenship (Kallio, Wood and Hakli (2020) offers an approach to considering the citizenship related experiences of young people as part of the mundane, everyday experience of formal schooling. Situating the citizen science experience within this conception also acknowledges the non-voluntary nature of the young people's participation in the experience.

In this analysis, the four dimensions of lived citizenship, described by Kallio, Wood and Hakli (2020) were applied as a priori codes in relation to the relevant situational and relational maps. These are:

Spatial

Drawing on Lister et al (2007), the context and circumstances of life cannot be separated from the experience of citizenship. This dimension highlights the relationship between the

global and local citizenship realms, and looks to draw out connections between public and private worlds. The spatial component of the citizen science experience for the young people involved took them to local and remote places, constrained within the boundaries of a school/curriculum-driven situation. Conceptions of place and the material lived experiences of place (e.g., Lynch and Mannion, 2021, Ma and Green, 2021), both familiar and remote, will be explored here in order to understand their importance in the citizen science experience. The opportunities and challenges of these experiences in supporting the eco-citizenship capabilities of the young people involved will be identified.

Intersubjective

Kallio, Wood and Halki (2020) define this dimension as the intergenerational and interpersonal relationships that locate citizenship-related experiences within and across communities. This dimension highlights the relational experiences of citizenship, working with others, peer pressure, family relationships and communication. In this study, the intersubjective dimension relates to the peer and intergenerational relationships developed during, and as part of the citizen science experience. The importance of these relationships in enabling the pupils to explore their eco-citizenship capabilities will be drawn out and the opportunities and challenges associated with this will be identified.

Performed

This refers to the actions and practices associated with citizenship, and is related to “acts of citizenship” by Isin and Neilsen (2008). This dimension describes the constitution of subjects as citizens in respect to their own actions or behaviours. These actions are those which assert the individual as a citizen at a range of different scales and positions, not just individual-group or formal-informal. In the performed dimension, this analysis will identify the eco-citizenship related actions that take place during the citizen science activity and those which may be considered by the participants in response to it.

Affective

This dimension looks to illuminate the feelings associated with being a citizen, this can relate to belonging, in relation to a nation or a community, but it can also be expressed attributes of care and responsibility. In this study, an analysis of the affective dimension experiences and reflections will demonstrate the connections that the pupil participants make together with the natural world through citizen science experience in which they participate.

Lived Green Citizenship

While lived citizenship is not explicitly defined in relation to environmental or ecological citizenship, Wood and Kallio (2019) describe the concept of 'lived green citizenship' (p. 2), in which they argue for a greater understanding of the variety of scales and practices that citizenship encompasses beyond the traditional liberal conceptions. Reflecting on the participation models suggested by Philips et al (2018), Shirk et al (2012) and Haywood (2014), environmental action is identified as an outcome. Outcome-focused approaches contrast with the idea that participating in a citizen science experience itself, could be considered an 'environmental action' and as such be considered as an act of citizenship in the mundane, everyday sense. This is particularly relevant to consider in the formal education sphere, where the opportunities to engage in meaningful (self-directed) eco-citizenship related behaviours may not be easy to come by.

Capabilities and conversion factors

The capability approach (Nussbaum, 2011, Sen, 1993, Robeyns, 2017) offers an alternative to considering 'environmental action' as a key end goal. Instead, taking a processual approach to the identification of a suite of eco-citizenship 'capabilities' that can be brought into being as 'functionings' should the pupils involved feel compelled to do so. Robeyns (2017) describes three 'conversion factors', or "the factors which determine the degree to which a person can transform a resource into a functioning" (ibid. P.45), 'personal' or internal to the person, 'social' or stemming from the society, and 'environmental', the physical or built environment. In this analysis, the ways in which the citizen science experience can be considered to provide the different types of 'conversion factor' will be identified and the opportunities and constraints of these explored.

Self-reported self-efficacy

Pupils who had participated in the different citizen science projects over the duration of this research, and two additional classes of pupils who had not participated in any citizen science in school (n=74), were asked to respond to five statements selected from the Cornell Lab of Ornithology Evaluation Research, 'Self-Efficacy for environmental action' evaluation tool. The Cornell Lab of Ornithology Evaluation Research survey instruments were selected as they were designed specifically for use with citizen science experiences rather than environmental education more broadly. Selection of the self-efficacy survey in particular related to its explicit definition as "a person's beliefs about his/her capabilities" (Phillips et al,

2018), which builds a picture of the confidence that the young people in this study may have to actually enact eco-citizenship capabilities. Furthermore, self-efficacy is seen (by Berkowitz et al, 2005) as an essential component of environmental citizenship, the authors define self-efficacy as “having the capacity to learn and act with respect to personal values and interests in the environment” (ibid. p. 230).

The original suite of statements includes eight statements intended for adults, this research selected the five most appropriate statements for pupils, and omitted two negatively positioned statements as these can be problematic in ensuring the reliability of a survey (Hamby and Taylor, 2016, Yan and Tourangeau, 2008).

The surveys were completed after the citizen science fieldwork day, in most cases around 2/3 weeks, and in the case of the non-citizen science participants, as part of Advanced Higher Biology/Geography classes (it is expected that these pupils would have some environmental awareness as part of their course of study). It is acknowledged that there are many factors that contribute to the self-efficacy of young people throughout their school experience, as such it is not assumed that any differences in the self-efficacy responses are solely related to the citizen science experience, or lack thereof.

The responses were collated in Microsoft Excel, and changed into a percentage to mitigate for the differing number of participants in each category (MICCI = 19, OPAL = 21, SFL = 9, NONE = 25). The self-efficacy tool (Phillips et al, 2018) was used to generate an overall ‘score’ for each individual or group involved, however for this research it is also useful to look at the responses to each statement in relation to the development of eco-citizenship capabilities.

In order to assign a self-efficacy score, a numerical value was assigned to the pupil responses (strongly disagree = 1 to strongly agree = 5), for each participant an average score for all five statements was assigned and then the average for each citizen science category was calculated.

Self-efficacy results

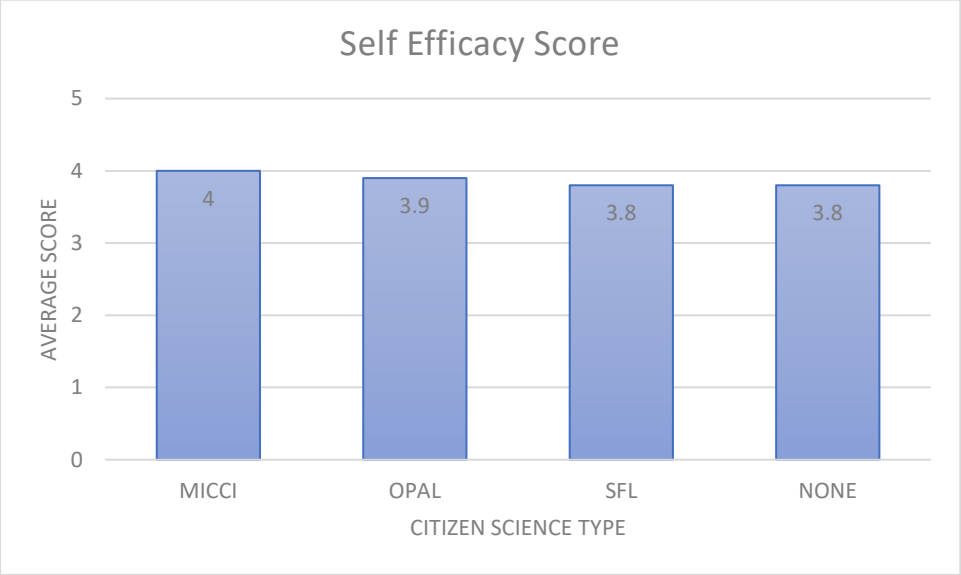

Figure 25: Self-reported self-efficacy scores

The results of this survey (fig. 25) show a strongly positive self-efficacy for all the groups, suggesting they generally agree that they have the potential to have a positive impact on environmental matters. As can clearly be seen there is very little difference between the citizen science types, suggesting that despite the different topics and approaches taken by each project, there is little difference between them in terms of the self-efficacy of the pupils involved. There is also very little difference between the pupils who have participated in citizen science project (collated average of 3.9) and the pupils with no citizen science experience. In considering the young people involved in the survey, the pupils who have not done any citizen science were advanced higher biology and geography pupils and through exposure to both of these subjects throughout school, they are likely to have experienced some environmental education. It can therefore be suggested that the citizen science experience alone does not generate sufficient difference in the self-efficacy of pupils who are already (at least tentatively) environmentally inclined. It may be useful to extend the self-efficacy survey to pupils who have not taken environmental or scientific subjects so far in school, or to those with no specific interest (see recommendations, p. 220 for more on this). This would be relevant as the volunteers who participate in citizen science beyond school typically have a scientific background or existing interest (Martin, 2017). One value of engaging schools in citizen science experience is in accessing young people who would not typically choose to be involved in environmental education projects. This may be where a possible difference could be identified in future. It may also be that self-efficacy was not an effective measure here.

To more fully interrogate this survey data, each question was analysed separately. Each statement contained three elements; a capability statement e.g. I am able, or I believe, a place identifier e.g., nature or the planet, and a solution-oriented term e.g., positive impact or protect. Relating these elements to the experience of participating in citizen science in schools, I intended to generate a deeper understanding of the challenges and opportunities of this for the pupils involved. The five statements included were: I am able to take care of nature, I feel confident in my ability to help protect the planet, I am capable of making a positive impact on the environment, I believe I can contribute to solutions to environmental problems by my actions, and I believe that I personally, working with others, can help solve environmental issues.

Overall, there is a generally positive identification with environmental self-efficacy, with 'agree' being the most common response in all groups across all five statements. Strongly agree is chosen second most often in the 'ability to take care of nature' statement, suggesting that this statement has the most strongly positive responses. There are strong similarities between the neutral and strongly agree responses for two statements, 'I am capable of making a positive impact on the environment' and 'I believe that I personally, working with others can solve environmental issues'. The remaining two statements have neutral as their second most common response with 'I believe that I can contribute to solutions to environmental problems by my actions' having a little more strongly agree from the OPAL participants only, and 'I feel confident in my ability to help protect the planet' having the only one response in the strongly agree category, from the MICCI participants.

The subsequent analysis of the self-efficacy survey questions will be included in the relevant 'lived citizenship dimension'. These statements have been selected for further discussion as they represent the extremes of responses, some interesting contrasts between groups, or direct relevance to the lived citizenship dimension.

Lived citizenship dimensions

The spatial dimension

Lister et al (2007) suggest that "citizenship cannot be divorced from its context" (ibid. p. 1). Using the situational analysis approach to explore the fullness of the 'context' of the citizen science experience, this analysis will show that the pupils have the opportunity to engage in eco-citizenship actions situated in a pre-determined location that extends into different parts of their lives. The nature of the physical location varies across the projects and the pupils undergo a range of physical and sensory experiences and responses to these. In this

section, the analysis explores the components of the citizen science experience that enable the conversion of these physical and sensory experiences in place into eco-citizenship capabilities. In the spatial dimension, this invokes the capability to 'live in relation to animals, plants and the world of nature' (Nussbaum, 2011).

In drawing together the components of the spatial dimension in a relational map (fig. 26), three themes were created. These offer different ways to consider the environmental 'conversion factors' identified in the course of the fieldwork experience. These themes will be explored here and the opportunities and challenges involved will be identified.

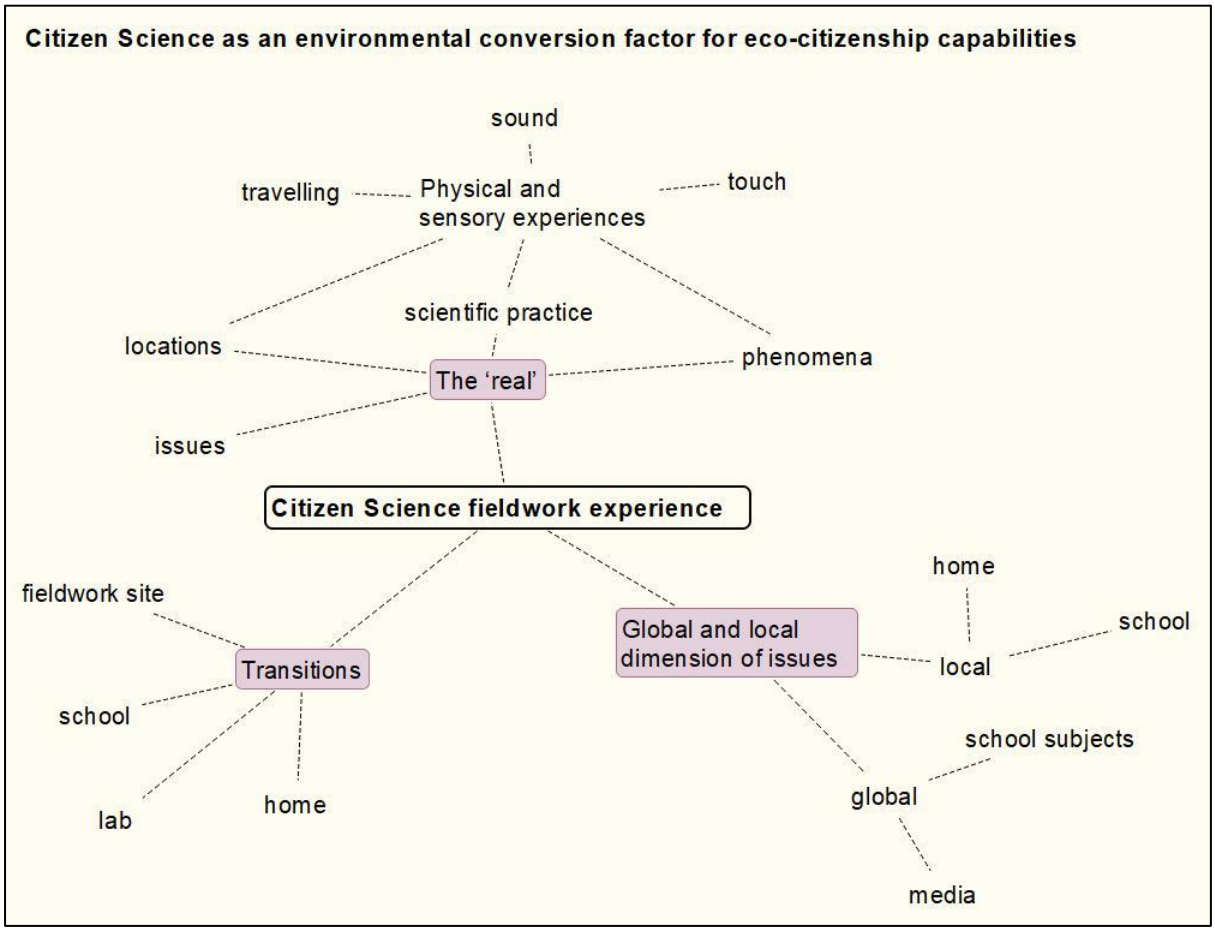

Figure 26: Environmental conversion factor themes identified

'The real'

Dillon et al (2016), among others, suggests that fieldwork opens up pupils to 'real-life' experiences. As environmental education in formal schooling is generally delivered through geography, science (biology) and voluntary (e.g., eco-schools) programmes, the opportunity to access complex concepts in authentic situations is thought to be meaningful (Barker, 2005; Boyle et al, 2007; Scott et al, 2011, for example). The citizen science experiences (in

the cases described here) have multiple ways of contributing to ‘the real’, firstly, engaging the pupils with the ‘real’ phenomenon, for example, the identification of a soil profile. Secondly, engaging the pupils in ‘real’ scientific enquiry, e.g., collecting biodiversity data on a moorland to compare with other moorlands in the UK, and finally, connecting these components together in a ‘real’ place, for example their school garden area.

The role of ‘real’ experiences in the environment as a conversion factor is an opportunity for pupils to engage in active eco-citizenship in a supported and scaffolded way. The ‘reality’ of the contribution is an opportunity to engage with an issue of current and topical importance, raising the pupils’ awareness of the existence of such projects and the reality (or ease) of participating. One possible constraint is that citizen science projects may have multiple intended outcomes and operate over differing scales and as such the curricular connections may be more or less well defined depending on the project (Roche et al, 2020). In these cases, the MICCI and SFL projects were developed closely with particular schools, while OPAL had a wider intended audience including, but not limited to school participation. As such, connecting the ‘real’ issue to the relevant curricular ‘place’ may be challenging.

Temporal and spatial constraints exist between the citizen science project needs and the school timetable. The phenomena or issue in question may only be observable at certain times of year, if these do not coincide with the availability of pupils to engage, then the collaboration is either impossible, or compromised. As an example, in the case of the MICCI project, the initial data collection time was scheduled for spring, to coincide with National Science Week, however, the more northerly sites were frequently snow-covered at this time, compromising the data collection process. In discussions with the various school partners, the data collection time was moved to September, with the intention of enabling wider participation and encountering less inclement weather. This demonstrates the ‘reality’ of the project, working collaboratively to maximise the impact, though some compromises have had to be made, for example, in the comparability of data before and after the date change.

The pupils were exposed to a wide range of physical and sensory experiences during the fieldwork day. The impact of these, as described in chapter 5, include reducing fear of, and increasing awareness of, and connection to plants, animals and the natural world. These physical and sensory experiences are a key part of the ‘real’ experience, feeling the boggy, bumpy ground underfoot, for example, added a deepened appreciation of the nature of a moorland that the pupils couldn’t extract from an image or a presentation. The role of this relational, ‘coming to know’ of the ‘real’ fieldwork site acts as an environmental conversion factor, bringing the pupils into relation with the plants, animals and the natural world during their fieldwork day.

Transitions

The fieldwork experience for most of the groups took place outwith their usual learning environment. Even when the experience took place in the school grounds, there was the period of moving between the experience and their 'normal' lives. The process of travelling in single file, over bumpy terrain or getting out of the school through a teacher-controlled exit delineated the event from the 'normal'. This disconnect may be part of what makes outdoor learning experiences memorable and meaningful, however, it also reflects a distance between the experience and the everyday lives of the pupils.

> *On the walk back, there was lots of discussion, lots of giggling, lots of laughter relating to the conditions being wet underfoot, the bogginess, some pupils slipping and falling, the wellies getting stuck in the mud. The mood on the way back was much more buoyant than it had been on the way out, the pupils were more comfortable with the terrain.*
>
> *Discussion moved on to a Halloween disco that had been cancelled, there was some chatter about that. There was also some chatter about part-time jobs, these pupils are Advanced Higher and have bigger, more worldly concerns in relation to their experience of school. I became conscious of the 'normal' life that they were heading back into.*
>
> MICCI School 2 Fieldnotes: 31.10.2019

The transitions into and out of the fieldwork experience marked a boundary between the citizen science experience and the home/school lives of the pupils. That boundary was varyingly defined across the projects, in OPAL, the typical close proximity to the classroom meant that the transition was less dramatic. Contrastingly, the MICCI and SFL projects both involved lengthy bus journeys and significant travel across challenging terrain to reach the data collection sites. As an environmental conversion factor, the transition to the fieldwork site offers the opportunity to take pupils beyond their 'normal' classroom and home environments. The 'move between' marking that change and easing the pupils into an alternative landscape. The scale of the transition can be a constraint however, a short transition, from classroom to school grounds may be limited in impact, while an extensive transition may serve to re-enforce the distance between 'the environment' and the lives of the pupils.

Global and local dimensions of environmental issues

The pupils reflected that the experience enabled them to connect the environmental issues that they are aware of in the wider global arena to the locations and issues closer to them.

> Interviewer: *what about for yourselves then, what did you get from it?*
>
> Participant 1: *it gave us an understanding of how climate change influences the environment around us, so it's not just foreign countries and on telly,*
>
> Participant 2: *it's like, happening where we are*
>
> MICCI School 2: Focus Group Response: 7.11.2020

This suggests that making the connection to a local example of an issue like climate change helped the pupils in this study to develop the capability to relate to a complex global issue. The challenge for the teachers and scientists involved is how to maximise the impact of that particular experience on the pupils going into their own lives. Some of the pupils from the OPAL group reflected on the challenges of bringing environmental activities into a busy life.

> Participant 1: *like I'd cut the grass and all that so the grass wouldn't get to long and stuff but I don't think I would have much time to go out gardening and stuff.*
>
> Interviewer: *What do you think will take up your time?*
>
> Participant 1: *Well, what I want to do in my career, I'll be out most of the time, so I don't really think I'll have much time to garden and stuff.*
>
> OPAL School 2: Focus Group Response: 23.10.19

Drawing on the lived citizenship (Kallio, Wood and Hakli, 2020) conception, domestic scale eco-citizenship actions are important in "Understanding the way citizenship plays out within the messiness of daily living" (ibid. p. 7). The above quote is an example of the conflicting economic and environmental factors that are implicated in any decision to act in a pro-environmental way.

In the focus group discussions, when presented with statements describing environmental citizenship for discussion in relation to their citizen science experience, the statement, 'thinks about the future of the planet' was mentioned by MICCI and OPAL pupils. Generally, the MICCI pupils simply suggested that this statement was important or relevant, while one

group expanded this by suggesting that helping future generations and considering how to conserve the planet for the future had been part of their citizen science experience. The OPAL pupils commented on this statement in an observational way, suggesting that by monitoring the trees they would be able to inform those making observations in the future if things had changed. Conservation and stewardship were driving the pupils' discussions in relation to this statement, considering monitoring for the future, connecting with the scientific experience and protecting the planet for future generations, all suggest a sustainability vision in looking to the future. For the teachers, only the OPAL teacher made comments on this statement, suggesting that monitoring and improving a particular area over time may result in the pupils 'caring about the environment'.

