



Becoming 'Wild Citizens': Children's Articulation of Environmental Citizenship in the Context of Biodiversity Loss

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Abstract

Calls to tackle the global disasters of climate change and loss of biodiversity are becoming more and more prominent and urgent. Such calls require environmental citizens, that is citizens who act at local, national and transnational scales, assuming environmental agency through pro-environmental behaviours, attitudes and values in public and private spheres. To enable children to become active environmental citizens, we collaborated with five inner city primary schools in the south-east of England in co-designing a school-based, outdoor 'Wild Citizens' programme, underpinned by socioscientific inquiry-based learning, focusing on biodiversity loss. Approximately 130 primary school children (6–10 years old) explored their school grounds, discussed, decided on, and implemented interventions to enhance biodiversity, and communicated their findings within their community (schools, peers, parents, teachers). Semi-structured group interviews were conducted with a sub-sample (60%) exploring how children articulate environmental citizenship within this context. We found that environmental citizenship was articulated at both local and global scales of influence in relation to (a) environmental awareness, (b) values and (c) action competence. Children articulate the links between their performed actions to the impact these might have at a global scale, showing their ability to conceptualise and discuss implications and consequences of issues such as biodiversity loss in simple terms. Their articulation of actions as *relevant* and *impactful* to their school's grounds, transforms the issue of biodiversity loss from a slow, invisible disaster to an observable phenomenon for children, which they then act to mitigate against. This work provides empirical grounding towards the operationalisation of environmental citizenship at the primary school level in the context of a less discussed, but as urgent, ecological disaster, that of biodiversity loss.

Keywords Environmental citizenship · Primary science education · Socioscientific inquiry-based learning · Action competence · Citizenship-as-practice

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1 Introduction

Calls to tackle the global disasters of climate change and loss of biodiversity are becoming more and more prominent and urgent (Bencze et al., 2020; SDSN & IEEP, 2019; WWF, 2022). The most recent Living Planet Report (WWF, 2022) calls for urgent and collective action to protect our environment. Such action to support mitigation and adaptation as a response to the climate change crisis within society requires environmental citizens; that is, citizens able to take action at local, national and transnational levels and to assume environmental agency through pro-environmental behaviours, attitudes and values (ENEC, 2018; van Harskamp et al., 2022). This need for environmental citizenship and action also requires, and demands, a more ‘eco-reflexive’ science education (Sjöström et al., 2016) that aims at social transformation as well as learning the content and processes of scientific practice (Valladares, 2021).

The need for science education for citizenship has been discussed for more than two decades (e.g., Ratcliffe & Grace, 2003; Kolstø, 2001, 2008), yet, now more than ever before, we need to consider and adopt a more critical perspective on science education, its aims and outcomes. Science education in the Anthropocene needs to refocus its emphasis on ‘science-for-citizenship’ and within that, allow students to become critical, and *responsible* citizens (European Commission, 2015; Kolstø, 2001; Herman et al. 2022). The framework for PISA 2025 (OECD, 2023) embraces this change in direction for science education, and now includes competencies such as ‘research, evaluate and use scientific information for decision making and action’ (p.16) and a focus on ‘agency in the Anthropocene’ (p.49) such as more eco-centric values towards nature, and a strengthening self-efficacy in relation to actions taken to mitigate issues such as climate change and biodiversity loss. Current UK policy changes also now emphasise and promote environmental sustainability through recent initiatives such as the National Education Nature Park project, a crucial component of the Department for Education’s Sustainability and Climate Change strategy (DFE, 2022), which sets out to ‘engage children and young people with the natural world’, ‘directly involve them in measuring and improving biodiversity in their nursery, school, college or university’, and ‘help reinforce their connection with nature’.

This study focuses on an education for environmental citizenship programme using biodiversity loss as the socioscientific context, implemented with children in inner city schools in the south of England. Our aim was to develop and implement a practical and realistic approach in primary education and to investigate what environmental citizenship can look like within school settings, through children’s articulation of it. The research question guiding this study is: *How is environmental citizenship articulated by primary school children taking part in an educational programme addressing biodiversity loss?*