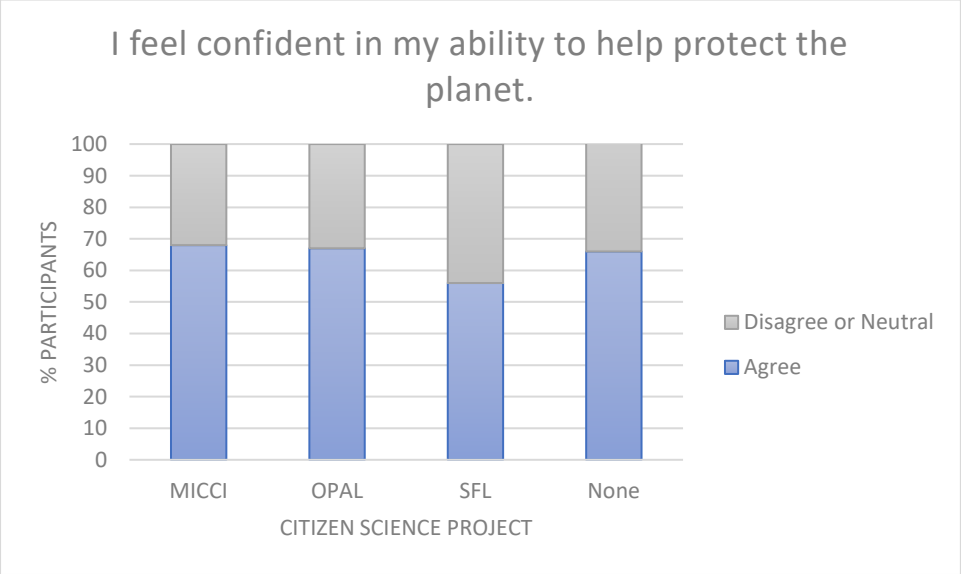

Figure 27: Self-reported self-efficacy: planetary scale

The statement 'I feel confident in my ability to help protect the planet' (fig. 27) reflects the lowest level of agreement from the non-citizen science participants, at 66% and the lowest equal for the SFL pupils at 56%. The nature of the statement is a much more definite expression of ability compared to the other statements, 'confident' rather than merely 'able'. This suggests a greater likelihood of success in the action. The notion of 'protection' is perhaps a more extreme and less relatable concept than that of, for example 'care'. 'Protect' may signify something that is under threat or likely to become in danger, therefore 'protection' could be considered to be a more active or reactive term than 'care'. 'The planet' also, is a complex idea, taking into consideration the wide range of biomes, species, and environmental systems of which any number of interconnecting and contradictory challenges may be faced. To be 'confident' in 'protecting' the whole planet is an understandably challenging idea and as such gained a lower 'agree' response from many pupils. That this

had the lowest agree response from the non-citizen scientists may reflect that the act of getting involved in a citizen science project could boost an individual's confidence in their ability to protect the planet. However, the lower 'agree' response from the SFL citizen science group suggests that this is not consistent across all citizen science projects. The SFL project content made the least explicitly environmental connections for the pupils, which may have, in part, accounted for this difference.

The citizen science experience, and the subsequent focus group discussions, have given the pupils the opportunity to consider eco-citizenship in relation to environmental issues from a wide range of perspectives, including, planetary, global, local and domestic points of view. In the spatial dimension, the citizen science experience contained environmental conversion factors, including the experience of 'real' phenomena and explorations of moving between places. These factors can contribute to the development of the eco-citizenship capabilities of the pupils to "live in relation to animals, plants and the world of nature" (Nussbaum, 2011).

The intersubjective dimension

In the intersubjective dimension, two key themes will be described, the first relates to the communication that the pupils had with their peers. The importance of working as a team and being out 'with friends' was described across all of the activities. Secondly, the intergenerational conversations that were made possible by the citizen science experience will be discussed. This includes opportunities for the pupils to consider their experiences in the home in relation to environmental citizenship behaviours, but also to consider the conversations between the adults and young people as part of the experience itself. This relates directly to the social conversion factors (Robeyns, 2017) that are important in developing eco-citizenship capabilities in young people.

Peer relationships

Communication between peers was important to many of the young people, with peer relationships referred to within the fieldnotes.

> *The pupils were showing some animated behaviour by this stage, one boy tried to tip a specimen jar of spiders onto a girl, she responded by putting the sweep net over his head to 'capture' him.*
>
> OPAL School 1: Fieldnotes 10.9.19

These interactions and behaviours could be considered potentially disruptive in a traditional classroom setting. However, the space and ethos of the citizen science experience made

these interactions possible and generally did not detract from the completion of the data collection activities that the pupils were engaged in. As a result, peer bonding and relationship building was facilitated in a positive way;

> *I would say was really positive, and even when we came back from the trip a lot of the pupils were really positive about their day out and actually having a little look there at their blog posts and their pictures and talking about it, so many times I've seen 'fun', so that tells you a lot doesn't it?*
>
> Participant Interview: MICCI School 1 Teacher: 15.5.2019

The pupils also reflected on being with their friends and working together as an important component of the day. The involvement of a group of independent young people offers diversity to the citizen science project and has the potential to bring the subject in question to a wider audience in a positive and enjoyable way. That they were able to 'run around on the moors with their friends for the day' generated a positive relationship with the outdoors and environmental experiences for these young people.

> Participant 1: *it was more fun as a team*
>
> Participant 2: *yeah*
>
> Participant 1: *than if we did it individually*
>
> Participant 2: *yeah*
>
> MICCI School 2: Focus Group: Best outcome: 10.9.2019

Science learning and scientific experiments also have the reputation of being difficult (Kirschner et al, 2008) and school science has tended to promote a transmissive, individualistic perspective on scientific enquiry (Gray and Bryce, 2006). However, the reality is that there is a great deal of discussion, collaboration, competition and teamwork involved in scientific discoveries. Giving pupils the chance to experience a group dynamic in the process of scientific enquiry has the potential to challenge expectations of scientific careers. This may enable pupils who would not have considered themselves to identify as 'a scientist' to change that perspective.

Bodenhorn and Lee (2021) suggest that "sociality often animates locality" (ibid. p. 123), which is borne out in the peer relations that emerge through the physicality of the fieldwork locations. Through their collective, creative explorations (e.g., bogtrolls) and their play with each other involving equipment and the muddy settings, the pupils demonstrated the

capability of ‘affiliation’ (Nussbaum, 2011). The ‘social’ conversion factors present during and after the fieldwork days enabled the pupils to develop eco-citizenship capability of relating to others in an environmental context.

Intergenerational relations

> *Well, I care about the environment because I help my mum in the back garden, when there is like weeds and stuff, I like help my mum so that plants aren’t dying.*
>
> OPAL School 2: Focus Group Response: 23.10.2019

> *The conversation between the group of boys moved on to flooding and the suggestion that, “I think we should just get rid of the land and just have ocean.” One of the nearby rangers asked “Where would people live then?” To which the boy responded “They would have to live in the ocean.” The conversation between the boys and the ranger was joined by one of the volunteers attending the day and moved onto a discussion about Bangladesh and the Ganges delta, the half million people who live on the Ganges and how they would be affected when flooding increases as a result of climate change.*
>
> MICCI School 1: Fieldnotes: 9.5.2019

These are two examples of very different types of intergenerational relations that were prompted during the citizen science experience. The reflections on helping at home offer the opportunity to ‘take’ the citizen science experience into their domestic spaces and make an impact on the everyday elements of their lives. Duarte et al (2017) found that family influences composed part of a complex series of processes, including school and peer interactions that drive pro-environmental attitudes. The Bangladesh conversation offers a different viewpoint, an ‘opening up’ of horizons. This intergenerational conversation brought different learning experiences together and encouraged the young people to make connections to global challenges that are facing our world. Chawla (2007) suggests that ‘influential adults’ e.g., family members or teachers, can have a positive influence on adult pro-environmental behaviour. Furthermore, Williams and Chawla (2017) found that ‘inspiring instructors’ persisted in the memories of young environmental programme participants on into their adulthood. While citizen science projects have the flexibility to include direct contact with practicing scientists/environmentalists or to be entirely independently undertaken by individuals/groups, a strength of these particular citizen science activities was

the potential to engage the pupils with ‘expert’ scientists and volunteers. These are examples of different ‘social’ conversion factors activated through the citizen science experience that build the pupils capability of ‘affiliation’, or social interaction in relation to eco-citizenship issues and behaviours.

Drawing on related ‘environmental citizenship’ terms, in the pupil focus group discussions, ‘contributes to debates and discussions about environmental issues’ was the only statement selected by only one group. In the MICCI project, the pupils felt that the experience gave them confidence to talk about environmental issues and that having scientific evidence helped them to back up their statements. There was also a reflection here of encouraging others to get involved in conservation and citizen science projects like MICCI. Two of the three teachers suggested that this statement was important, and that the projects may have an impact on this, one teacher related this statement to work being done elsewhere within the courses of their science department.

> *We have a specific climate change debate*
>
> OPAL (Group 2) Teacher: 23.10.2019

A reminder that the citizen science projects take place alongside a wide range of other learning experiences within (and out with) the school and that as Duarte et al (2017) suggests, that school-based experiences “should be integrated with a more general community effort in order to improve the results that guide environmental attitude construction” (ibid. p. 37).

‘Encouraging others’ was identified by some of the adults as a characteristic of an environmental citizen. One of the scientists suggested that they would consider themselves an environmental citizen and felt that being a role model to the young people that she works with enables them to see positive engagement with the environment and thereby reduce eco-anxiety. She felt that it could also empower young people to make changes. Additionally, a small number (24%) of young people included intersubjectivity, or communication with others, in their characterisation of an environmental citizen, although this was always in combination with another lived citizenship dimension. For example;

> *Someone who cares deeply about the environment and is willing to make personal changes for it and take time to educate others on environmental matters”*
>
> and

cares for the environment and wants to make a change and spread awareness

Pupil characterisations of an environmental citizen: Survey response: 1.11.2020

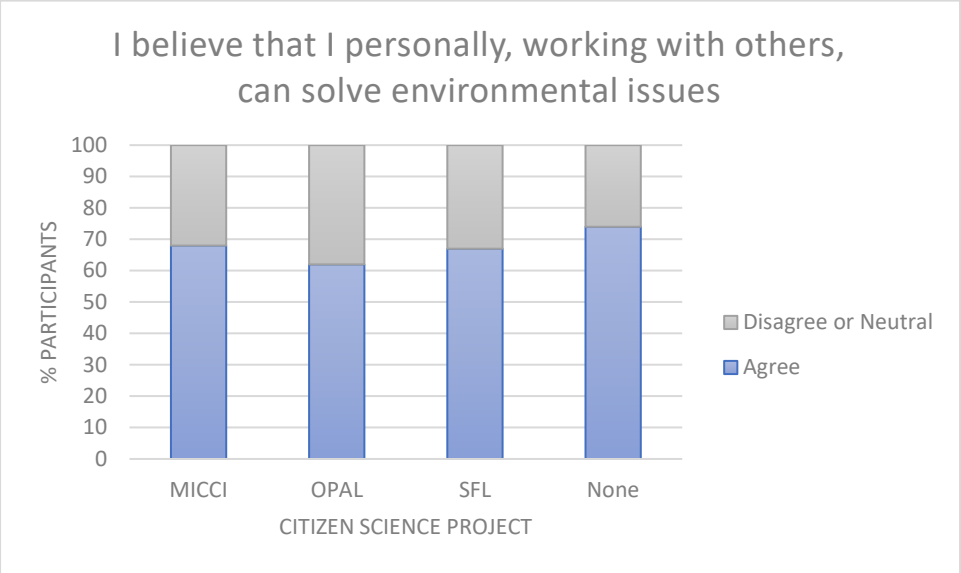

Figure 28: Self-reported self-efficacy: working with others

This graph above (fig. 28) shows that there is an overall agreement with the statement from the participants in all cases. There is not, however, a strongly confident agreement with the statement. The MICCI and OPAL scores were lowest or lowest equal across the five statements, while the other two were in the middle, neither highest or lowest. The highest level of agreement with this statement came from the non-citizen scientists, suggesting that the citizen science experience did not facilitate working together to solve environmental issues in a way that sets it apart from the experiences these young people had gained from the other experiences in their lives. As previously discussed, these young people are involved in courses of study with a high level of environmental content, and as such, may have an existing level of awareness of environmental issues. The wording of this statement may also have influenced the response. Containing both a statement of individual responsibility 'I personally', alongside a collaborative component 'working with others', may have resulted in the pupils emphasising either component more strongly and this cannot be discerned in their responses. Furthermore, 'solve' is a particularly strong term, in comparison to, for example, 'make a positive impact on …', to 'solve' suggests an end point or a resolution to the problem of environmental issues that these pupils may not have felt as confident in making. Despite this, the overall agreement with the statement suggests that the pupils involved in this research are confident in working with others to solve environmental issues.

Larkins (2014) suggests that “children’s practices of citizenship contribute to interdependence” (ibid. P. 18/19). Throughout the intersubjective dimension, the pupils have been shown to engage in citizen science experiences which facilitate peer and intergenerational communication. These ‘social’ conversion factors contribute to the development the eco-citizenship capability of ‘affiliation’ (Nussbaum, 2011), or working with others to improve environmental issues.

The performed dimension

In the performed dimension, two themes will be described. The first relating to the role of ‘contribution’ in the context of the citizen science project. In the experiences and reflections of the participants, making a meaningful contribution was discussed and questioned, this section will outline the context of these discussions and present some contrasting perspectives from different participants. Secondly, the research sought to understand if, and in what ways, the citizen science experience may influence environmental actions in the wider lives of the participants. Reflections on what actions the participants consider ‘good’ for the environment and how they considered their own lives in relation to the citizen science experience will be described, with a particular focus on protest and campaigning.

Nussbaum’s (2011) sixth ‘central capability’ suggests that applying ‘practical reason’ is a capability in which people are able to “engage in critical reflection about planning one’s life” (ibid. p 34). Engaging in citizen science as part of environmental education in school gives pupils the opportunity to explore a way of contributing to an environmental issue and raises awareness of participating in pro-environmental activities. Considered within the performed dimension, this analysis will show that the citizen science experience can invoke two types of conversion factor, personal and social, in developing the eco-citizenship capability of contributing to eco-citizenship actions on a range of scales.

Making a contribution

All of the adults interviewed reflected on the contribution that the pupils were making in getting involved in the citizen science experience. For most this was framed in a positive manner, as something more meaningful than doing an experiment ‘for the sake of it’.

> *Contributing data as a citizen scientist that is meaningful and is getting used.*
>
> Participant interview: MICCI Scientist AC 2.11.2020

To the extent that we will be looking at incorporating some of that data into [PhD student's] heat maps, so she's been sampling obviously on a much bigger scale, at [fieldwork location] where we were for example, she has mapped all that, we've got the nutrient miles at different depths but we do just want to maybe build the schools data as it were, into that kind of analysis just a wee bit to see how it compares and checks and so on

Participant Interview: SFL Scientist: 5.12.2019

One of the teachers however, expressed frustration with the constraints of the citizen science process, suggesting that uploading the data may not be a particularly engaging lesson and that where long timescales were involved it may limit the impact of the experience on the pupils. These concerns are good examples of the conflicting priorities between the citizen science projects and the reality of the school experience.

The pupils attributed much less importance to the idea of making a contribution. In the survey responses, 'feeling useful' or 'helpful' was a response to 'how did the citizen science experience make you feel' for a low proportion (5/19 OPAL, 8/23 MICCI, 1/8 SFL, 28% in total). While these reflections suggest that only a small number of pupils made the connection between the citizen science experience and the contribution that they could make to an environmental issue, that where it *was* made, it resulted in a meaningful experience for those young people.

By actively taking part it makes you feel more involved in helping the environment.

OPAL School 1: Survey Response: 10.9.2019

I also learned that data can be taken in multiple ways and compared to ensure the data is accurate, this is important if the data is for something particularly important and that most data can be traced back to more data and each soil forming factor has a great affect on the soil overall and how these can be put together to make a supported conclusion.

Participant survey response: SFL pupil: 15.11.2019

For some pupils, getting involved in the citizen science experience had encouraged them to think about their own future contribution.

Try to contribute more often on useful things

OPAL School 1: Participant survey response: Most important: 10.9.2019

When asked whether they considered the citizen science project itself as an ‘act of citizenship’, the following response was given by one of the teachers;

> *“It’s definitely an act of citizenship in the way that they were then sending the results in, I think that’s what makes it, if they were just, and that’s why I’ve said it’s given there, it’s like, rather than them just doing their own fieldwork to practice a skill and it’s sort of not that relevant, this makes it an act of citizenship because they are being part of this wider, yeah, so it is, yeah I hadn’t even thought of that one, I was thinking of acts to protect the environment, I guess I was thinking of other things they would go on to do to, different things but yes, I can see that is like a they are, they’re doing aren’t they, they’re providing data which is going to supply something which is going to help inform decision making and things in the future, so yes”.*

Participant Interview: MICCI School 2: Teacher: 7.11.2019

The contributory component of the citizen science project was less visible to the pupils involved than it was to the adults. However, the contributory nature of the citizen science project was identified as an ‘act’ of citizenship by the teacher only after discussion with the researcher. As will be discussed further in the next section, what can be considered pro-environmental actions may take a wide range of forms, including public facing, large scale actions such as the ‘Friday for the Future’ protests, through to private, domestic level actions such as reduced meat consumption or intergenerational discussions about environmental issues. Goldman et al (2020) describe classification of behaviours that can be considered pro-environmental, these include the public/private sphere activities, described by Stern et al (2000), a civic activities dimension proposed by Thogersen (1999) and purchase related behaviours (e.g., Gardner and Stern, 2008). Exposure to the eco-citizenship action of engaging in a citizen science project, though not (necessarily) an intentional one on the part of the many of the pupils, serves to demonstrate an action that can be taken to contribute to overcoming a challenging environmental issue. The personal conversion factors of awareness, and desire to act are identified in these cases, supporting the development of the pupils’ eco-citizenship capability of applying ‘practical reason’ to decisions about their own lives in relation to environmental issues.

Wider perspectives

In the performed dimension, the 'actions' that young people take are often constrained by their circumstances and the limitations of their power to make decisions about actions. When the pupils were asked in the focus groups, to suggest what they considered 'good' for the environment, they suggested a wide range of positive environmental actions. These included waste reduction and recycling, energy reduction through more walking and cycling, and lifestyle changes such as reducing red meat consumption or a vegetarian diet. When discussing environmental citizenship related terms, similar reflections were made.

> *Participant 2: yeah. But definitely like, takes responsibility for their impact on the environment, I think I'm way more aware of what I recycle and like put in the bins and stuff than I used to be*
>
> *Participant 1: yeah definitely,*
>
> *Participant 2: reusable water bottles and stuff, I really don't like getting plastic water bottles now*
>
> *Participant 3: anymore,*
>
> *Participant 1: I feel a bit bad when I do it, so yeah.*
>
> MICCI School 2: Focus group discussion, good for the environment: 7.11.2019

This reflects many of the 'thin' citizenship ideas (Hayward, 2012) which suggests that young people are able to:

> Address some of the symptoms of our sustainability crisis, but they leave the drivers of ecological and social justice unchallenged
>
> Hayward, 2012. p. 43

These aspects also generally did not relate to the citizen science experience undertaken by the pupils. This suggests that they didn't consider the citizen science experience in itself an act of eco-citizenship. They did, however suggested some things that could be related more closely to the citizen science experience, for example reducing the use of peat as a fuel (MICCI project) and the importance of reducing the intensity of farming to improve soil quality (SFL project). Participating in environmental citizen science through school can be considered as a personal conversion factor, developing the pupils' capability to "engage in critical reflection about planning one's life" (Nussbaum, 2011). More explicit exploration of

the citizen science-related content and relevant eco-citizenship actions would strengthen the connection between the two ideas (more detail on this can be found in my recommendations section, p. 220).

Campaigning and protest

When asked to select terms that they felt represented 'environmental citizenship' and comment on their citizen science experiences contribution to these, two statements were included that reflect more politically active or visible types of eco-citizenship behaviours (Dobson, 2007; Latta, 2007). 'Campaigns for change' and 'gets involved in protests about environmental issues' both generated discussion but there was not a consensus on their relationship to the citizen science project for the participants in this project.

On reflecting on the statement 'campaigns for change', in all of the cases, the pupils in this study suggested that they had not campaigned and that they were not more inclined to campaign as a result of the project. 'Getting involved in protests' divided opinion, with the OPAL focus group unable to make any connections between the citizen science and protesting, one of the MICCI focus groups discussed the impact of the 'strikes for the climate' being on school days.

> Interviewer*: are there any that stick out as more relevant than others, to you, do you campaign for change?*
>
> Participant 1: *No, I've not campaigned for change*
>
> Participant 2: *I haven't campaigned either*
>
> Participant 3: *probably takes responsibility, it obviously sends a clear message about*
>
> Participant 1: *shows you passion*
>
> Participant 2: *yeah*
>
> Participant 3: *and that they want change*
>
> Interviewer: *So, you don't feel that you're in that position yet?*
>
> Participant 1: *no, I think I would be,*
>
> Participant 2: *Yeah, except I just, you know, couldn't miss school last year, Highers were important*

> Participant 3: *that was the thing it was like, Highers and I was like a whole day, homework*
>
> Participant 1: *I mean I would of but it was always a Friday, so …*
>
> MICCI School 2: Focus Group Discussion: Environmental citizenship terms: 7.11.2019

These pupils expressed a conflict between missing school and participating in the protests. The importance of their personal responsibilities in relation to study and exams took priority over engaging in active protest, despite a tentative agreement that they 'would be' able to. Huttunen and Albrecht (2021) describe the 'Fridays for Future (FFF)' movement viewed through a citizenship lens, finding that despite significant youth participation, adult voices remain dominant in the media responses to the protests. Feldman (2020) suggests that critique of the 'School Strikers' by mainstream (adult) media focusing on the age or lifestyle choices of the participants attempts to discredit and exclude young people from the adult decision-making arenas. These critiques may also have an impact on young people considering participating in public-facing activism or campaigns, already conflicted around their school responsibilities. If the activism is dismissed as futile or not recognised by those in power, it may dissuade them from participating. However, Iversen and Jonsdottir (2019) found that despite being unable to change a decision at local municipal level, the process of engaging in a campaign to attempt such was effective in enabling pupils in their study to practice environmental citizenship in relation to a relevant local issue. In their study, the pupils engaged in environmental monitoring and followed up by presenting their findings to local decision-makers in relation to a proposed development. The direct relationship between the monitoring activity and the presentation of implications to decision makers more closely resembles the citizen science model of eco-citizenship behaviours experienced in these cases. One of the teachers suggested;

> *We do a lot of fieldwork – we go on a trip to Arran, but this was different as part of a bigger project and the data is going towards something.*
>
> MICCI School 2 Teacher: 7.11.2019

When asked specifically about the activities that they thought an environmental citizen would undertake, the pupils again gave predominantly practical examples, including waste reduction activities such as recycling or composting, and stewardship activities, such as litter picking or beach/river cleaning. Getting involved in citizen science or data collection activities were also suggested by some pupils. The second most common type of response was social

activities, this included participation in eco-groups or volunteering, and raising awareness/educating others. Finally, 17% of the responses included a reference to more political acts, including protesting or starting petitions. The ability to practice or 'perform' citizen science and engage with its contributory nature offers an opportunity for young people to experience an aspect of eco-citizenship, and in doing so they can be supported to reflect on their own eco-citizenship capabilities.

The adults involved were also somewhat tentative about campaign and protest as eco-citizenship acts, with one teacher suggesting that campaigning and protesting were outwith the realms of what they were trying to achieve within the citizen science project at school, reflecting that;

> *campaigns and getting in the protests, they're more background* (dimensions of eco-citizenship that could be identified during the citizen science experience)
>
> MICCI School 2 Teacher: 7.11.2019

Another teacher expressed that they didn't believe that campaigning was what they would expect from an environmental citizen and felt the protests would have;

> *minimal impact on the public and it has no impact on the corporations*
>
> OPAL School 2 Teacher: 23.10.2019

In their reflections on what they thought an environmental citizen might do, political acts were not mention as all by the adults. In general, they felt that learning was most important component, with one of the scientists suggesting that understanding the environment, how it works, and the cultural and historic connections was important to them, and another proposing that an 'enquiring mind' was key to their understanding of being an environmental citizen. One of the teachers also echoed these points suggesting that an environmental citizen is;

> *Someone who has an interest in exploring the environment around them and understanding how it works.*
>
> MICCI School 1 Teacher: 9.4.2019

These diverging attitudes to campaigning and protest exemplify Latta's (2007) consideration of environmental citizenship from an environmental justice perspective, he suggests that;

> Protest and direct action, especially when internationally co-ordinated, might seem a long way from the simple citizenly duty of taking the blue box down to the curb. This distance points to divergent possibilities for the future of environmental citizenship.
>
> Latta, 2007, p. 19

It is clear from the discussions here that engaging in an environmental citizen science project did not, in these cases, support the intention to engage in more political or overt forms of eco-citizenship action. The focus group discussions, however, gave the participants the opportunity to consider what they thought *were* appropriate forms of eco-citizenship action. As discussed in more depth in my recommendations section (p. 220), including more explicit discussion about the nature of eco-citizenship actions can prompt the pupils to reflect on their own eco-citizenship capabilities.

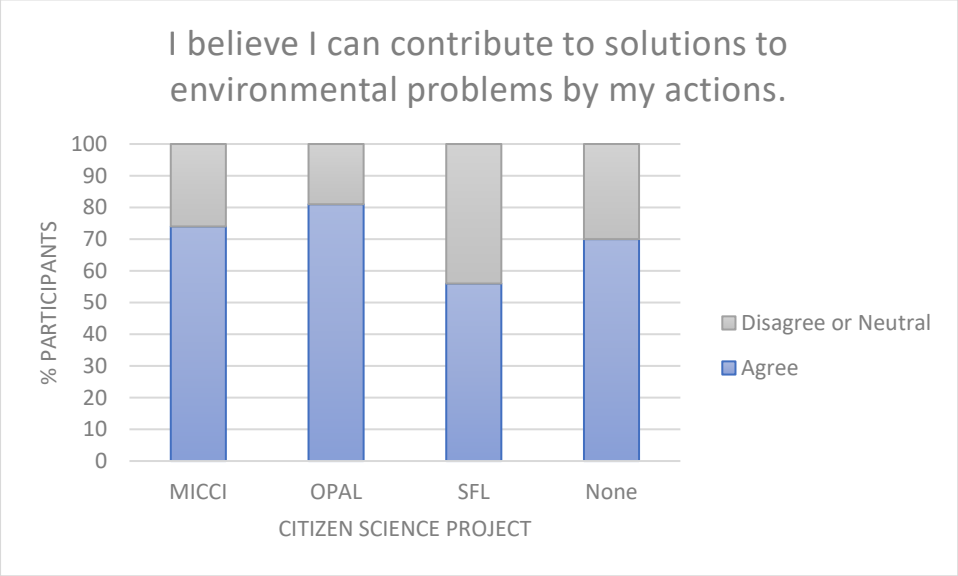

Figure 29: Self-reported self-efficacy: actions

The statement 'I believe I can contribute to solutions to environmental problems by my actions' (fig. 29) is the only one in which OPAL participants demonstrated higher agreement level than the other three citizen science projects. For four out of the five statements, the MICCI participants had the highest proprtion of agree responses overall, and in all other statements, more MICCI participants than OPAL participants agreed with the statements. The nature of the phrase 'contribution to solutions' is perhaps the most clearly related to the citizen science idea of contributing to an environmental issue, and OPAL of the three projects is the most explicitly 'contributory' project. The MICCI project had some 'collaborative' elements, with the pupils discussing the data collection approach with the

scientists involved ahead of the fieldwork day. In the SFL project the pupils were unaware of the contributory nature of their data collection. Explicitly considering 'environmental problems' also has a clear connection to the nature of the OPAL study. In this, the groups were comparing the biodiversity found in three locations, each differently affected by human activity. Thus the 'problem' of human development (of a building or a car park, for example) was clearly visible within their data collection, analysis and results. By comparison, in the MICCI project, a more in-depth analysis of a visibly 'natural' landscape was undertaken. The 'problem' of climate change in the context of the moorland landscape is one in which the solutions are presented and managed by the relevant National Park authorities. So, while the pupils were contributing to observations in relation to the problem, they were not actively involved in the solutions, which may account for the lower self-efficacy score for these pupils in comparison with the OPAL participants.

In summary, in the performed dimension, the eco-citizenship capabilities of contribution, personal action, and political action were described. In bringing together the personal conversion factors, of increased personal awareness, and desire to act, with the social conversion factors of political and visible eco-citizenship action, participating in the citizen science experience was considered by some pupils and teachers an 'act' of eco-citizenship, thereby developing the pupils' capability to "engage in critical reflection about planning one's life" (Nussbaum, 2011). However, as will be discussed in more depth in my recommendations, making this connection more explicit for the pupils would further strengthen the impact of this (see p. 220 for more on this).

The affective dimension

In the affective dimension, two key areas for discussion have been identified. The first is the role of 'caring' in environmental citizenship, reflecting on what young people think it means to 'care' for the environment. Secondly, the impact of eco-anxiety on the young participants (Albrecht, 2019; Panu, 2020; Ojala, 2018; Coffey et al, 2021 among others) and the potential of citizen science to combat this by providing a way for young people to get involved and feel productive. Ojala (2018) suggests that collaborative work with others on environmental issues can challenge the feelings of powerlessness and despair that can be associated with big, wicked challenges such as climate change.

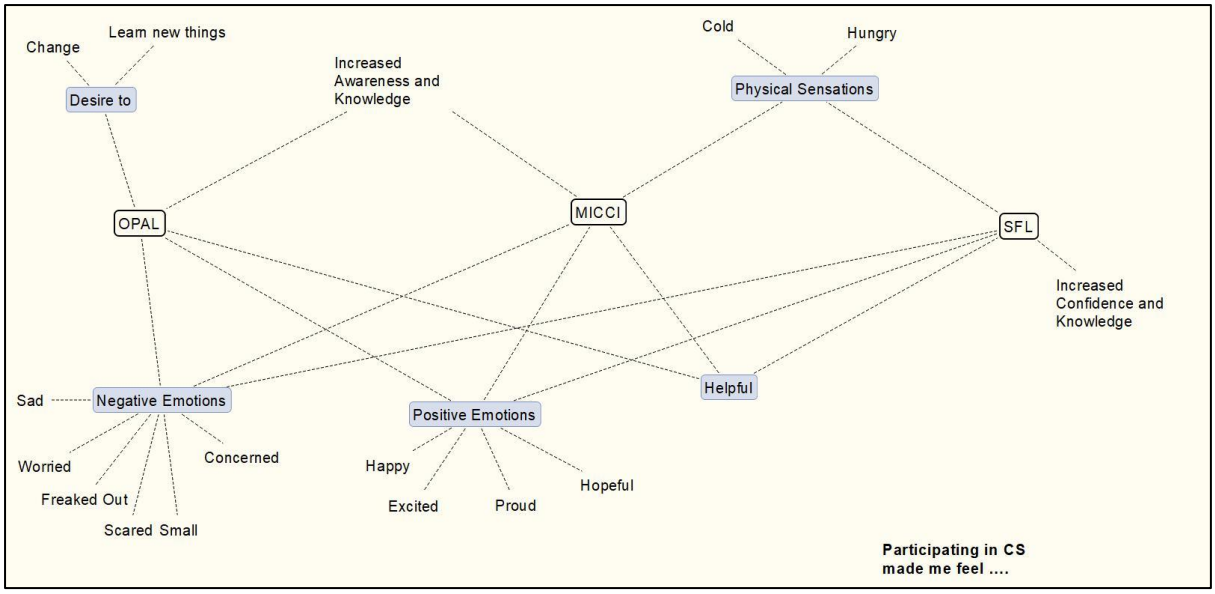

Figure 30: Relational map of affective responses to the citizen science experiences across all cases

The relational map of the affective responses of the pupils (fig. 30) brings the complexity of the emotions involved into clear view. The really positive emotions of hope, excitement and pride, coupled with increased confidence and awareness suggest that this experience could have a significant impact on the pupils. However, the presence of the more negative emotions, including worry, fear and sadness, alongside the negative physical experiences of the fieldwork day may work to counter these positives. In any outdoor learning/environmental experience, the need to balance physical/emotional discomfort with the opportunities for joy and hope is absolutely crucial.

Caring for/about the environment

In the focus group discussions (see methodology p. 74 for a more detailed description). 'Cares about the environment' was selected for discussion by pupils in all three cases. The OPAL group reflected on not damaging the environment that they were surveying, and helping family to weed the garden, thereby protecting an identified and localised environment. The SFL group suggested that the citizen science experience had encouraged them to;

> *think about things I didn't know before*
>
> and had;
>
> *made me appreciate it more*
>
> SFL Pupil: Focus Group 15.11.2019

suggesting that the learning experience had increased their sense of care for the environment as a result of raising their awareness of it. However, their discussions around this were tentative, rather than affirmative, suggesting that their confidence in this aspect was not strong. They also reflected on damage to the landscape,

> *we put it back the way it was*
>
> SFL Pupil: Focus Group 15.11.2019

acknowledging the damage that had been inflicted by the digging of the soil pits, but that efforts had been taken to mitigate for that. Of the adults, only the OPAL teacher selected this statement, suggesting that this was an important element of the project for them.

> *I really do want to instil care about the environment, in doing that you are getting them to think about their impact.*
>
> OPAL School 2: Teacher Interview: 23.10.2019

Quigly and Lyons (2017) draw on Noddings (1984) work on care in educational systems to describe the importance of the concept of 'care' in environmental education. They suggest that care is not only an emotion but an action, the act of caring *for* another involves both the feeling of compassion or empathy and the actions that demonstrate that feeling (ibid). Martin (2007) suggests that in order to nurture care for the environment, young people must spend time "getting to know nature" (Martin, 2007, p. 62). This time spent enables a relationship with the environment to develop and a desire to care for it to grow. The diversity of 'environments' that pupils were directed to spend time in through the different projects offers a range of 'places' that the pupils may begin to 'know' and care for. The one-off visit that was characteristic of the MICCI project affords the pupils the opportunity to 'spend time' in a moorland, remote, isolated and unlike their typical landscape. However, both the OPAL and SFL projects were located in places with more existing connections for the pupils, e.g., their school grounds or a local village. This deepening relationship with the nature found in local and familiar areas locates 'caring for' *their* environment within the lived experience of the young people and begins to reduce the abstract and remote nature of caring for *the* environment.

The affective domain was also well represented in the responses to the question 'what characteristics do you think an environmental citizen has? With 59% of the young people including terms like 'caring', 'passionate', thoughtful' or 'dedicated' in their sentences. However, many of the young people included both affective and active elements into their definitions, for example;

Active in the environment and loves to learn about it. They can old or young, small or tall but the one thing they have in common is their love for nature

and

cares about the environment and wants to protect it and learn about the environment and how they can help it.

Pupil Survey Responses: 1.11.2020

It is apparent that for many of these pupils, it is not enough to only 'care' or only 'do', but it is the combination of 'caring' and 'doing' that are important in their characterisation of an environmental citizen.

Utilising the positional mapping approach taken as part of situational analysis (Clarke et al, 2018), the following map (fig. 31) considers the relative positions of 'caring' for the environment and the importance of making a meaningful contribution in the reflections of the pupils and the adults involved in the citizen science projects. The 'positions' on the map do not represent actual individuals or discrete values, rather, as Clarke et al (2018) describe, "broadly portray the different positions held on key issues in the situation under study" (ibid. p. 166).

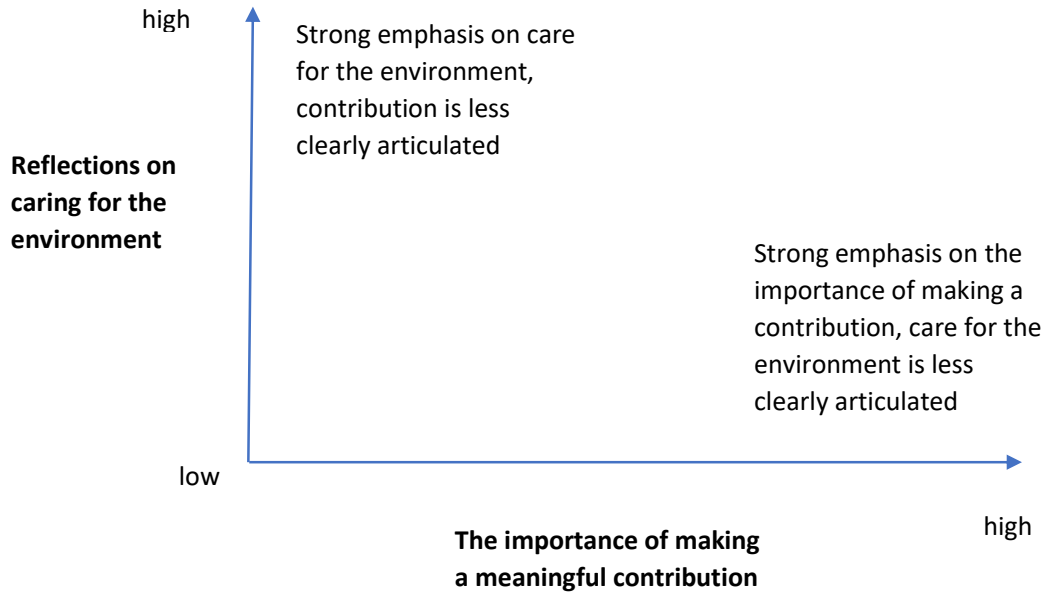

Figure 31: Positional map of caring and contribution

The affective domain is where the greatest difference between the adults and the young people in their characterisation of an environmental citizen, the adults rarely mentioned any emotional elements, with the exception of one of the scientists who described being able to 'talk passionately' as a way of encouraging others to make changes. The adults interviewed are all involved in environmental education in some way, and as such perhaps the emotional connection is implicit in their choice of career. In contrast, the adults involved were more explicit than the pupils about the importance of making a 'meaningful contribution' as an important component of the citizen science experience, one which set it apart from outdoor fieldwork typically undertaken in schools. The differences in emphasis here suggest that while the 'performed' and 'affective' lived (eco) citizenship dimensions are present within the citizen science experience, that the adults and young people involved view and perceive the experience across the different dimensions.

In the affective domain, the 'personal' conversion factor of caring for the environment was strongly reflected upon by the pupils. This has the potential to develop the eco-citizenship capability of living with concern for animals, plants and the world of nature (Nussbaum, 2011).

Eco-anxiety

Eco-anxiety is a key challenge when dealing with learning about complex topics such as climate change and biodiversity reduction. Eco-anxiety can be defined as "the generalized sense that the ecological foundations of existence are in the process of collapse" (Albrecht, 2012, p. 250) or by Clayton et al (2014) as a "chronic fear of environmental doom" (ibid. p. 68). Panu (2020) describes these as strong forms of anxiety concerning fear, worry and stress. While in general terms these emotions are described in negative terms, Ojala (2018) describes coping strategies that include positive and practical responses to eco-anxiety, including problem-focused and meaning-focused strategies. The young people in this study reported some concerns that relate to feelings of eco-anxiety, for example:

> *Kinda freaked out by climate change (…) want to help the bog stay safe*
>
> MICCI School 2: Survey response; CS made me feel …. 7.11.2019

Eco-anxiety is linked to uncertainty, unpredictability and uncontrollability (Panu, 2020), the future of the bog and its role in climate change mitigation is an example of the pupils coming into contact with a factor which may have a direct impact on climate change, but that they are not in a strong position to influence (the 'safety' of the moorland) going forward.

However, as Ojala (2018) suggests, intergenerational and collective actions can demonstrate hope and empowerment.

> *Reassured that there are good projects and solutions which have been set up to reduce climate change*
>
> MICCI School 2: Survey responses; CS made me feel …. 7.11.2019

Therefore, the increased awareness that participating in the citizen science project brings and the knowledge of other similar projects could alleviate some of the concern that was apparent in the pupils' responses. It is crucial that citizen science projects take adequate consideration of the potential impacts of eco-anxiety on their, particularly young, participants. As discussed previously, considering citizenship from the socio-legal, adult-centred perspective, young people have limited power to change and influence existing systems (Hayward, 2012, Ojala, 2018). It is therefore vital to ensure that in the everyday experiences of attending school and participating in projects such as these described, that the pupils are able to see positive action and take positive messages away from their experiences. As Quigly and Lyons (2017) suggest, feeling and seeing the response to an action can increase the sense of obligation to continue to care for that place or about a particular issue.

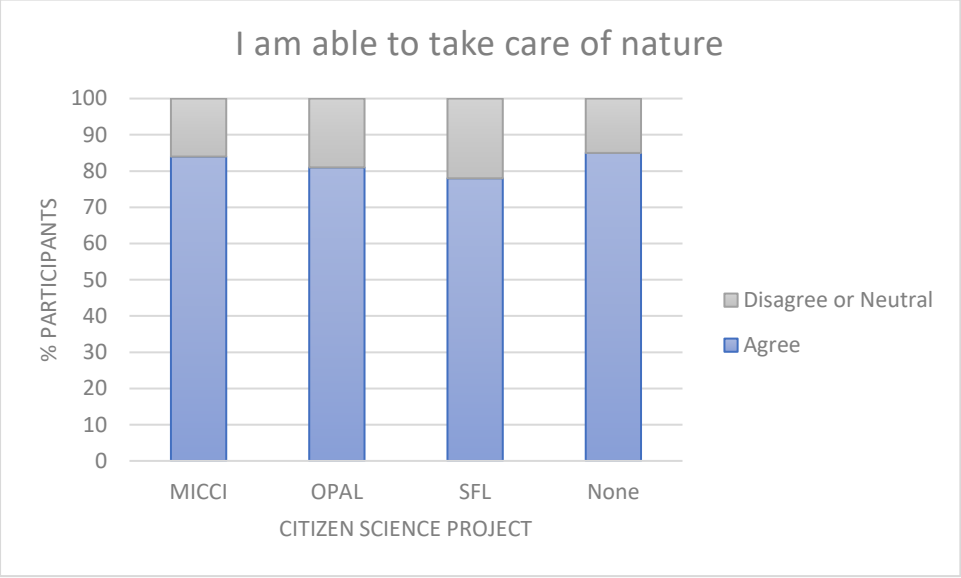

Figure 32: Self-reported self-efficacy: taking care of nature

The statement 'I am able to take care of the future' (fig. 32) was the most consistently agreed with across all the citizen science projects. It uses clear and accessible language to describe environmental self-efficacy. The recognisable and accessible nature of the terms used; to 'take care of' rather than 'protect', and 'nature' rather than 'the environment' may go some way to giving the pupils confidence that these are achievable actions that they can

envisage themselves doing. Organisations have used similar language to engage with the wider public, for example the RSPB's homes for nature campaign uses relatable language to appeal to families and young people.