2 Biodiversity Loss as a Slow Disaster

Biodiversity loss is the socioscientific issue (SSI) addressed in the present study, within a wider disasters education approach. An SSI is an issue which has a basis in science and has a potentially large impact on society (Ratcliffe & Grace, 2003). In recent years, disasters education is emerging as an interdisciplinary field that can be advanced and help advance science education for responsible citizenship (Park, 2020). The reciprocal relationship of science and disasters education is illustrated when environmental and global challenges

arise as a result of natural, technological or human-made disasters such as climate change and extreme weather phenomena (Park et al., 2023); these challenges are often considered within a science education context as SSIs. A recent review of SSI-based research shows that the key SSIs explored within science education research in the last 20 years include predominantly environmental issues as well as prevention and emergency issues related to natural disasters (Ban & Mahmud, 2023). Framing disasters as SSIs and within SSI-based education can provide a space for considering the societal, political, cultural and scientific dimensions of disaster-related issues and bridge the gap previously identified (Park et al., 2023) between curriculum subjects (e.g., through science and environmental studies) and disaster-related issues.

Environmental disasters arise at different levels (local, national, global) and different temporal scales (e.g., slow disasters) and this can have different implications for how they can be addressed as SSIs. For example, current biodiversity loss is generally a slow-onset event impacted by anthropogenic climate change and other, more direct, human activity (Caro et al., 2022) over a period of time involving a series of gradual transformations that can lead to irreversible impact (Schafer et al., 2021; UNFCCC, 2012). The slow temporal nature of biodiversity loss is a key characteristic that needs to be considered in educational approaches that support learning about and mitigating this SSI. Most environmental challenges, such as climate change and biodiversity loss, are not directly apparent or visible to humans (Väliverronen & Hellsten, 2002). Selby and Kagawa (2013, p.5) warn that the 'stealthy and invisible' nature of climate change makes individuals prone to just put this threat easily aside. Similarly, biodiversity loss and conservation efforts to mitigate it often occupy a space between 'visibility and invisibility', especially when focusing on species close to extinction (McCorristine & Adams, 2020, p.103). Bjaerke (2019) discusses how communicating biodiversity loss through animal examples that evoke emotions, values and cultural associations can make biodiversity loss visible to the public as both a cultural issue and an environmental issue, and by extension as an SSI. This is important to consider within educational approaches at the primary education level; younger children would not have been exposed to 'slow' environmental changes over time as adults might have been, so they would not have been able to visualise, and observe, this change.

The temporal nature of biodiversity loss as a slow environmental/ecological disaster requires a pedagogical approach that makes this issue an observable phenomenon for the children. Hamlin and Richardson (2022) point out the need to make biodiversity more visible if we are to encourage nature connectedness and pro-conservation actions; their study on 'visible garden biodiversity' however was conducted based on an analysis of data from young people and adults (16–93 year olds). A recent study by Montgomery et al. (2022) with 509 UK primary school children taking part in weekly nature engagement sessions within their school grounds found that children in their intervention group initially were able to identify more easily wildlife which was already available to them, compared to the end of the study, pointing out the importance of exposing children to different species so that they become more visible to them.

The extent of biodiversity loss as an environmental disaster at a global level is best illustrated and summarised in the WWF 2022 Living Planet Report, which warns that wildlife populations have plummeted by 69% on average since the 1970s (WWF, 2022), and it calls for collective action to mitigate this disaster. At a national scale, agricultural management, habitat loss, overexploitation and climate change are major drivers of biodiversity changes in the UK (Burns et al., 2016; Caro et al., 2022). In the UK, 97% of wild meadows since the 1930s have disappeared (Natural England, 2020), and almost one in six species are now threatened with extinction (Burns et al., 2023).

Understanding what influences pro-environmental behaviours is crucial in developing such behaviours and supporting agency (Cheng & Monroe, 2012) to address issues such as biodiversity loss through science education and environmental education. Connection to nature is one aspect to consider as a precursor to environmental citizenship and pro-environmental behaviours, and evidence shows that nature connectedness is more strongly associated with pro-environmental behaviours compared to environmental knowledge (Otto & Pensini, 2017); if children do not feel connected to nature, then their actions will not reflect an interest in protecting the environment. Cheng and Monroe (2012) report that children's connection to nature influences their intention to participate in nature-based activities in the future. Similarly, Harvey et al. (2020) reported sustained significant benefits to children's mood and wellbeing resulting from a biodiversity-focussed outdoor learning programme for primary school children. Spending time outdoors as a child is important for developing and carrying into adulthood environmentally responsible behaviours (Evans et al., 2018). This body of work points out the necessity of engaging young children in active, outdoors activities so as to support them in developing such environmentally responsible behaviours in their formative years, and through educational approaches that can enable them to become active environmental citizens.