The experience of 'personal' conversion factors, such as care and concern, through involvement in citizen science activities are powerful motivating factors in encouraging eco-citizenship. Coupling this with the participation in, and increased awareness of, activities with a directly positive impact on environmental issues contributes to the development of the eco-citizenship capability to 'live with concern for animals, plants and the world of nature' (Nussbaum, 2011). The development of this capability can have a reducing effect on eco-anxiety.

Spotlight on conversion factors

In order to more fully understand the way in which young people view conversion factors, a sample (n = 33) of the pupils in this study were asked to comment on particular conversion factors. These pupils represented a mixture of citizen science and non-citizen science participants, and were asked to respond via an online survey tool. This part of the data collection took place during covid restrictions, so face-to-face interactions with pupils were not possible. A selection of social and environmental conversion factors was provided and the pupils asked to rate their perceived importance in contributing to eco-citizenship. These factors were drawn from literature on perceived childhood influences on nature connectedness (e.g., Chawla, 2007) and active citizenship (e.g., Lee, 2016). Citizen science experiences as part of a school programme and also outwith the classroom were also included as potential factors. The results are shown in fig 33.

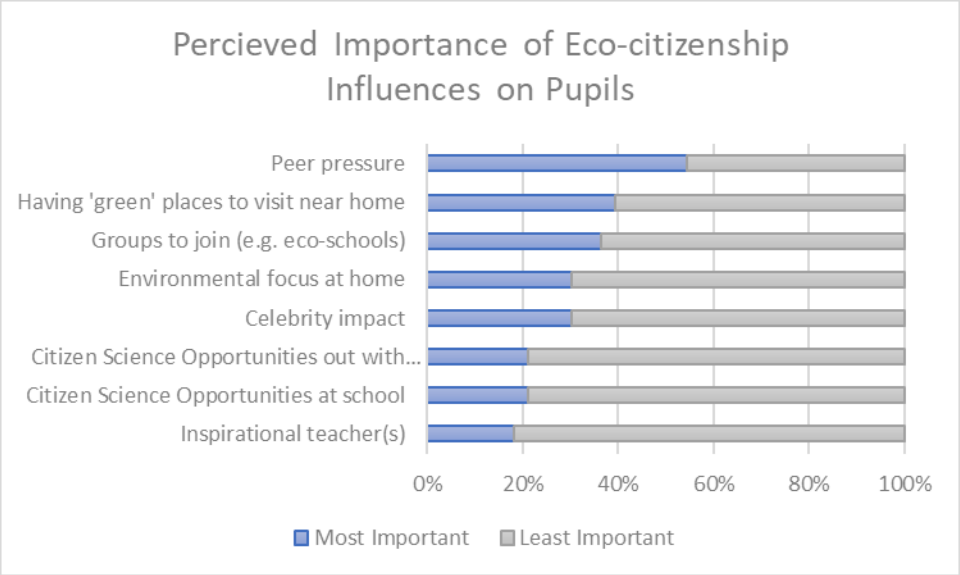

Figure 33: Perceived importance of eco-citizenship influences to pupils

A social conversion factor (peer pressure), and an environmental conversion factor (having 'green' places to visit near home), were ranked as most important by these pupils. Citizen science opportunities (within or outwith school) were ranked as least important, alongside 'inspirational teachers'. This suggests that if citizen science is to be considered by the pupils as something important in helping to develop eco-citizenship capabilities, then more needs to be done to make this relevant to the pupils.

This sample of pupils were also asked to suggest their own 'conversion factors'. The most common responses related to raising awareness of environmental issues through education, the media and other people. For example;

> *Education on how their actions can either positively or negatively impact the environment and what things they can change in their life which would benefit the environment*
>
> and
>
> *The experiences of other environmental citizens and how it changed or made a difference in their life*
>
> Conversion Factors Survey Response: 1.11.2020

These are examples of both personal and social conversion factors that the young people involved in this study felt would have an impact on them. Interestingly while 'inspirational teachers' scored among the least important factors overall, one pupil felt compelled to suggest that:

> *If everyone had* [SFL Teacher] *as a teacher, as she's hella inspirational about environmental issues.*
>
> Conversion Factors Survey Response: 1.11.2020

There were also reflections on environmental conversion factors, e.g.

> *Being in and around nature allows people to see the effects we have on our planet. It also allows us to learn visually instead of just being taught in class. Someone in the city may never of seen a volcano or high mountain.*
>
> Conversion Factors Survey Response: 1.11.2020

By providing opportunities and support for pupils to experience, learn about and consider solutions to local and global environmental issues, citizen science activities, when experienced through formal schooling, have the potential to act as conversions factors supporting the development of eco-citizenship capabilities. The low level of reflections on citizen science as a direct conversion factor suggests that citizen science should be considered part of a range of factors contributing to eco-citizenship capabilities and functionings in young people.

Chapter 6 conclusions

In this chapter, the following research question was addressed;

> *What conversion factors contribute to the development of eco-citizenship capabilities in young people's experience of environmental citizen science in schools?*

The pupils involved in my research reported high levels of self-efficacy in relation to environmental action. This suggests that they have confidence in their ability to contribute to positive actions for the environment. The lack of difference between the self-efficacy levels across the citizen science projects (and none) also suggests that, for these pupils who all participate in environmental or scientific subjects through their formal school experience, the nature of the citizen science experience did not inspire a radical change for them.

Environmental, social and personal conversion factors were, however, recognised and reported in my observations of the pupils engaged in the citizen science activities, and in their reflections and responses. These include, physical and sensory encounters, working with others and caring for the environment. While the short-term, single encounter with citizen science, as experienced here, could not be shown to move the pupils towards more public actions such as campaigning and protest, the nurturing of eco-citizenship capabilities

can begin with relational, sensory and affective experiences. Environmental citizen science affords young people opportunities that can be a springboard towards authentic eco-citizenship actions and dispositions.

Chapter 6: Findings summary

In the spatial dimension, the environmental conversion factors identified for pupils were: physical and sensory experiences, authentic practices in place, and opportunities to reflect and situate themselves as active response-makers to global and local environmental concerns.
In the intersubjective dimension, the social conversion factors identified for pupils were: peer interaction and communication, and intergenerational relationships, providing a relational context for young people to explore environmental concerns.
In the performed dimension, personal and social conversion factors were identified for pupils:

- The personal conversion factors were: making a contribution, and personal environmental actions. The adults expressed greater value in relation to the 'contribution' component of the citizen science experience than the pupils. For pupils, participation in their respective projects resulted in an increased awareness of citizen science as a way to take positive action for the environment.
- A social conversion factor of involvement in public actions, such as campaigning and protest, was also identified. My participants described a general reluctance to engage in overtly political acts, this suggests that their environmental citizen science experiences did not directly support this type of eco-citizenship action.

In the affective dimension, the personal conversion factors identified for pupils were: actively caring for a place, and alleviating environmental concerns or anxieties through participation in collective action. These led to feelings of hope and empowerment in relation to environmental issues for the pupils involved.

My study has shown that citizen science practices in school allows pupils, as young citizens, to make personal responses to environmental concerns. My findings suggest that schools can provide a vital context for young people to encounter and engage with citizen science practices and that these experiences can lead to the development of important eco-citizenship capabilities.

Overall Findings Summary

What contribution is made by fieldwork experiences in curriculum-based environmental citizen science to support eco-citizenship capabilities?

In my analysis across chapters 4, 5 and 6, I have shown that participation in environmental citizen science can contribute to the development of the capability to learn about environmental issues, and consider the impact humans can have on the environment. Across all cases the pupils were able to:

- Offer their own reflections and thoughts about environmental issues
- Demonstrate understanding of environmental knowledge
- Reflect on the impact of human activity on the environment in positive, negative and neutral terms

The formal curriculum was observed to be a consistent frame of reference for the fieldwork experiences.

In my analysis, I have shown that participation in environmental citizen science contributed to the development of the capability to sense, analyse and reflect on environmental issues using scientific enquiry skills. Across all cases, the pupils in my study:

- Were observed engaging in data collection, analysis, and accurate recording of results.
- Reported that they were able to experience scientific enquiry in an authentic manner.

However, the role of authenticity in the experience and its contribution to scientific enquiry was less highly valued in the reflections of the pupils than those of the adults.

My analysis of the observations and participant reflections showed me that participation in environmental citizen science can contribute to the development of the capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

The descriptions of converging and diverging organisational priorities by the adults involved reflect opportunities and challenges to the implementation and operational sustainability of school-based citizen science projects.

- Resource issues such as workload and funding challenges are shared by the citizen science providers and schools.
- The priorities of conservation practice and research can be at odds with engagement and participation activities for citizen science providers.

What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities in young people?

Analysis of pupil reflections suggest that interacting with other living things supported their ability to relate to other species.

School based citizen science provides opportunities for fear and discomfort were reported by some pupils to be reduced as a result of interacting with other species, such as spiders and snakes, during their citizen science activities.

Encounters with other living things were reflected on as the most important and memorable for pupils across most cases.

Analysis suggest that physical and sensory encounters were a key part of fieldwork activities.

Reciprocal response-making in the more-than-human was observed in, and important to pupils across all of the fieldwork experiences. Young people's creative, empathetic and playful reactions to the different citizen science experiences demonstrates a significant basis for the emergence of eco-citizenship capabilities.

Changes in their perceived relation to animals, plants and the world of nature were described by some pupils, however, others reflected that their already established affinity was not changed by the citizen science experience.

Pupils with less affinity for the world of nature benefited from citizen science experiences and developed a new capability.

What conversion factors contribute to the development of eco-citizenship capabilities in young people's experience of environmental citizen science in schools?

In the spatial dimension, the environmental conversion factors identified for pupils were: physical and sensory experiences, authentic practices in place, and opportunities to reflect

and situate themselves as active response-makers to global and local environmental concerns.

In the intersubjective dimension, the social conversion factors identified for pupils were: peer interaction and communication, and intergenerational relationships, providing a relational context for young people to explore environmental concerns.

In the performed dimension, personal and social conversion factors were identified for pupils:

The personal conversion factors were: making a contribution, and personal environmental actions. The adults expressed greater value in relation to the 'contribution' component of the citizen science experience than the pupils. For pupils, participation in their respective projects resulted in an increased awareness of citizen science as a way to take positive action for the environment.

A social conversion factor of involvement in public actions, such as campaigning and protest, was also identified. My participants described a general reluctance to engage in overtly political acts, this suggests that their environmental citizen science experiences did not directly support this type of eco-citizenship action.

In the affective dimension, the personal conversion factors identified for pupils were: actively caring for a place, and alleviating environmental concerns or anxieties through participation in collective action. These led to feelings of hope and empowerment in relation to environmental issues for the pupils involved.

My study has shown that citizen science practices in school allows pupils, as young citizens, to make personal responses to environmental concerns across spatial, intersubjective, affective and performed dimensions. My findings suggest that schools can provide a vital context for young people to encounter and engage with citizen science practices and that these experiences can lead to the development of important eco-citizenship capabilities.

In summary, eco-citizenship capabilities arising from citizen science programming in school (in the cases described here) were identified.

The citizen science experiences were seen to contribute to the development of Nussbaum's (2011) Ten Central Capabilities, in particular:

4. Senses, imagination and thought (being able to use the senses, to imagine, think and reason)

6. Practical reason (being able to form a conception of good and to engage in critical reflection about the planning of one's life)
7. Affiliation (being able to live with and toward others)
8. Other species (being able to live with concern for and in relation to animals, plants, and the world of nature)

Nussbaum (2011) p. 34

Furthermore, the eco-citizenship capabilities arising from citizen science programming in school (in the cases described here) were:

- the capability to learn about environmental issues, and consider the impact humans can have on the environment.
- the capability to sense, analyse and reflect on environmental issues using scientific enquiry skills.
- the capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

Chapter 7: Discussion, conclusions and recommendations

In the first section of this chapter, I have selected findings for further discussion in three parts. The first focusing on the lived experience of the participants, the second discusses the development and of eco-citizenship capabilities, and the third reflects on the role of citizen science in education for sustainable (ESD) more widely. Some limitations of my study and some personal reflections are then explored.

The second, and final section draws some conclusions and comments on the implications of these for citizen science practice in schools and ends with some recommendations for future research directions.

Section 1: Discussion, limitations and personal reflections

Discussion part 1: Lived experience of citizen science, place-responsive citizen science in schools

Lived experience related findings

In my analysis, I have shown that participation in environmental citizen science contributed to the development of the capability to sense, analyse and reflect on environmental issues using scientific enquiry skills. Across all cases, the pupils in my study:

- Were observed engaging in data collection, analysis, and accurate recording of results.
- Reported that they were able to experience scientific enquiry in an authentic manner.

However, the role of authenticity in the experience and its contribution to scientific enquiry was less highly valued in the reflections of the pupils than those of the adults.

Reciprocal response-making in the more-than-human was observed in, and important to pupils across all of the fieldwork experiences. Young people's creative, empathetic and playful reactions to the different citizen science experiences demonstrates a significant basis for the emergence of eco-citizenship capabilities.

My analysis of the observations and participant reflections showed me that participation in environmental citizen science can contribute to the development of the capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

Through the observations that I have made in this research, I have shown that citizen science has the potential to engage school pupils in a place-responsive manner. The pupils in my study investigated and responded to their fieldwork environments. They asked questions of it, and each other, in relation to the topic-related content, and the physical and sensory encounters that they were part of. Place-responsive pedagogies are those learning experiences that involve "explicitly teaching by-means-of-an-environment with the aim of understanding and improving human-environment relations." (Mannion, Fenwick and Lynch,

2012). They are activities and approaches which support and develop the abilities of young people to ‘attune’ to their environment. This helps them to notice, sense and observe phenomena as it happens, in a place that it happens (Lynch and Mannion, 2021; Colucci-Gray, 2020). I argue that environmental citizen science is an approach that has the potential to encourage and enable pupils to be ‘present in and with a place’ (Wattchow and Brown, 2011, p 182), whilst engaging in an activity which remains connected to their school experience.

Participation in environmental citizen science, as they did in this study, enabled the pupils involved to work collaboratively with each other and professional scientists on an identified scientific issue in a relevant location. Traditionally, science and science learning has been perceived as an individual pursuit, occurring in ‘placeless’ labs with sterile and controlled conditions (Stroupe and Carlone, 2022). Challenging this dissociation between phenomena, place and people has the potential to challenge the way we currently experience the world. Place-responsive pedagogies contrast with these traditional approaches to (science) education by focusing on our part within the natural world rather than as external entities. Science and science learning, when viewed as cerebral and objective may serve to disconnect us from the world, this study has shown instead that science learning can be an embodied, connected practice. This distinctive and original research reflects on the role of environmental citizen science as an opportunity for pupils to come to view their relationship with their environment differently.

The adults, teachers and scientists, in my study emphasised the importance of the ‘real’ nature of these experiences for the pupils, though the pupils themselves were less concerned with this. Citizen science experiences more widely are considered to be opportunities to engage young people in science learning that is directly connected to real and authentic science practices (e.g., Saunders, 2018). Particularly in environmental citizen science is the opportunity present to connect learners with the natural world by undertaking practical research in locations beyond the classroom. Evidencing the impact of this can be challenging, for example, in attempting to measure the ‘outcomes’ of citizen science experiences, Groulx et al (2017) found an increase in nature connectedness and environmental concern. In contrast, Williams et al (2021) found no significant change in science identity and nature connectedness in their evaluation of two school-based citizen science projects. The conflicting findings of these and other (e.g., Hiller and Kitsantas, 2014; Paige, 2010) studies emphasises the need to more fully understand what is happening during the lived experience of citizen science projects for young people. My study contributes to this body of work, showing ways in which citizen-science fieldwork

experiences enabled the pupils involved to engage in new ways of looking at plants, animals and the natural world. This had the effect of raising awareness of environmental issues, and invoking creative and affective responses to the fieldwork locations which were meaningful for the pupils in my research.

In implementing the citizen science projects with schools, the scientists in my study reflected on the need to consider approaches that they felt would 'work' for the pupils. One was actively restructuring the activities in response to feedback from teachers and another worked directly with the teacher to ensure that the project met not only the scientific objectives, but that it connected clearly and explicitly to the curricular requirements of a specific course of study (Higher and Advanced Higher geography, in this case). The prescriptive, protocol-based approach that is common in large-scale, contributory-type citizen science projects may lack the flexibility and depth needed to avoid becoming 'just another worksheet'. For example, Francis (2020) describes their experience of using citizen science to engage pupils with litter on a local beach. They suggest that while the citizen science experience provided a 'way-in', a way of coming into contact with the litter, that it remained a sanitary and 'incomplete' experience for the pupils. Extending the learning by bringing the collected and logged litter into the classroom and producing art works from it opened up a wider range of sensory experiences that made for more meaningful connections between the children and the litter on the beach. By working together, educators and citizen science practitioners have an opportunity to build citizen science experiences that are place-responsive, curriculum connected and relevant.

In my study, the pupils demonstrated active engagement with the landscape during their citizen science experiences, 'bouncing' on and being bounced by the moorland, for example. The embodied experiences of the pupils responding to the environment in this way is suggestive of a connected way of knowing the world around us, as suggested by Pirrie (2020):

> Phenomena such as the environment or time are not simply 'resources' or 'commodities' that we can waste or save. Rather they are part and parcel of the very fabric of our lives.
>
> Pirrie, 2020, p. 26

The reciprocity in the embodied experience was particularly evident when the pupils shared the 'bounce', encouraging each other to stand further and further apart to determine how far the vibrations would travel. Drawing on Deleuze and Guattari (1987) and Ingold (2011), this entanglement of pupil-moorland-pupil demonstrates one of many ways in which these pupils

attempted to ‘come to know’ the moorland. The effect of learning ‘in’ and ‘with’ the ecosystem in question revealed the nature of the moorland in a way that the information given in the preceding classroom session was unable to do.

Biesta (2021) suggests that a move to a ‘world-centred’ education is desirable, by this he means an education that is “focused on equipping and encouraging the next generation to exist “in” and “with” the world” (ibid. p. 3). In my study, reflections on the physical and sensory encounters, while present, were less powerful in the pupils’ post-visit reflections than they had been on the fieldwork day, instead ‘content’ related reflections increased in prominence. Engaging in the citizen science activity provided an important place-responsive experience for these pupils’, however, the opportunity remains to extend and deepen the impact of this going forward. My research emphasises the importance of understanding the lived experience of being in a place and the effect that can have on the pupils’ ability to connect with environmental issues in relatable, relational and meaningful ways.

Intra-actions with other species are suggested as a way that educators can challenge problematic relationships between humans and animals (Lloro-Bidart, 2016). Haraway (2016) describes ‘contact zones’, the entanglements with other species that enable a ‘becoming with’.

> Co-shaping in unfolding dances of becoming-with each other is the name of the mortal earthly game. Joy and beauty are other names for attraction and attachment.
>
> Hadfield and Haraway, 2019, p. 229

The delight and curiosity that the young people in my research showed in response to their encounters with other species is a demonstration of the impact that the citizen science experience can have in establishing such ‘contact zones’. In the focus group discussions, some pupils were prompted to consider the natural world from the perspective of the organisms that they encountered there, this alternative viewpoint provided them with an opportunity to more deeply consider the relationship that they have with the world around them. My study showed that intra-actions with other species resulted in raised awareness of, and a reduction in the fear response associated with unfamiliar species. This was reported consistently as a positive experience for the participating pupils. This supports the findings of Stroupe and Carlone (2022) who found evidence of awe and wonder in young participants of citizen science projects where unfamiliar organisms such as snakes and moths were the focus. In this research, observing and reflecting on young peoples’ encounters with living

things contributes to deepening understanding of the potential impact of environmental citizen science as part of a place-responsive pedagogical approach.

During my observations of the fieldwork activities, pupils across each of the citizen science projects responded in creative and imaginative ways to the landscapes and the organisms that they encountered. These responses were separate and different from the intended data collection protocols or specified learning intentions of the days. The pupils described these responses as memorable and important, their creation of 'bogtrolls' for example. Jensen (2016) describes the role of empathy and imagination in understanding sustainability. She draws on narrative imagination and other creative ways of encouraging school pupils to 'become' a river or an object in the landscape, reporting that these experiences brought greater connectedness and had the effect of restricting the 'otherness' of the object, even when this was not physically present for the pupils. In my research, the pupils created and 'became' characters in response to the landscape. They also demonstrated empathetic responses, to the perceived hardships in the lives of the insects they encountered, for example. This demonstrates that while these responses were not an intended outcome of the citizen science projects, in bringing the pupils to look closely at the moorland or the invertebrates, empathetic and imaginative responses can be made possible.

Sandri (2013) suggests that in sustainability and environmental education, creativity can have an important role in tackling complex or 'wicked' problems, while Lozano (2014) suggests that creativity and learning support one another to move thinking towards sustainability-related goals. In my research, engaging in the citizen science activities provided the pupils with the opportunity to be in, and respond to the environment in creative and imaginative ways. By doing this whilst also considering the complex and challenging issues of climate change, biodiversity loss and soil fertility, there is the potential to connect and deepen understanding of these concepts. However, it was notable that the adults involved did not typically reflect on the creative or imaginative responses of the pupils, except to comment on the 'fun' that the pupils reported having during their fieldwork experiences. Stewart (2020) suggests that while considerations of imagination are found widely in educational literature, it is a much less prevalent concept in outdoor and environmental education. Paying attention to the creative, imaginative and empathetic responses of pupils in relation to outdoor and environmental encounters, as the ethnographic approach taken in this research has enabled, highlights the possibilities of citizen science experiences beyond data collection. As Sandri (2013) suggests:

> “To ignore creativity in EfS is to ignore a key tool in creating social and technological change to help us consider, account for and enhance the social, environmental, cultural and political in our professional decisions and innovations.”
>
> (Sandri, 2013, p. 768)

Achieving a balance between the learning, scientific and creative intentions of citizen science experiences is crucial however, in enabling schools and pupils to commit to participation in any citizen science project. Recognising the creative and imaginative elements of the experiences may serve to facilitate citizen science engagement beyond data collection, while the scientific and learning experiences may provide the justification and validation to participate in an increasingly overcrowded curriculum.

To conclude, environmental citizen science experiences, as reciprocal, place-responsive encounters, have the potential to reposition the learner in a more world-centred (Biesta, 2021) orientation. This research contributes to more fully understanding the lived experience of these encounters, illuminating the possibilities of enabling young people to not only learn about animals, plants and the world of nature, but to understand, care for, respond creatively and empathetically, and ultimately live more sustainably with the world around us.

Discussion part 2: Citizen science and the development of eco-citizenship capabilities

Eco-citizenship capabilities related findings

My study has shown that citizen science practices in school allows pupils, as young citizens, to make personal responses to environmental concerns. My findings suggest that schools can provide a viable context for young people to encounter and engage with citizen science practices and that these experiences can lead to the development of important eco-citizenship capabilities.

In summary, eco-citizenship capabilities arising from citizen science programming in school (in the cases described here) were identified.

The citizen science experiences were seen to contribute to the development of Nussbaum's (2011) Ten Central Capabilities, in particular:

> 4. Senses, imagination and thought (being able to use the senses, to imagine, think and reason)
> 6. Practical reason (being able to form a conception of good and to engage in critical reflection about the planning of one's life)
> 7. Affiliation (being able to live with and toward others)
> 8. Other species (being able to live with concern for and in relation to animals, plants, and the world of nature)
>
> Nussbaum (2011) p. 34

Furthermore, the eco-citizenship capabilities arising from citizen science programming in school (in the cases described here) were:

- the capability to learn about environmental issues, and consider the impact humans can have on the environment.
- the capability to sense, analyse and reflect on environmental issues using scientific enquiry skills.
- the capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

In utilising the eighth of Nussbaum's (2011) central capabilities in my survey and focus group questions with pupils, I was prompted to consider its meaning more widely. The 'other species' capability is described by Nussbaum as "being able to live with concern for and in relation to animals, plants and the world of nature" (Nussbaum, 2011, p. 34). Nussbaum (2011) suggests five possible positions that can be taken in relation to the capabilities of other species. These range from suggesting that only the capabilities of humans should be considered to the consideration of the capabilities of all living organisms and ecosystems should be counted as 'ends in themselves' (ibid. p. 158). She argues that the individualism inherent in the capability approach makes it difficult to argue that an ecosystem has a 'life-project or striving' and as such "it seems odd to suggest that an ecosystem suffers injustice" (Nussbaum, 2011 p. 159). Encountering an ecosystem via outdoor experiential fieldwork and citizen science practice, a reciprocal relationship was evident between some pupils and the ecosystem. This, accompanied by their reflected concerns for the future of the planet suggests that the pupils did recognise the capabilities of these ecosystems. This offers a powerful position from which to connect young people more deeply to concepts of eco-justice and human-nature relationships.

Reflections on the global and local contexts of environmental issues were evident in both my observations of pupil-pupil and pupil-adult conversations, and also in the pupil survey responses. Holland (2008) argues that Nussbaum's rejection of the role of the natural environment in capabilities will result in a rejection of the necessary protections that enable societal justice. She proposes that the "capabilities approach should treat certain ecological conditions as a meta-capability necessary for all the capabilities" (Holland, 2008, p 321), arguing that this would account for the value of the natural world in relation to human capabilities. Kramm (2020) describes how the capability approach can be utilised and modified to consider the 'personhood' of a river. He argues that the 'functionings' of the Whanganui River can be identified and the well-being of the river protected in alignment with the well-being of the humans who live in association with it. On reflecting on the fieldwork experiences in this research, engagement in citizen science projects can not only facilitate place-responsiveness in a particular local area, but also connect that experience to a network of related or comparative places. The opportunity to compare 'your' fieldwork site or school grounds with others in a related manner offers opportunities for teachers and scientists to deepen understanding of ecosystems as a 'meta-capability' of which the pupils are part of rather than separate from.

Employing the capability approach in my research, rather than outcome measures, such as that of environmental action/nature connectedness has enabled me to consider the potential

value of the relationship between the pupils and the environment as a means rather than as an end (van Jaarsveld, 2021). However, the application of the capability approach in relation to environmental education and education for sustainable development (ESD) is critiqued by Schultz et al (2013) who argue that in order for the capability approach to be meaningfully applied in relation to the concept of sustainable development, it must be expanded beyond its current understanding. In particular, reflecting on the dynamic relationship between the 'human and natural dimension' within the capability approach, the authors suggest that the intra- and inter-generational nature of sustainable development and environmental justice are not reflected in the current, somewhat static approach to capabilities. They also argue that the priority of human flourishing in the capability approach fits with an anthropocentric approach to sustainable development, which does not adequately consider the inter-related nature of humans and environment. They suggest an expanded model of the capability approach which explicitly contains feedback loops integrating the natural dimension and intergenerational justice in an evaluative framing (Schultz et al, 2013). This research contributes to a broader understanding of the application of the capability approach in environmental education research, in identifying the emerging 'capabilities' present in the pupil-moorland-invertebrate assemblages. This also connects strongly to the posthuman perspective that suggests "as humans we are of the world, not in the world" (Murris, 2021, p. 72).

I have shown using the capability approach in this study was successful in helping me to identify the emerging eco-citizenship capabilities of the pupil participants on an individual level, however, it also showed clearly the challenges involved for young people when moving towards more collective actions. Leβman and Rauchmayer (2013) suggest that replacing 'needs' with 'capabilities' in the Brundtland report (1987) definition of sustainable development demonstrates the need for an approach that takes not only the intergenerational challenges discussed by Schultz et al (2013) into deeper consideration, but also the relationship "between the systemic and the individual level" (Leβman and Rauchmayer, 2013, p. 99). In considering collective actions which have the potential to negatively impact their individual capabilities, e.g., non-attendance in school to attend climate related protests, the pupils in this study described this as a source of conflict, reflecting a limitation of the application of the capability approach from an eco-citizenship perspective.

In attempting to overcome the conflict between individual and collective capabilities in relation to environmental issues, Leβman and Rauschmayer (2013) suggest that a shift in focus to the natural environment rather than the current emphasis on human flourishing is a

possible way to develop the capability approach in supporting sustainable development in a complex system. Voget-Kleschin (2013) also critiques the capability approach, suggesting that the consideration of environmental conditions is built upon their implications for human capabilities, rather than as a reciprocal relationship. Nussbaum (2018) argues that the separation between humans and animals is a recent, cultural phenomenon and that human capabilities are enriched by "an attunement to the lives of animals and a sense of wonder at their complexity" (ibid. p. 18). While she tentatively suggests that the capability approach could be applied to animal species, Nussbaum (2018) considers that applying it to plants and ecosystems more widely is a problematic consideration. Schlosberg (2007) suggests however, that the concept of flourishing is just as appropriate for ecosystems and ecological justice as it is for human development. Returning to Haraway,

> Holding open space for possible multispecies, including human, flourishing in the face of past and ongoing destruction. Multispecies environmental justice is the goal.
>
> Hadfield and Haraway, 2019, p. 231

In each of the citizen science experiences I observed, it could be suggested that they 'opened a space' for the pupils to consider 'multispecies flourishing'. An example is the curiosity of a pupil asking if the moorland was 'better now'? This gave them, alongside their teachers and peers, the opportunity to explore the role of human intervention and reparation in the existence, protection and flourishing of that particular moorland ecosystem.

In summary, this research makes an important contribution to understand the implications of using the capability approach as a way of understanding the development and experience of eco-citizenship. Utilising the capability approach in this context allows us to see the process and pathways towards attunement to the flourishing of the other species and the ecosystems that the pupils find themselves in relation with. However, challenges remain in accounting for both individual and collective flourishing within this conception, as such the application of capabilities to ecosystems and other complex systems remain areas for further consideration.

Discussion part 3: The role of environmental citizen science in education for sustainable development (ESD)

ESD related findings

In my analysis, I have shown that participation in environmental citizen science can contribute to the development of the capability to learn about environmental issues, and consider the impact humans can have on the environment. Across all cases the pupils were able to:

- Offer their own reflections and thoughts about environmental issues
- Demonstrate understanding of environmental knowledge
- Reflect on the impact of human activity on the environment in positive, negative and neutral terms

The formal curriculum was observed to be a consistent frame of reference for the fieldwork experiences.

The descriptions of converging and diverging organisational priorities by the adults involved reflect opportunities and challenges to the implementation and operational sustainability of school-based citizen science projects.

- Resource issues such as workload and funding challenges are shared by the citizen science providers and schools.
- The priorities of conservation practice and research can be at odds with engagement and participation activities for citizen science providers.

Education for Sustainable Development (ESD) is described by UNESCO (2020) as “born from the need for education to address growing sustainability challenges” (ibid. p. 1). Considered as an enabler and facilitator towards achieving the Sustainable Development Goals (SDG’s), ESD aims to ‘raise knowledge, awareness and action’ in order to transform and redesign our societies to “enhance resilience and preparedness for future global crises” (UNESCO, 2022, p. 4). Kopnina (2020) suggests however, that a simplistic view of using ESD to achieve the SDG’s does not account for the complexity and contradictions inherent in addressing each goal.

This study explores the opportunities and challenges of using environmental citizen science as an approach to ESD in schools. ESD can be supported in formal education settings by two differing approaches as described by Vare and Scott (2007). The first is related to a

transmissive approach where learning specific environmentally-focused content, and improvements in ‘pro-environmental behaviours’ are the measures of success. The second approach described intends to take a more holistic and critical approach to ESD, drawing particular attention to the related contradiction and dilemmas, building confidence and competence in future decision making. Wals (2011) describes the role of ‘transformative learning’ in the move towards a more sustainable world, echoing the need for young people to live with uncertainty and criticality in relation to issues of sustainability. Ollson and Gericke (2016) demonstrate an ‘adolescent dip’ in sustainability consciousness, which suggests that there is a strong need to consider approaches to ESD that meet the particular needs of this group. The focus of this research on secondary school pupils contributes to understanding the role that citizen science can play in providing ESD of the second type, which may enable to the development of eco-citizenship capabilities in this cohort, attempting to alleviate this so-called ‘adolescent dip’.

The pupils in my study were able to demonstrate the capability to learn about environmental issues while out in field study locations. School-based science education is often predominantly associated with classrooms and lab science, Stroupe and Carlone (2021) suggest that field science has the potential to expand and engage young people in disruptive practices in relation to traditionally held scientific ‘ways of knowing’. This echoes assertions by Wals et al (2014) who suggest that citizen science, as an approach to science learning, has the potential to connect science education and environmental education in a way that can “deepen the experience of the physical place of which people are part and to develop their understanding of how science works” (ibid. p. 584). Turrini et al (2018) suggest that in order to increase the transformative power of citizen science, there is a need to engage participants with the full research process. This acknowledgement that the data collection or ‘sensor’ role of participants remains only a partial insight in to scientific processes is an important step in looking towards a more collaborative community of citizen science practice in the future. Pitt et al (2019) found that collaboration between students in three different citizen science projects was an important component of the experience, which they suggest led to environmental stewardship outcomes in their study. The pupils in my research worked collaboratively, in the field, on their different projects, supporting and challenging each other throughout the experience. However, their key role could be considered predominantly as ‘data sensors’ in relation to the citizen science data collection process. This meant that they had little deep involvement in the scientific process. Expanding this role is crucial to ensuring the meaningful impact of any school-based citizen science projects.

My findings suggest that the formal education context, even when pupils are out in a ‘wild’ place, is strongly connected to (or refracted through) the citizen science experience. Jickling et al (2018) suggests that the current educational emphasis on performativity via examinations and tests serves to reduce the importance of learning that isn’t required to pass those exams. They suggest that ‘deeper learning’, that which attends to values, relationships and flourishing, is needed to help people face the challenges that our current ecological crisis demands. The authors go on to suggest that a change in the way education is experienced is necessary to engage more deeply with sustainability and the natural world. However, they acknowledge that the education system that we have is what we must work within at present. While aspirations of wider change are admirable, indeed desirable, the reality of such change seems unlikely at this particular time. Jickling et al (2018) suggest ‘wild pedagogies’ as a way of working within and with challenge to current constraints. Biesta’s (2021) ‘world-centred’ pedagogy, as described in part one of this discussion (p. 190), offers another way of approaching ESD in a more holistic way. The citizen science experiences that I observed in this research have been clearly bounded by curriculum. They were informed by a desire to pass exams, to collect data for assignments and to participate in ‘school work’. However, in the process the pupils (and their teachers) have been surprised and amazed, they have engaged with species and sensations other than themselves, and were afforded a little time and space to ‘be’ in that time and space. The very constraints that could be seen as limiting were also that which enabled the ‘event’ to take place, and in that participation is the opportunity to connect with, and be part of ‘plants, animals and the world of nature’.

Gericke et al (2020) suggest that including Education for Environmental Citizenship within secondary school subject curriculum, in particular in the younger stages, can build confidence and move towards environmental change. This potential is compromised, the authors suggest, by the disciplinary nature of the secondary curriculum. Different strengths and challenges could be identified across school, local and national scales. The authors alternative solution of Education for Environmental Citizenship as a discrete, interdisciplinary subject would require political and longer-term changes to be made that are somewhat unrealistic in the current climate. Suggestions that making citizen science a part of the curriculum pose similar challenges. Integration into formal programming would increase the visibility and open up the potential of citizen science practice for many teachers and pupils. However, making citizen science projects accessible and achievable in the current challenging school climate might result in a ‘tick-box’ approach rather than a meaningful exploration. This, I feel, would run counter to opportunities to challenge the positionality of

the learners and the teachers which were an important component of the citizen science experiences described here.

In summary, Stein et al (2022) suggest that the limits to ‘education for sustainable development’ have been reached, and instead there is a need for an alternative proposition, an “education for the end of the world as we know it” (ibid. p 275). The authors suggest that ‘re-membering’ our relationship with the world as the “larger metabolism that invariably physically, and otherwise, sustains all of us” (ibid. p. 284), whilst being disturbing and unsettling, may provide a way towards a different “way of knowing and being in the world” (ibid. p. 285). This study makes an important contribution to understanding the processes involved in engaging with environmental citizen science as an approach to ESD. In these cases, the citizen science experience elevated the science learning opportunities for the pupils, giving them the opportunity to connect science learning to eco-citizenship actions. Taking a capability approach has revealed a complex array of emerging capabilities in young people amid the presence of many important conversion factors. These factors and capabilities are likely to be relevant to other outdoor learning and ESD provision.

Limitations and personal reflections

Limitations

Participant observations

In engaging in participant observations of the citizen science fieldwork days, I was aware of the challenging nature of this data collection method. In the pilot study, I attempted to video large sections of the day, to overcome the nature of fieldnotes as a partial record of the experience. However, using video proved to be a distraction, with some of the pupils speaking directly to the camera and others noticeably avoiding it. Acknowledging that any observation will only ever be a partial representation of what happened in the event, I moved to capture as much of each day as I could without the use of the camera. As Emerson et al (2007) suggest, the observations made in the field and the subsequent fieldnotes and maps that are generated in response are a representation of the event from the perspective of the researcher. Geertz (1973) suggests that the process of writing about an event "turns it from a passing event which only exists in its own moment of occurrence, into an account, which exists in its inscription and can be reconsulted" (ibid. p. 19). I have a responsibility then, as a researcher, to rigorously reflect on what was important for me to commit to writing and what was to be omitted. In doing so I acknowledge that I can never truly capture what is important about the experience for anyone else, only my interpretation of it.

Atkinson (1992) suggests that while the observer sets the boundaries of the field under study, that these may be facilitated or constrained by the participants and gatekeepers. Having a part in the activity, a history with the project(s), undoubtedly made accessing the field easier for me than for a 'new' face. This meant, however that I came to the field with prior experience and assumptions of what to expect. It was crucial for me to acknowledge and challenge these throughout the events and activities. Evans (2012) suggests that a limitation of participant observation is the "numerous roles the researcher is require to play" (ibid. p. 170). This was absolutely the case for me, even though I had no prior knowledge of the participants involved, I share a career history with many of the scientists. So, in coming to the fieldwork days, I was familiar with many of the field study sites, and with the activities planned. In some of the sessions, I led and supported groups to complete their tasks. Having previously been the teacher on sessions just like these, it was not possible for me to erase that identity in the sessions that I was observing. In order to minimise the impact of this, I employed multiple methods of data collection, including note writing, audio description and

on-site messy maps. As described in situational analysis (Clarke et al, 2012), I ensured that I was present in all the messy maps and consistently reflected on my experience and role in the situation.

Identification (or not) of capabilities

In applying the capability approach to my research, I became aware of the debate around the generation of a capability set or list. In his approach, Sen does not use lists, rather suggesting that "each application […] will always require a selection of valuable functionings that fits the purpose" (Robeyns, 2017, p. 172). Nussbaum, however, proposed what she defined as the "ten central human capabilities" (Nussbaum, 2006, p. 76 – 78). More recently, Walshe et al (2022) created a list of eco-capabilities that echoes Nussbaum's list but is expanded to include capabilities attuned to nature practice. For me, creating a list of capabilities feels like assigning learning objectives. They are necessary in planning what is to be 'learned' in a lesson, however, in reality, being required to measure something against an objective or a list often results in the performativity of that list. I am prompted to question whether this reduces flexibility and freedom of the approach, or does it mean that it might be more widely accepted as it is easy to use? Voget-Kleschin (2013) suggests that using Sen's approach "necessitates a higher amount of additional substantial decisions" (ibid. p 496) in relation to the complex nature of sustainable development, and as such makes it more difficult to use in a functional way. The application of the capability approach was useful in this study as the evidence that I gathered in the field connected both to supporting the development of Nussbaum's central capabilities, but also to developing capabilities unique to the citizen science experience (and subsequently to each individual young person). Walshe et al (2020) propose the conception of eco-capabilities, "how children define what is important to them, particularly in terms of environmental sustainability, social justice and future economic wellbeing (i.e., the three pillars of sustainability)" (Walshe et al, 2020, p. 349). My study found that the experiences that the pupils gained through their participation in citizen science activities supported the development of the 'other species' capability. Additionally, there were a series of eco-citizenship capabilities that were unique to this experience that were identified. The development of situation specific eco-citizenship capabilities compared with supporting the development of an existing, external list of 'central' capabilities is an important area for future research in understanding the potential of the capability approach in environmental education.

Personal reflection

Using situational analysis

As a newcomer to new-materialist approaches to research, situational analysis (Clarke et al, 2018) offered a method in which the necessary emersion in the messy, complicated and unpredictable 'data' could be undertaken in a structured and sensitive manner. Coming to use situational analysis was born from my interest in the empirically-based emphasis of grounded theory (Glaser and Strauss, 1967). Drawing on pragmatist roots, the evolution of constructivist grounded theory towards situational analysis resonates strongly with my own experience of research. Clarke et al's (2018) approach reflects the multiple perspectives that I am interested in making palpable in my research and also the explicit consideration of the non-human elements present in a given 'situation'.

As described in detail in the methodology (p. 82), situational analysis involves the production of three types of map; situational, social worlds and positional maps. The messy and relational maps involved in producing situational maps were very successful in my experience. Producing these maps was an easy and flexible way to immerse myself in the empirical data I was collecting (and was part of). Engaging in this process throughout the data collection events enabled me to reflect and (re)consider what I believed to be important in the situation. The biggest challenge in these maps was my feeling of a gap between what I could see on the map and how I could express this clearly in relation to my research intention. Using the idea of a 'sensitising concept' enabled me to return to my research intention with relative ease, though this at times felt counter to the ideas of sensing and re-turning that I was exploring through new-materialist approaches. The need to have the researcher within the maps consistently reminded me to maintain a reflexive stance, I was/am a part of the research, not an external observer.

The social worlds map, described by Clarke et al (2005) as mapping "sites of action" (ibid. p. 86) in my experience was an effective tool to explore the arenas that I was beginning to identify as important in my research. The relationship between the relational maps and the arenas/social worlds maps was initially challenging, but the process was effective in drawing my attention to missing or less well articulated parts of the data. Like den Outer et al (2013) and Mills et al (2006), I found constructing the positional maps particularly challenging. The 'positions' of interest in the data were not immediately clear, it took time and a consistent re-turning to the data to identify and articulate a relationship that I felt warranted further exploration. Once I had this, however, the value of the positional map became apparent. In identifying and manipulating 'positions', I was able to ask deeper questions of the

relationship between the concepts of ‘contribution’ and ‘care’ as they were explicated in my analysis. I was also prompted to consider the positions that were absent in my particular data set, and the potential implications of this in relation to citizen science experiences for school pupils.

Situational analysis is an emerging research approach that has been explored a little in environmental and educational research (den Outer et al, 2013; Ruck and Mannion, 2018 for example). The synergy between this analytical approach and new-materialist sensitivities is one that I feel warrants further development and exploration.

Researching with young people and my role as a teacher-researcher

The young people in this research were involved as a result of their teacher selecting to use citizen science in their lessons/activities. This raises questions for me about the nature of ethics in working with young people in school settings where the power to agree or disagree with an action is not easily taken by them. Throughout all stages of this research, approval processes were followed and consent discussed regularly, the pupils assured that participation was voluntary. However, as the experiences were included within science or geography lessons, it would have been difficult for them to ‘opt out’, this draws attention for me to the challenges of engaging in ‘voluntary’ research within ‘compulsory’ settings. Additionally, it is important for me to fully acknowledge that the young people involved here were absolutely participants, they were not involved in the development processes of my research at any stage. Going forward, for me, I would like to think that there is an opportunity to engage young people more deeply in the process of research which speaks to the more collaborative and co-created approaches to environmental citizen science practice. Lee (2022) describes a dialogic approach taken to research with children that she felt recognised the dynamic and unique interactions between researcher and young participants. In developing a more dialogic approach to my relationship with the young people involved, I am prompted to reflect that the research included within this thesis answers *my* questions. I am left wondering what would be the questions that the pupils involved would ask, and how could we answer them together?

It is important to reflect also on my own positionality in relation to this study. My engagement with citizen science and eco-citizenship has come about through my experiences as a science teacher. As such, this affects my worldview and my perspective on the participants, their experiences, and the meanings that I have made in response to their contributions (Berger, 2015). Situational Analysis (Clarke et al, 2012) asks that reflexivity is a key component of the mapping and analytical relations between the researcher and the other

elements on the maps. The authors suggest that noticing where and why certain aspects cause a personal reaction, e.g. excitement or surprise, is a vital part of the process and "not some external 'noise' or bias" (Clarke et al, 2012, p. 354). With this in mind, my research was framed in a manner that would prioritise the educational potential of environmental citizen science, as experienced by the pupils in this particular study, rather than looking to overtly critique the field(s) of eco-citizenship or environmental citizen science more widely. My desire to communicate my findings to teachers and citizen science practitioners working with schools also informed the direction of my research. Reflecting on aspects of the citizen science experience that would be relevant and actionable in the school context whilst also considering the conflicting aspects of eco-citizenship as a personal and a political concept is an example of where self-reflection on my role and experiences as a teacher-researcher was particularly important to undertake.

Section 2: Conclusions, implications and future recommendations

In this chapter, conclusions relating to each of my research questions will be drawn. Following this, some implications for citizen science practice in schools, and future directions for further research will be suggested.

Conclusions

Research question 1

> *What contribution is made by citizen science fieldwork experiences in curriculum-based environmental citizen science to support eco-citizenship capabilities?*

The capability to learn about environmental issues and consider the impact humans can have on the environment.

This was supported by opportunities for pupils to demonstrate their understanding of environmental concepts and issues. The pupils were encouraged, by teachers, scientists and peers, to reflect on human activity on the environment during their fieldwork encounters. Offering their own thoughts and reflections on environmental issues demonstrated the important role of citizen science experiences in making space for these important conversations and reflections.

The capability to sense, analyse and reflect on environmental issues using scientific enquiry skills.

This was supported by opportunities for pupils to engage in authentic scientific enquiry. The importance of collecting, analysing and recording data accurately was emphasised throughout the citizen science activities. By engaging in citizen science practice, the pupils were able to participate in practical, relevant and realistic experiences, which showed them a different perspective to the scientific enquiry than is typically experienced in school science classes.

The capability to learn collaboratively, through shared experiences and meaning-making with the environment alongside peers and adults.

This was supported by opportunities for pupils to work together to solve problems in an authentic situation. Teachers and scientists were able to collaborate and support each other to enhance the learning experience for pupils. Emphasising the importance of collaboration in scientific enquiry enabled the participants to engage with the citizen science activities as a relational encounter, challenging the isolationist perspectives of science and science learning.

Research question 2

> *What contribution is made by more-than-human encounters in environmental citizen science to support eco-citizenship capabilities?*

Place-responsive experiences

Being reciprocally responsive through place-based encounters within the environmental citizen science fieldwork experience can afford pupils the opportunity to think about and consider their impact on the environment in a more meaningful way than can be afforded in a traditional classroom setting. Unfamiliar landscapes may be more memorable, however more familiar or local landscapes may prompt deeper thought and hold greater meaning for the participants. The ability of citizen science projects to be adapted to different locations and landscapes affords significant flexibility in their use.

Intra-actions with other species

Raising awareness and reducing fear of other species can contribute to positive experiences for participating pupils. The persistence of this in their affective and memory related responses suggests that this engagement can support the eco-citizenship capability of living with concern for plants, animals and the world of nature (Nussbaum, 2011).

Possibility of change as a result of the citizen science experience

The entanglements of the pupils 'becoming with' the fieldwork locations and experiencing new ways of looking at plants, animals and the natural world supports the capability to have attachments to things and people outside ourselves (Nussbaum, 2011).

Creative responses

Utilising the experience of citizen science projects to encourage pupils to look at their surroundings in different ways provided them with different viewpoints and perspectives. This experience can open up space for pupils to be creative and 'play' in the natural world, with the possibility of increasing the connectedness that they feel towards it.

My analysis suggests that environmental citizen science experiences have the potential to change the way the participants relate to plants, animals and the world of nature by;

- Increasing their awareness of it
- Increasing their awareness of the human impact on it
- Reducing their fear of it

However, for pupils who already have a high level of affinity with plants, animals and the world of nature, or those with greater experience, the impact of the projects were limited.

Therefore, the eco-citizenship capability of ‘Being able to live with concern for and in relation to animals, plants, and the world of nature’ (Nussbaum, 2011, p. 34), can be supported by school-based environmental citizen science experiences. This is of particular importance for pupils whose relationship with environmental issues is mediated predominantly by their school experiences.

Research question 3

> *What conversion factors contribute to the development of eco-citizenship capabilities in young people’s experience of environmental citizen science in schools?*

The pupils involved in my research reported high levels of self-efficacy in relation to environmental action. This suggests that they have confidence in their ability to contribute to positive actions for the environment. The lack of difference between the self-efficacy levels across the citizen science projects (and none) also suggests that, for these pupils who all participate in environmental or scientific subjects through their formal school experience, the nature of the citizen science experience did not inspire a radical change for them.

Citizen science experiences were not identified directly as ‘conversion factors’ (Robeyns, 2017) by the young people involved in this research. Environmental, social and personal conversion factors were, however, recognised and reported in my observations of the pupils engaged in the citizen science activities, and in their reflections and responses. These include, physical and sensory encounters, working with others and caring for the environment. While the short-term, single encounter with citizen science, as experienced here, could not be shown to move the pupils towards more public actions such as campaigning and protest, the nurturing of eco-citizenship capabilities can begin with relational, sensory and affective experiences. Environmental citizen science affords young people opportunities that can be a springboard towards authentic eco-citizenship actions and dispositions.

Implications

A key element of challenge in integrating citizen science projects into schools is the competition for time and resources with attainment and exam related activities. The recommendations in the Scottish Government (2023) report propose a move towards ‘Project Learning’ and a ‘Personal Pathway’ as an approach to qualifications and assessment in Scotland going forward. Citizen science, as experienced by the young people in this research offers a starting point to consider ways of integrating project learning into the school experience. Not only did the experiences described here connect the pupils to key

scientific and environmental challenges, but they were able to respond to more-than-human encounters in both familiar and remote locations. The capability to find joy and delight in the more-than-human encounters, in particular those in relation to animals such as snakes and lizards brings to the fore the concept of 'biophilia'. This is defined as "the innate human tendency to be fascinated by Nature and in some circumstances to become emotionally affiliated with it" (Barbiero et al, 2021, p. 2). Barbiero et al (2021) identify a connection between school environments that have been designed to explicitly stimulate biophilia, and improved school performance (in a four-year longitudinal study in a primary school setting). The improvement was attributed in part to the 'improved capacity to recover from mental fatigue' as a result of spending time continuously immersed in nature. While citizen science projects such as that experienced in this research do not offer the opportunity to 'continuously' immerse pupils in nature. They do, however, offer an achievable option to spending time, with purpose, in nature, that if replicated regularly may move towards the improved school performances that could contribute to a radical change in the approach to education, assessment and qualification in Scotland.

In attempting to describe the experiences of citizen science participants, Lorke et al (2021) identify five types of engagement observed as part of a bioblitz experience (exploring, observing, identifying organisms, documenting, and recording). Drawing on participant narratives, Dunkley (2023) identifies similar stages of engagement (encountering, recognising, identification, development and enactment of response-ability, and enhanced ecological kinship), terming these 'interconnected phases' (ibid. p. 4) in relation to a 'more-than-human muddle'. Through my research it is possible to identify these engagement types/phases as experienced via school settings, for example, the reduced fear and increased awareness of other species described is as result of observing, identifying and encountering these species. Noting the low level of 'reporting' behaviours from Lorke et al (2021) and the importance placed by teachers and scientists in my study on the 'contribution' component of citizen science for young people, there are implications for practice going forward to improve (or move away from) this element of citizen science. My research contributes to these debates by highlighting the different perspectives of the adults and young people involved.

In bringing together a case-study approach with orientations towards more-than-human encounters, this research offers a unique methodological perspective. Drawing the theoretical positions of lived (green) citizenship (Kallio, Wood and Halki, 2020) and the capability approach (Sen, 1980, Nussbaum, 2011, Robeyns, 2017, etc) into the direct experiences of pupils via the mapping approach of situational analysis (Clarke et al, 2018),

the view of the participants was deeply considered. This enabled tensions in the expectations, educational intentions, and political motivations to be identified and further explored. This research contributes to a deeper understanding of the unique experiences of young people participating in citizen science experiences as part of their schooling, adding to the work of Lorke et al (2021), Dunkley (2023) and others in this field.

Recommendations

Making connections

The use of environmental citizen science as a resource for schools is viable and valuable. It affords authentic (environmental) science and citizenship learning opportunities and can provide an opportunity to engage with place-responsive pedagogies. This should be communicated to schools through appropriate professional networks and support provided for further engagement.

The need to connect and engage with the formal curriculum is clearly vital for school-based citizen science. This is somewhat different to the learning outcomes and aspirations of citizen science projects in general where the 'learning' relates specifically to the scientific topic or component, for example the accurate identification of bird/invertebrate species (Jordan et al, 2012). As such, awareness of the potential connections to formal curriculum is beneficial for citizen science projects which aim to have a high level of engagement with school groups. Taking this further, engagement of teachers and other educational professionals in the initiation and early development of citizen science projects may facilitate projects which can extend and deepen the learning experiences provided and undertaken in and through school settings.

Communication and collaboration

Clear signposting should be used to communicate with schools about the connections between the citizen science experience and the potential contribution that can be made to eco-citizenship capabilities. The findings included in my research represent a starting point for this. Ongoing collaborative work with citizen science providers and schools should provide relevant routes for this. Achieving a balance between the formal and less formal learning experiences afforded by the experience is an issue that both citizen science practitioners and teachers need to work more closely on. Greater collaboration between schools, including pupils, and citizen science providers should be encouraged in order to develop environmental citizen science resources in manner that more fully meets the needs of all parties.

Evidence and accountability

When engaging in school-based citizen science activities, schools (via the teachers and scientists involved) should look to develop ways of attuning to the more-than-human possibilities inherent in the experience. This should include allowing time for time for creativity and play across all stages, but would be particularly valuable in the 'high-stakes' senior phase. Policy makers, curriculum designers and assessment decision-makers would be well placed to develop a method of evidencing non-traditional experiences like those that were valued by the young people in this study. This is particularly relevant where there is significant pressure not to spend too long away from formal exam structures.

Future research

Application of the capability approach

My research successfully applied the capability approach to young people's experience of environmental citizen science. There is an opportunity to apply this approach more widely, building an understanding of the power of personal, social, and environmental conversion factors across environmental and science education. Ballet et al (2013) argue that the capability approach can be used as an evaluative framework for ecological justice, in particular in representations of the complex relationships between nature and humans. Reflecting on this, and my experience of using the capability approach with young people, there is undoubtedly potential to more fully explore the application of conversion factors in environmental education research. Research can also continue to potentially discern other capabilities needed to help us re-orient and improve our relations with the environment in the time of the Anthropocene.

More-than-human encounters

More-than-human encounters were shown to be important and memorable to the pupils in my study. In particular, the impact of interactions with other living things, insects and invertebrates for example, was strongly positive. The physical and sensory experiences were reflected upon less strongly by my participants. The development of methodologies to more fully understand and illuminate these experiences would enable educators to make better use of citizen science and related environmental fieldwork. In building place-responsive, sensory and embodied opportunities for young people, their relationship to, and with the natural world can be strengthened. Further research into the mechanisms and

duration of these positive effects would help to build a deeper understanding of the impact and potential of encounters with other species.

Children's eco-citizenship

The pupils involved in this research were mostly those with an existing interest in science or the environment. Going forward, it is important to consider the experiences of pupils who have not had the opportunity, or the inclination to act on concerns around environmental issues. There is a need to more fully understanding the democratising potential of education and environmental citizen science collaborations and their power to enact meaningful change in young peoples' relationship with the world around them, with particular emphasis on those pupils who would not choose to engage in environmental activities beyond their school experience. Research is needed to explore new forms of partnership working between communities and schools in delivering on active approaches to eco-citizenship pedagogies.

There is a need for a fuller theorisation of eco-citizenship in children and young people, particularly from the perspective of the young people themselves. The application of lived (eco) citizenship dimensions in my study was a useful starting point towards this. Utilising visual and participatory methods with young people has the potential to more fully explore the wider experiences and perspectives of young people's development of eco-citizenship.

Overtly political environmental education was shown in my study to be a sensitive topic in school settings, with both teachers and pupils expressing reservations about acts such as protest and campaigning. Hayward (2020), among others, reflect on the presence of the Fridays For Future (FFF) movement and related youth activism. There is a need to further explore the affordances of school settings in political environmental education, from a multi-disciplinary, eco-justice perspective. Research is also needed to explore and discern the frameworks needed in curriculum making in support of eco-citizenship.

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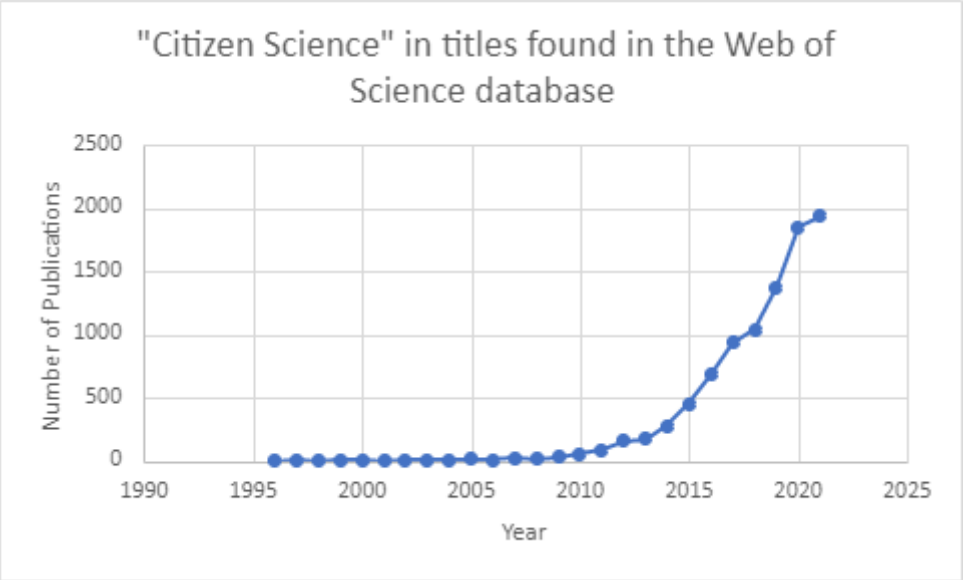
Appendices

Appendix 1: Web of Science Search

A search of the 'Web of Science' database for the term 'Citizen Science' was conducted on the 24th August 2022. The results are as follows:



Appendix 2: Ethical Approval

General University Ethics Panel (GUEP)
University of Stirling
Stirling
FK9 4LA
Scotland UK

E: GUEP@stir.ac.uk

Claire Ramjan
Faculty of Social Sciences
University of Stirling
Stirling
FK9 4LA

13th March 2019

Dear Claire,

Re: Ethics Application: Citizen Science for Environmental Citizenship: How do different approaches to school-based citizen science support environmental citizenship? GUEP 608 (576 R)

Thank you for making the requested revisions to your submission of the above to the General University Ethics Panel. The ethical approaches of this project have now been approved by GUEP.

Please note that should any of your proposal change, a further submission (amendment) to GUEP will be necessary.

Please ensure that your research complies with the University of Stirling policy on storage of research data which is available at:
https://www.stir.ac.uk/about/faculties-and-services/information-services-and-library/current-students-and-staff/researchers/research-data/plan-and-design/our-policy/

If you have not already done so, I would also strongly encourage you to complete the Research Integrity training which is available at: https://canvas.stir.ac.uk/enroll/CJ43KW

If you have any further queries, please do not hesitate to contact the Committee by email to guep@stir.ac.uk.

Good luck with your research.

Yours sincerely,

Katie Hamilton

p.p. On behalf of GUEP
Dr William Munro
Deputy Chair of GUEP

Appendix 3: Example pupil participant information sheet

PhD research project

Citizen Science for Environmental Citizenship

Who am I?

I am Claire Ramjan, a researcher from the University of Stirling. I am interested in finding out about how Citizen Science can affect young people's relationship with the environment.

What am I researching?

I would like to understand what you think and talk about during and after a Citizen Science lesson and if that affects your views on environmental issues.

Why?

Citizen Science is a particular way of doing practical activities in science. It involves working with scientists or taking part in real scientific projects.

I want to find out if this way of doing science can help pupils to understand and do something about big environmental issues (like climate change).

What would I like you to do?

Be part of a citizen science fieldwork lesson, this will be at the MICCI data collection site. Just act as you would normally in a practical science lesson and I will watch the things that you do and listen to the things that you talk about.

I'd also like you to take part in a workshop to discuss the lesson with me in small groups after we have finished the lesson.

What do you need to know?

I might video record the fieldwork, but only with your permission. No-one except me will watch the recording. I will watch the recording to see what you do and to hear what you talk about during the lesson. I will make notes to describe the things that you do and say, and then I will destroy the video.

I will take a sound recording of the workshop, I will listen to the recording and write down what you say and then I will destroy the recording. No-one except me will listen to the recording.

I will also take photos during the fieldwork lesson that we will use in the workshop afterwards, these images will be destroyed after the discussion. If I want to use these images in the final report, I will ask your permission to do this.

What say and do will be written in a report. This will be anonymous and I will not use your name in the report. Because I will ask you questions in a group, you might be able to recognise the things that you said, or that the others in your group said during the research.

If you tell me anything that involves concerns about yourself or anyone else, I will have to follow school procedures and report the concern.

I will tell you about my findings after the report is written. Other researchers and organisations that pay for research might be interested in the things that you have said. I will ask for your permission to share this information. If I share this research you will not be able to be identified in anything that is shared.

Do I have to take part?

No. You do not have to take part.

If you do decide to take part, you can withdraw your participation at any time without needing to explain and without penalty by advising me or my supervisor of this decision. You can also withdraw your data before January 2021 if you wish to.

You will be given this information sheet to keep and be asked to sign a consent form.

Contact:

If you would like to discuss the research with someone please contact me at Claire.ramjan@stir.ac.uk, or my PhD supervisor; Dr Greg Mannion at greg.mannion@stir.ac.uk.

You have the right to lodge a complaint against the University regarding data protection issues with the Information Commissioner's Office (https://ico.org.uk/concerns/).

You will be given a copy of this information sheet to keep.

Thank you for your participation.

Appendix 4: Data collection instrument (pupils) example

Citizen Science Data Collection

Focus Group Questions

Reflections on 2 of Nussbaum's capabilities:

1. Being able to live with concern for and relation to animals, plants and the world of nature.
2. Being able to form a conception of the good and engage in critical reflection about the planning of one's life.

Questions:

1. Using this image to help you, can you talk to me about whether and how the citizen science experience you have just participated in might have in some way change the way you connect with animals, plants or the world of nature? (select as appropriate to the citizen science experience)
    a. Prompts include: what was new to you, what had you seen before, what was surprising, how did you feel about the species/landscape, what were you thinking about during the encounter?
2. Can you describe what you learned or what the scientific process helped you to understand in relation to the animals, plants and world of nature (select as appropriate to the citizen science experience)
    a. Prompts include: Exploring the what and how the change was made possible. How did you find out about xx, was it easy to do this, what did you agree/disagree about, what did you know about xx before, how has that changed now, what will you tell others about xx after this?
3. In relation to (this citizen science topic) can you suggest what the best possible impact of the research would be?
    a. Prompts include: what does an ideal xx look like, have you ever seen this, what is xx like in other places (where you live/have visited?), what about an example of really bad xx, how is it different from here?
4. Thinking about your own life, has this experience led you to think, feel or act in a new way in relation to (this citizen science topic) and what you might do in the future?
    a. Prompts include; what do you already do about xx, will you change anything, do you think these changes will make a difference, why, what will you tell others about xx, do you think xx is more important to you now that before the citizen science experience?
5. And what might you do in the future?

Citizen Science and the Environment

Answer the following 3 questions as honestly as you can, you can discuss the questions but please respond individually.

Q1. After participating in this Citizen Science project, please indicate how much you **DISAGREE** or **AGREE** with each of the following statements by circling the number in the appropriate column. Please respond as you really feel, rather than how you think "most people" feel.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel confident in my ability to help protect the planet.	1	2	3	4	5
I am capable of making a positive impact on the environment.	1	2	3	4	5
I am able to help take care of nature.	1	2	3	4	5
I believe I can contribute to solutions to environmental problems by my actions.	1	2	3	4	5
I believe that I personally, working with others, can help solve environmental issues.	1	2	3	4	5

Q2. Complete the following sentences.

1. Participating in this Citizen Science project made me think about ……

2. Participating in this Citizen Science project made me feel ……

3. The most memorable part of the fieldwork day was ……

4. The most important thing I will take away from this experience is ……

Q3. Answer the following question, give as much or as little detail as you would like.

Has the way you think or feel about animals, plants and the natural world changed while you participated in this Citizen Science project?

Tell my about why, or why not, and in what ways this Citizen Science experience has contributed to any changes.

Appendix 5: Data Source Table

Data Source	**Data type**	**Analytical Treatment**						
		Numerical analysis	*Thematic analysis*	*Messy Map*	*Relational Map Stage 1*	*Relational Map Stage 2*	*Social Worlds Map*	*Positional Map*
Participant Observations	Fieldnotes			Each event had a messy map created	Components of each messy map were selected and combined into a relational map.		Components of the relational maps were use to contribute to the SW map	Components of the relational maps were extracted and contributed to the positional map
Survey	Self-efficacy scale	Calculated self-efficacy score of each participant. This was averaged for each case (and the no CS group)	Self-efficacy responses were subjected to a thematic analysis. The lived citizenship dimensions were used as a thematic lens.			A relational map was created which combined the self-efficacy data, lived citizenship dimensions and conversion factors.		
	Think about	Proportion of codes across cases was calculated for comparison	Inductive codes were identified.	Messy maps were created including the identified codes across	Relational maps were created contrasting the identified			Identified codes relating to 'contribution' were reflected

					codes across the CS cases.			in the positional map
	Feel	Proportion of codes across cases was calculated for comparison	Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			Identified codes relating to 'care' were reflected in the positional map
	Most Memorable	Proportion of codes across cases was calculated for comparison	Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			
	Most important	Proportion of codes across cases was calculated for comparison	Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			
	Did the CS experience change your relationship with a, p & nw	Calculation of the number, and proportion of 'Yes' and 'No' responses across each case	Reasons given were inductively coded		Relational maps were created contrasting the identified codes across the CS cases.			
	Conversion Factors	Numerical analysis of the	Participant suggestions of		The identified codes were			

		researcher-provided conversion factors. These were summed and calculated for both the CS and non-CS participants.	conversion factors were inductively coded.		subjected to a relational mapping exercise applying the personal, social and environmental conversion factor categories.			
Focus Groups	Good for the environment		Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			
	A, p & nw		Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			
	Best outcomes		Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			

	Environmental citizenship terms		Responses were analysed against the provided environmental citizenship terms.		Relational maps were created contrasting the identified codes across the CS cases.			
Interviews	Experiences		Inductive codes were identified.				The identified codes were used to contribute to the SW map.	
	Opportunities		Inductive codes were identified.				The identified codes were used to contribute to the SW map.	
	Challenges		Inductive codes were identified.				The identified codes were used to contribute to the SW map.	
	Environmental citizenship reflections		Inductive codes were identified.		Relational maps were created contrasting the identified codes across the CS cases.			

Appendix 6: Worked example of data analysis.

Following the Soil Fertility Legacies project, the following mapping process is an example of how the data collected was analysed across the different cases in this research project. At the end of the fieldwork day, the messy map below (fig. 34) was produced. I used observations from the field in the form of fieldnotes, audio recordings and personal reflections to create this.

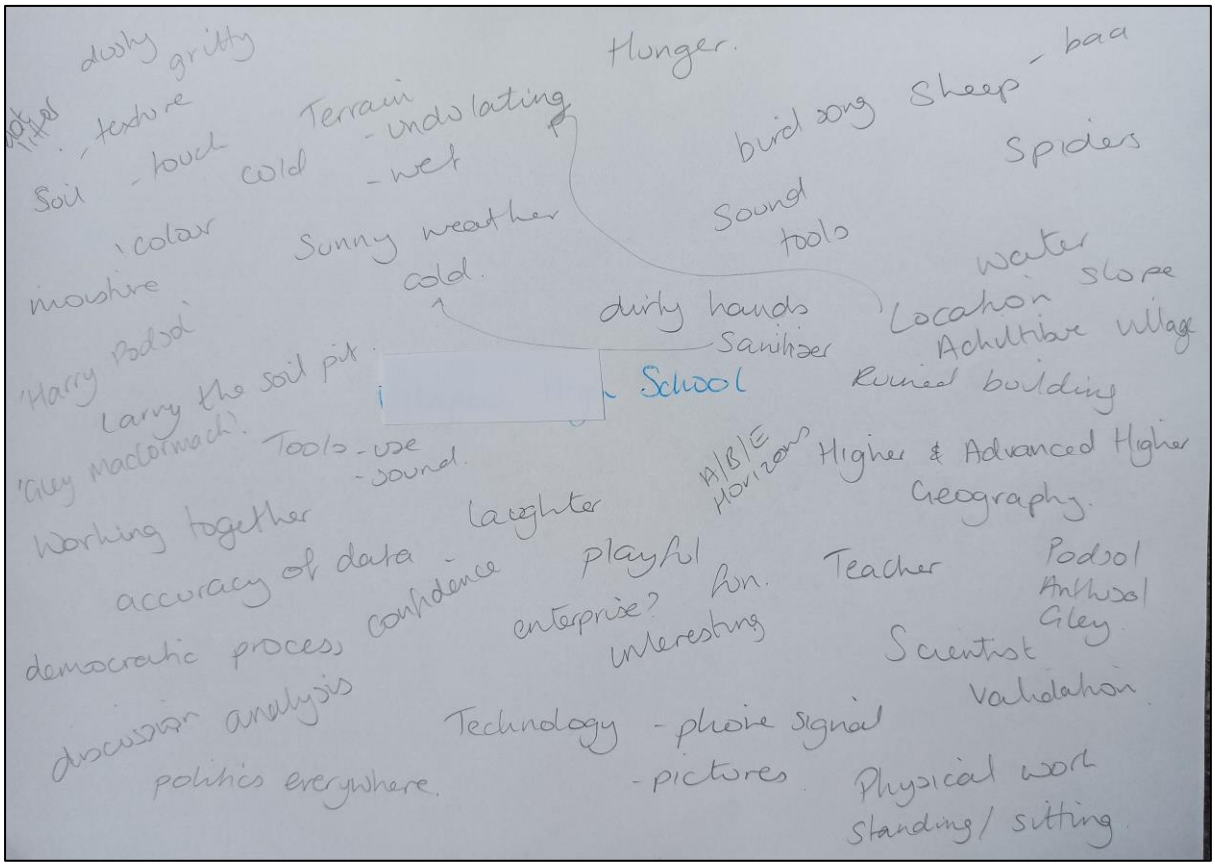


Figure 34: Soil Fertility Legacies Messy Map Example

The pencil map was then transcribed into the digital programme 'Scapple' (fig. 35). This transcription process was an opportunity to 'wallow' in the data and begin to reflect on the important elements of the data to me. Questions, ideas, thoughts, and other relevant information were recorded in a memo after each interaction with the data. An example of an analytic memo can be found in appendix 7.

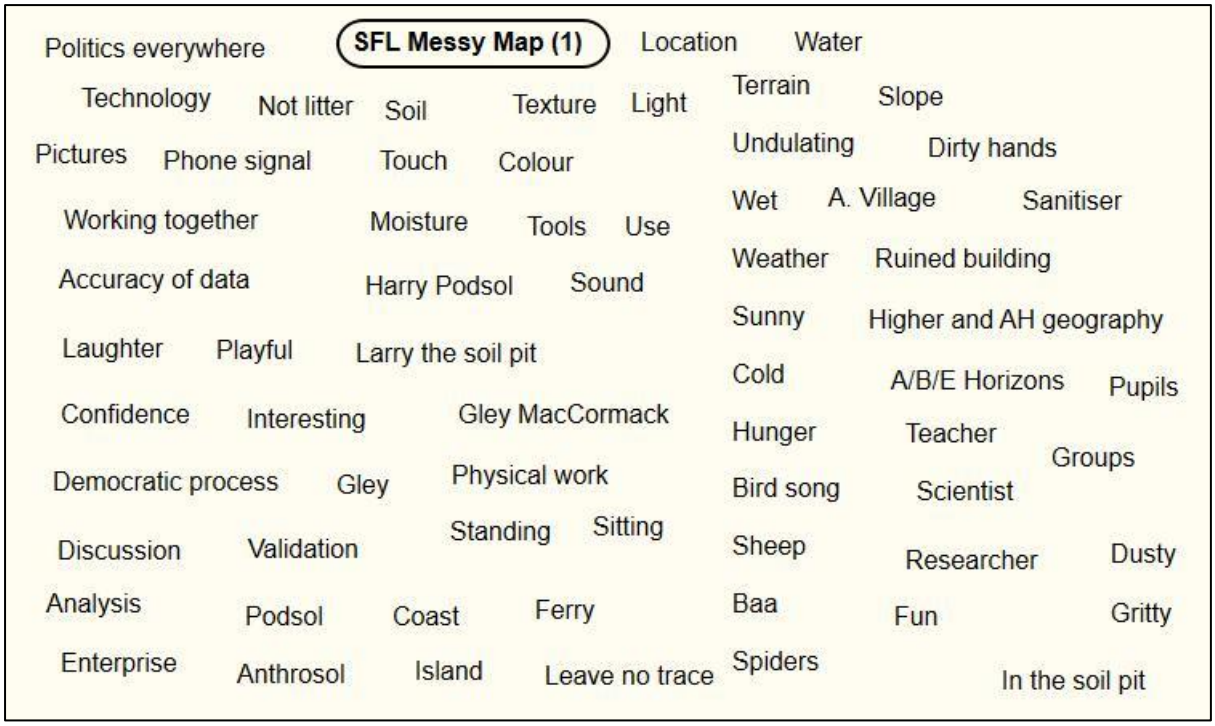


Figure 35: SFL Transcribed Messy Map

The various elements of the messy map were then considered in relation with and to the other elements of the map. This relational mapping process asks that you focus on one element and consider it in relation to the other elements on the map. Identifying connections that are relevant the research questions are key here and the positionality of me as researcher was particularly important to remain aware of. Analytic memo-ing takes place by asking questions of the relations, noting ideas and conceptual or theoretical links. Below are two examples of this stage, however, this was repeated many times until the I was satisfied that the data had been exhausted. Two examples of these relational maps can be found below (fig. 36 and 37).

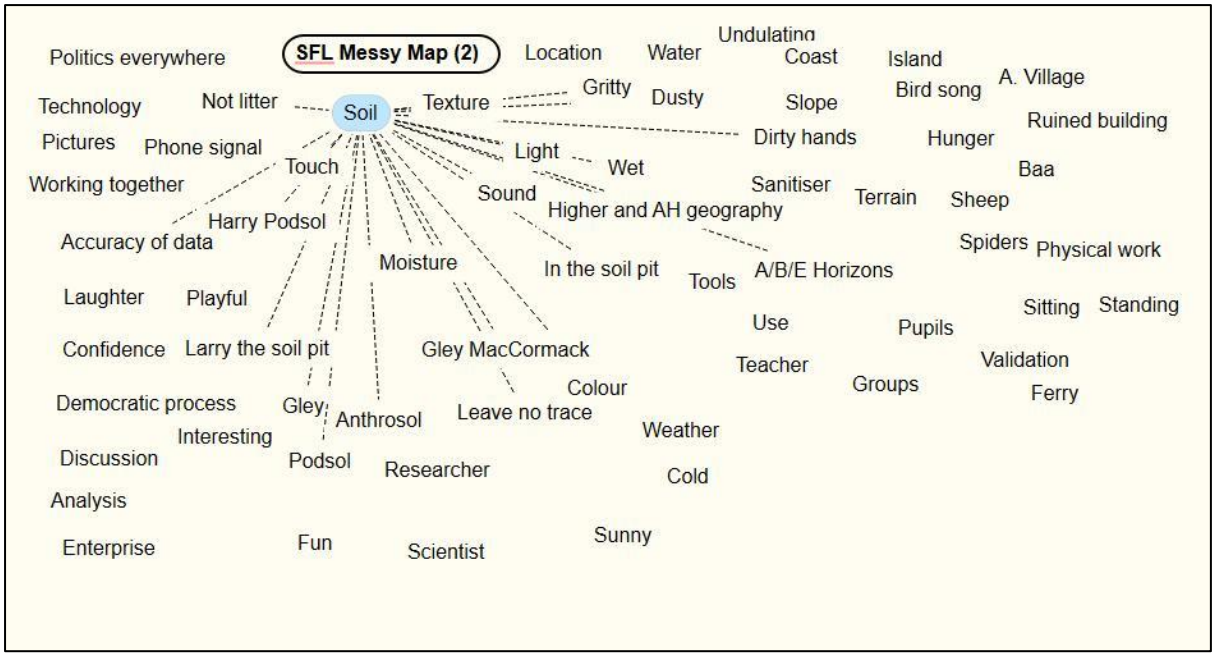


Figure 36: SFL Relational Map (Soil)

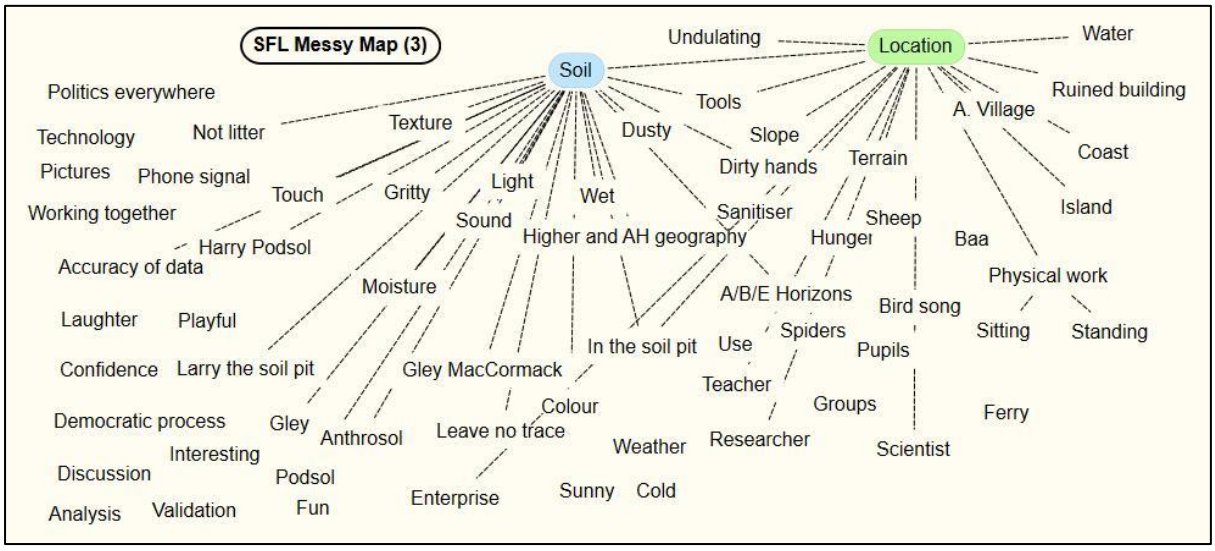


Figure 37: SFL Relational Map (Soil and Location)

As a result of the relational mapping and the memo-ing that went alongside it, a number of themes were identified within this particular data set. The map below (fig. 38) shows the identified themes for the Soil Fertility Legacies project as a result of my observations of the fieldwork day.

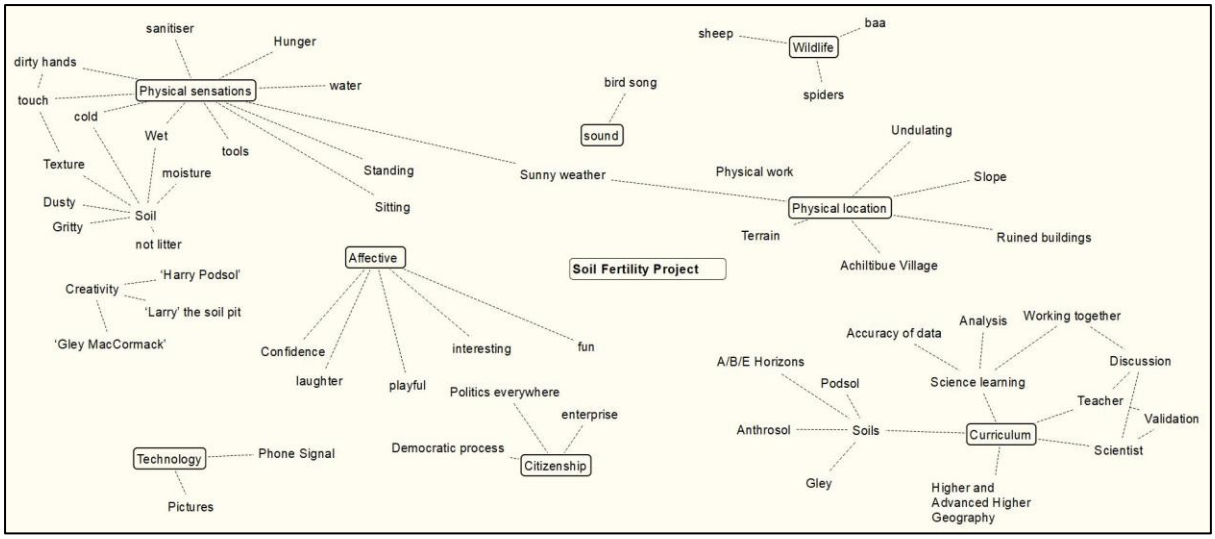


Figure 38: SFL Fieldwork Day Identified Themes

This process was repeated for each of the data sets produced as a result of the survey responses, focus group discussions and individual interviews. The map below (fig. 39) shows the responses from the Soil Fertility Legacies pupils to the sentence stem 'Participating in this Citizen Science project made me think about …'.

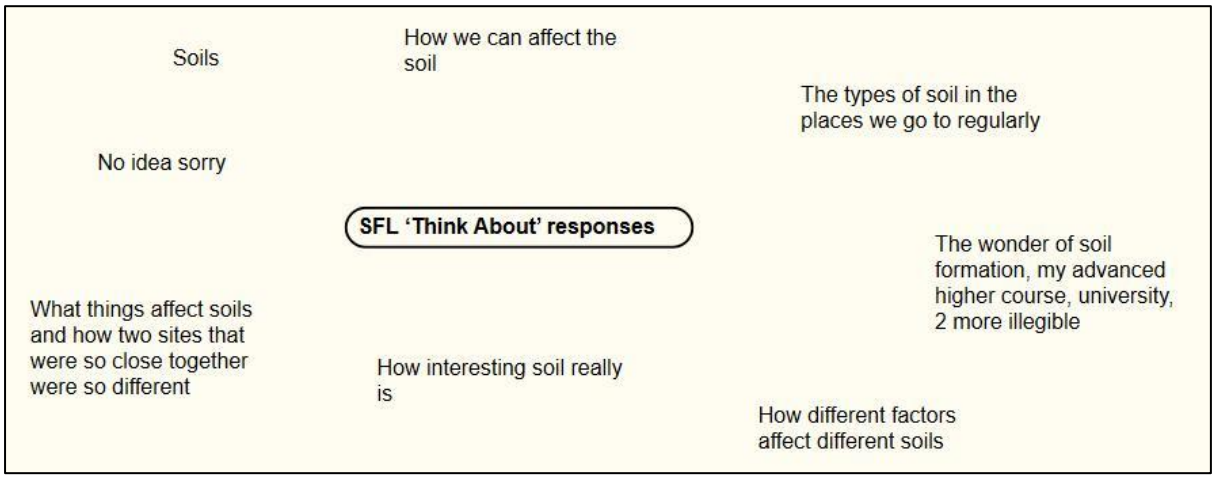


Figure 39: SFL 'Think About' survey responses

Themes in relation to this data were identified, as below (fig. 40).

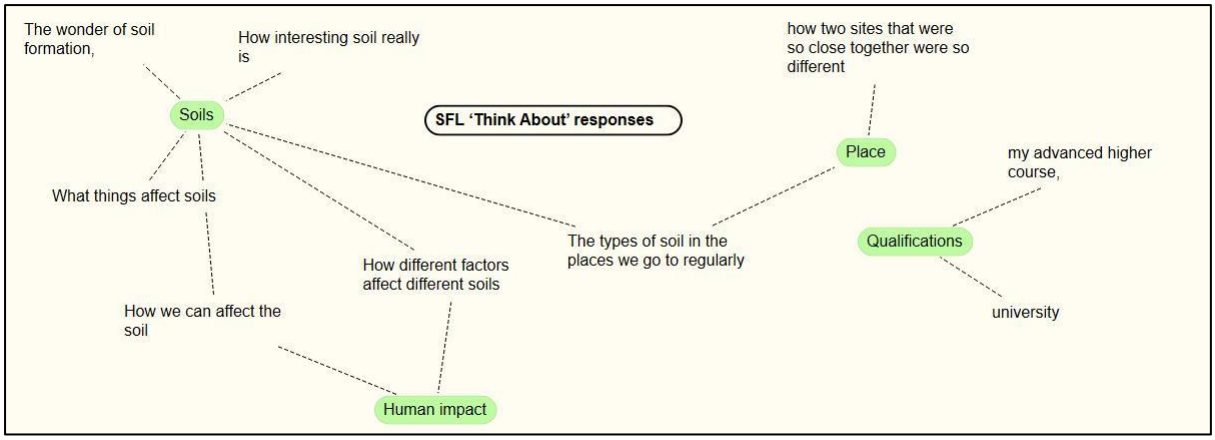


Figure 40: SFL Themed 'Think About' responses

Once each data set had been completely mapped, a summary of the complete case was assembled into a relational map. The example below (fig. 41) shows the complete case map for the Soil Fertility Legacies project.

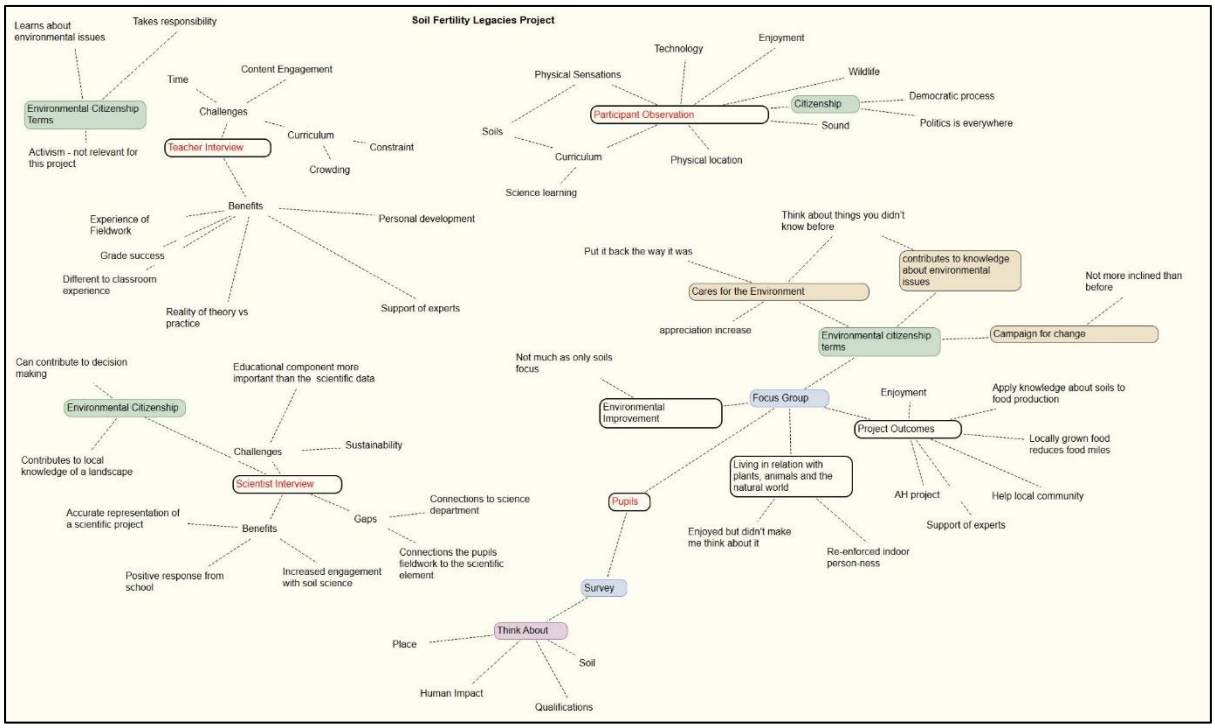


Figure 41: SFL Complete case map

For selected data, a cross case comparison was undertaken. In these maps, the themes in relation to each case were identified and the relations across the cases explored. The example below (fig. 42) shows the comparison of responses to the 'think about' question STEM across all three cases. This enabled the convergences and divergences in the pupil experiences to be drawn out and considered across the three citizen science experiences.

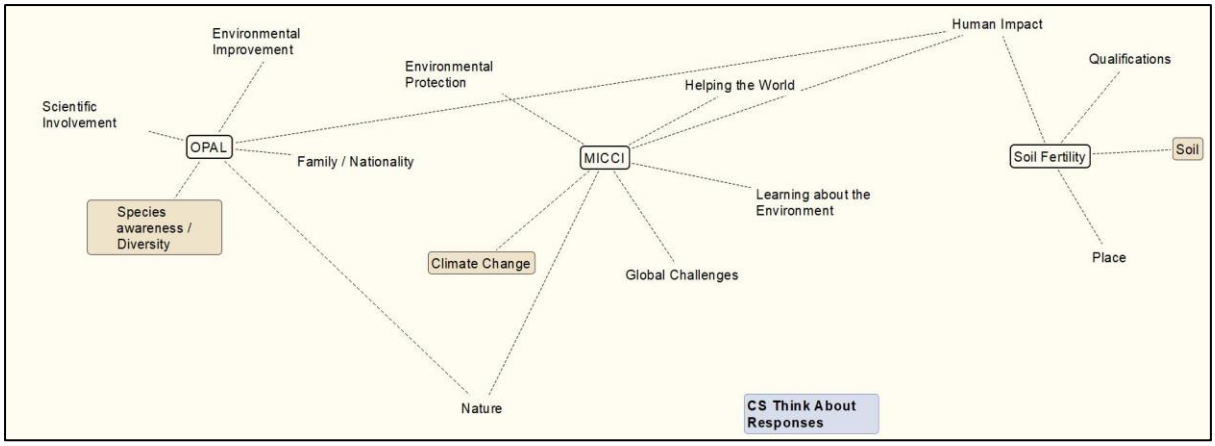


Figure 42: Cross case comparison of 'think about' response themes

The final stage of the relational mapping was to apply the selected theoretical frame(s) to data sets from each case. The example below (fig. 43) shows the relational map of the SFL fieldwork day with the conversion factors and lived citizenship domains applied to the data.

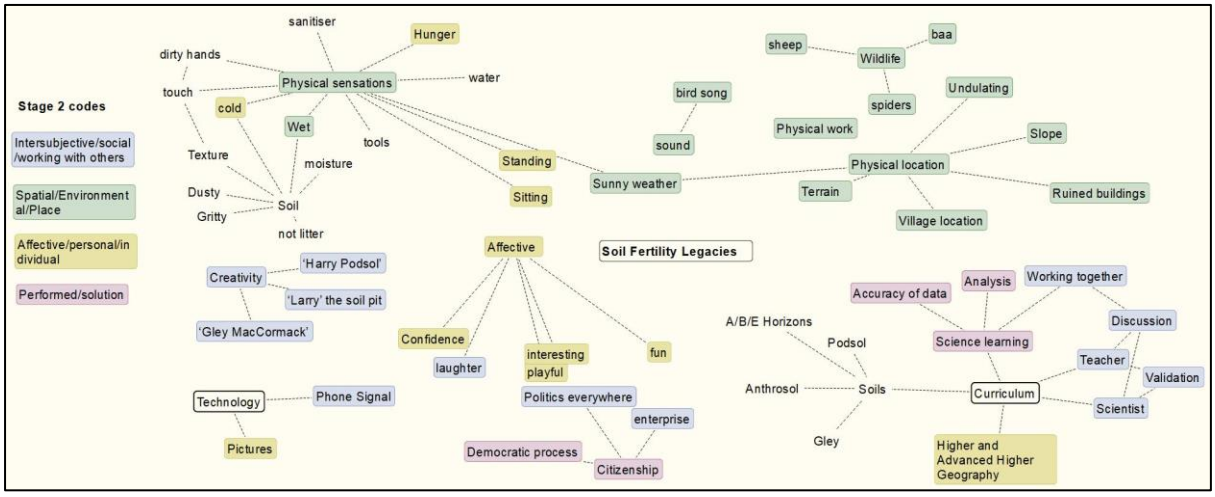


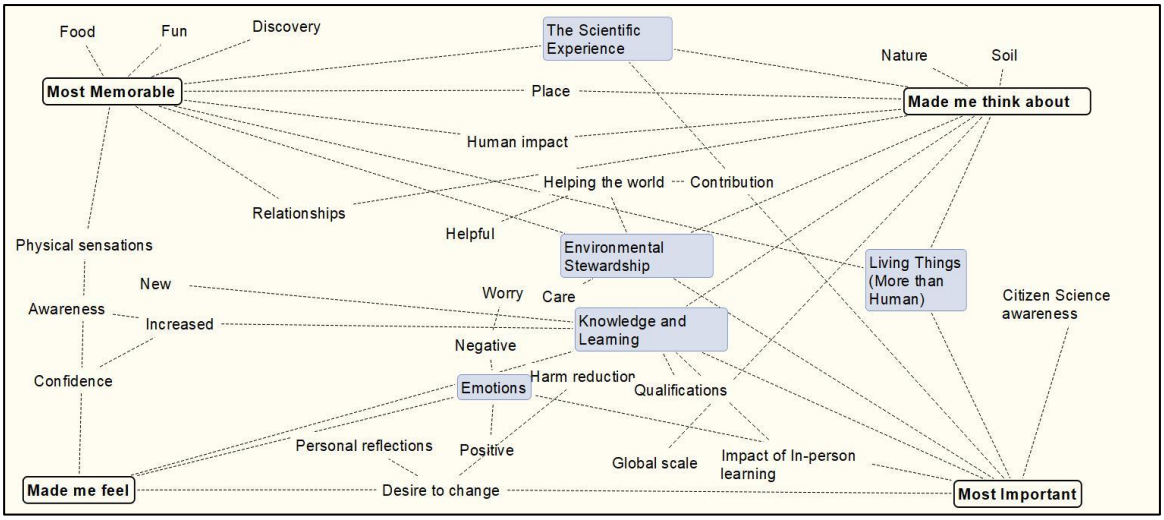
Figure 43: SFL project map with theoretical application

This process of systematically working through the elements of the different data sets enabled a deep engagement with the data. Acknowledging that the memos associated with each map are inherently 'partial and tentative' (Clarke et al, 2018, p. 140), the maps and their memos acted as provocations to thoughtfully consider the relations between the different cases, experiences and places associated with each citizen science project.

Appendix 7: Example analytical memo

Memo: Question STEMs messy and relational map

26th June 2021



Six key themes can be identified from the pupil's reflections on their fieldwork experience, these are:

1. Desire to change
2. More than human experiences
3. Environmental stewardship
4. Learning and Knowledge
5. The scientific experience
6. Emotions

Are these capabilities, conversion factors or functionings? I think that these can be connected to the conversion factors of the later survey, however writing these sections may enable the identification of capabilities that can be realised during the CS experience.

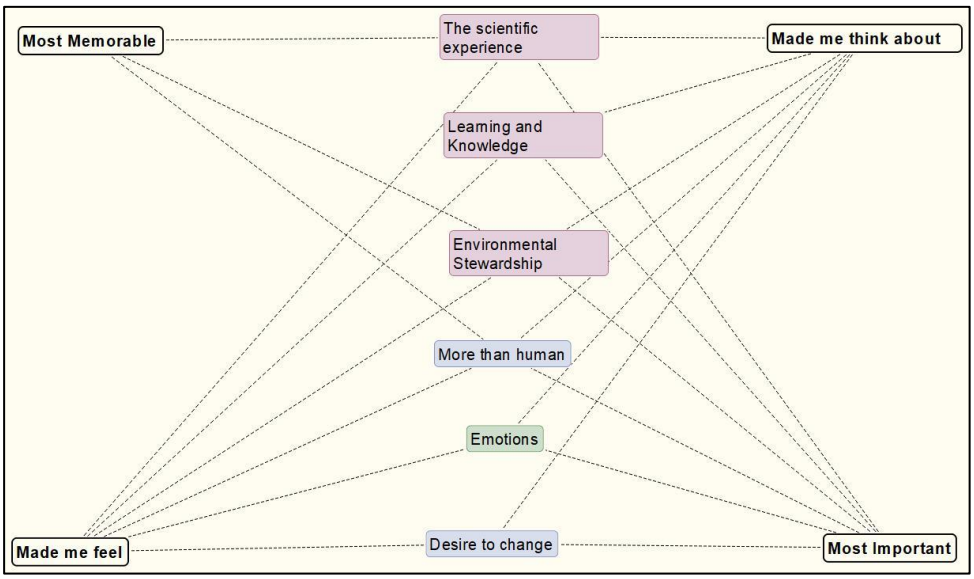
From each theme, I need to include:

- which response it came from and where appropriate, which was missing
- what it might mean, connections to relevant literature (is this here or in the discussion?)
- include quotes relating to each part,
- highlight the similarities and differences between the cases
- bring it together to suggest what it does mean for environmental citizenship capabilities.

Also make links to the environmental citizenship literature

Do the citizenship domains as defined by Kallio et al, work as a theoretical frame for this?

- spatial: the temporal and national context, this is described in their age and where they live, “the mundane spatio-temporalities of everyday life”, the messiness of daily life and the intersections between public and private.
- interpersonal: relationships with peers, family and un-named others (gender, race and class should be discussed here)
- performed: “acts of citizenship”
- affective elements: emotional aspects such as ‘care’ or ‘concern.



More-than-human Interactions

This was reflected in the responses to all four sentence stems.

It connects to the relationship between the pupils and the more-than-human elements that they engaged with on the day. This includes; living things, the place and the nature of that location, the wider concepts that may have been provoked by the experience.

Think About:

The wonder of soil formation (SFL pupil)

The environment (MICCI pupil)

Peat (MICCI pupil)

Wildlife and insects in particular (OPAL pupil)

All the different species that surround us (OPAL pupil)

All three cases make these connections, but they are all connected more or less strongly to the content of the case, soils/peat/insects. Drawing attention to the more than human, rather than just expecting young people to see it for themselves.

Feel:

More comfortable with the species that surround us (OPAL pupil)

Only OPAL participants mentioned the more-than-human in relation to 'feel'.

Most Important:

Nature is filled with loads of hidden species (OPAL pupil)

watch out for bogs in the grass (SFL pupil)

Don't touch caterpillars unless you want dirty hands (MICCI pupil)

Most Memorable:

Searching under rocks, the most interesting and colourful insects (OPAL pupil)

Bouncing on the bog (MICCI pupil)

When I found a frog (MICCI pupil)

The water in site 2 from groundwater flow and how it built up in the soil pit (SFL pupil)

This theme is really strongly connected to the think about, most important and most memorable sentence stems, suggesting that it is a really important theme, but that the connection to emotions was perhaps less clear to the pupils.

Local places were also mentioned within this theme.

This connects to the spatial element of Wood and Kallio's conception.

Also connect this to new-materialist ideas of relational nature (Haraway possibly)

The fieldwork experience could be considered a conversion factor, in drawing attention to the more-than-human may be a step towards developing a positive relationship with it, and seeing themselves as part of it rather than separate.

Desire to change (and awareness of human impact)

This was reflected in the responses to three of the four sentence stems,

It connects to the affective domain in relation to desire, but also the performed, 'acts' of citizenship, in that there is a new or deepened awareness of the need for change in their own lives, and the lives of others. There is no way of knowing whether these changes will happen, but the desire is there. There was an increase in awareness of the impact of humans on the natural world (is this the correct place for these ideas or does the title need to change to take this into account)?

Think about:

How the planet is changing and how I can help (MICCI pupil)

How we can affect the soil (SFL pupil)

Feel:

I should start to recycle more (OPAL pupil)

Most Important:

I need to change my way of living to be more sustainable and help the wildlife (OPAL pupil)

Like I should be contributing more to help solve environmental issues (OPAL pupil)

These connect strongly with Dobson's concepts of individual action for common good.

But this can also be challenged by considering Dimick's position which suggests that there are significant challenges with this conception of individual responsibility.

Bringing awareness of human impact into this theme might give the opportunity to bring the individual and public spheres together, connecting with the spatial aspects that Wood and Kallio describe.

Each case is represented in this theme, MICCI and OPAL more-so, but SFL is represented.

The scientific experience

This relates strongly to the performed dimension but raises questions about the relationship between the scientific experience and environmental citizenship.

Connect this to Jenkins paper on contributions to scientific decision making and critical thinking.

Think:

The importance of getting involved with the scientific community (OPAL pupil)

Only OPAL responded to this in think about, the emphasis in the OPAL study was on evaluating techniques for use in further study, so this may have influenced the importance of this element.

Feel:

Useful as my data is actually getting used (OPAL pupil)

I was helping a good cause and contributing to scientific research (MICCI pupil)

More included in something big that could help in the future (SFL pupil)

Most memorable:

Using new equipment and learning new techniques (OPAL pupil)

Measuring the amount of peat (MICCI pupil)

Taking the dirt samples (SFL pupil)

Most Important:

The results that the data gave us. (MICCI pupil)

How to go about doing soil data gathering techniques (SLF pupil)

The idea of a citizen project, I didn't know they existed (OPAL pupil)

The scientific elements, including data collection techniques, processing and analysing the data and being able to understand the results are referred to in all the cases. particularly

interesting for the citizen science element is the strong connection between the science and the contribution that is reflected in the 'feel' responses.

This is the only reference to citizen science directly in these contributions.

Learning and Knowledge

This can be considered as an element of the 'performed' conception, and possibly has element of the spatial in it as well as it is contextual to the school experience, this is not a voluntary or family event, but framed by formal schooling.

Connect this to the wider environmental citizenship in schools literature and the relationship between science learning and the environment.

Think about:

my advanced higher course, university (SFL pupil)

How privileged we are, learning about the environment (MICCI pupil)

Feel:

I have learned how to improve the environment around me (OPAL pupil)

Hopeful for my assessment and study (SFL pupil)

Most memorable: Not present in the pupil reflections

Most Important:

Knowledge on soil fieldwork and raw data for my assignment (SFL pupil)

Knowledge of peat (MICCI pupil)

Stagnern (pupil spelling) moss helps with the environment, it soaks up water and contains antiseptic qualities. (MICCI pupil)

Measuring the trees because not only does it help you with science but it helps you with maths and measuring (OPAL pupil)

There are strong connections here to the school curriculum, with assesments, courses and assignments mentioned.

Some learning around the environment and the particular species encountered was evident.

Environmental Stewardship

The ideas of caring for, protecting and looking after the environment are all reflected upon here. This connects with the performed dimension, or the acts of citizenship, however again the true nature of this care is self-reported rather than observed.

Think about:

The importance of conserving species (OPAL pupil)

How we can protect the planet and nature (MICCI pupil)

Feel:

I need to help other people respect the environment (MICCI)

We should put more effort into helping these species survive and not destroy their habitats (OPAL)

Most Memorable:

making sure they (the insects) *are not harmed* (OPAL pupil)

Most important:

There are many species in the wild that need help protecting (OPAL pupil)

To look after things (MICCI pupil)

There is an anthropocentric view of nature in many of these statements, with I and we commonly used.

Connect to Tidball and Krasny's cnceptions of stewardship practices and also Phillips et al.

Emotions

Connects to the affective domain of Wood and Kallio, can be both posisitve and negative, connected to the environment, place and the other people involved. There are some potentially interpersonal elements to be considered here too.

Think about:

The wonder of soil formation (SFL pupil) Tenuous??

Feel:

uncomfortable and scared of the bugs (OPAL pupil)

Happy and in peace as well as feeling that I was learning a lot of new things and was coming across new, unknown species (OPAL pupil)

Worried about the effects of climate change and my future (MICCI pupil)

Excited to learn about the environment (MICCI pupil)

Concerned but hopeful (MICCI pupil)

Good to know more about the soil (SFL)

Most Important:

I can't do much about the world (MICCI pupil)

I am still worried about climate change (MICCI pupil)

Xxx doesn't like to be buried alive in the soil pit. (SFL pupil) contrasts with *When two of my peers tried to bury me alive* in most memorable responses.

Positive emotional reactions include fun, joy, happiness, hope and determination. These connect to the affective impact of the experience to stimulate positive connections to the environment.

This contrasts with the negative emotions described, including; worry, concern, hopelessness, fear. These connect strongly to eco-anxiety (find texts to support this concept)

Do the positive outweigh the negative? Do a count and suggest why? Does the citizen science experience give an example of a thing that can be done to help, which may go some way to alleviating the sense of hopelessness in some young people.