3 Socioscientific Inquiry-Based Learning as a Means Towards Environmental Citizenship

Environmental citizenship entails the ability to take action at local, national and transnational scales and to assume environmental agency through pro-environmental behaviours, attitudes and values in the public and private sphere (ENEC, 2018; Hadjichambis et al., 2020). Within this conceptualisation of environmental citizenship, there is a focus on the collective good, rather than just focusing on individualised, self-interested behaviours (Dobson, 2007), to cultivate and strengthen individuals' commitment to act for environmental protection within their communities. Mackey (2012) argues that when the rights of young children are respected and their voices heard, then they are enabled to become active environmental citizens.

Promoting environmental citizenship in young people, including children, requires a conceptualisation of 'citizenship-as-practice' (Lawy & Biesta, 2006, p.37) rather than 'citizenship-as-achievement' or citizenship-as-outcome (Biesta et al., 2009). According to Lawy and Biesta (2006) citizenship-as-practice focuses on 'developing and nurturing the social and critical capabilities of young people' (p. 39) in an inclusive manner where all voice, participation and agency is valued from all community members, not only adults. Conversely, 'citizenship-as-achievement', which emphasises the learning of citizenship skills and knowledge to be implemented as future citizens of their society, implies that young people are 'not-yet-citizens', removing children's potential agency and voice from citizenship action and practice. Adopting a citizenship-as-practice approach to science and environmental education requires educational approaches that will enable young people to participate actively and responsibly within their social settings to address issues such as socio-environmental challenges (Kolstø, 2008; Kowasch et al., 2021), taking into account children's voice, and how they articulate and experience dimensions of environmental citizenship in their social contexts (Lawy & Biesta, 2006).

A pedagogical framework within science education for fostering environmental citizenship is socioscientific inquiry-based learning (SSIBL), which focuses on teaching and learning science for citizenship and action, through three stages: (a) ASK — placing learning within socioscientific issues (SSI) contexts, (b) FIND OUT — employing inquiry-based learning and (c) ACT — requiring learners to take meaningful action as a result of their learning (Ariza et al., 2021; Levinson, 2018). These three stages are implemented in educational settings with an overall objective of considering and aiming for the responsible research and innovation (RRI) principles of ethical responsibility, social desirability and sustainability (Levinson, 2018; Levinson and the PARRISE consortium, 2017) extending previously formulated SSI-based approaches such as STEPWISE (Bencze, 2017).

When SSIBL is focusing on socio-environmental issues such as climate change or biodiversity loss, then SSIBL becomes a pedagogical approach that supports young people's development of environmental citizenship and agency towards mitigating current unsustainable processes (van Harskamp et al., 2022). A key dimension of SSIBL that separates it from other SSI-based education approaches is its tripartite conceptualisation of inquiry, which places explicit emphasis on *social* and *personal* inquiries along with *scientific* inquiry, supporting learners to understand the links between scientific knowledge and their personal and social experiences (Knippels & van Harskamp, 2018; Levinson, 2022). This conceptualisation of socioscientific inquiry as 'socially responsible inquiry' (Amos & Christodoulou, 2018) underpinned by RRI principles adds to previously established approaches to SSI-based education (Ratcliffe & Grace, 2003; Sadler et al., 2007) and is consistent with Vision III of scientific literacy, as agency-oriented, socially-just science education (Sjöström & Eilks, 2018).

SSIBL emphasises action, that is, putting into practice and utilising the knowledge and skills developed during the learning process to not only identify solutions to issues but also to take action to mitigate or address these issues by implementing the identified solutions. The resulting action taken by learners in SSIBL can have a social justice orientation similar to that in the STEPWISE programme (Bencze, 2017). The emphasis on action is initiated from the start of the learning process (ASK stage) focusing on 'emergence' of issues (Ariza et al., 2021; Levinson, 2022) and the problematisation of knowledge, which can help bring forth the controversial and uncertain nature of SSIs and thus the need for further investigation, learning, and action (Levinson, 2018; Morin et al., 2014). Sass et al. (2020a) provide a conceptualisation of 'action competence' as consisting of three key domains: (a) knowledge and skills of the issue and action possibilities (b) willingness, commitment and passion to contribute to action, and (c) self-efficacy, with a focus on confidence in one's own influencing possibilities and in one's own skills and capacities for change. Action is embedded in the SSIBL framework supporting learners to take ownership of their learning by becoming active agents of change for their local communities, teaching them about content knowledge and also about how to be active citizens (Amos & Christodoulou, 2018).

Education for environmental citizenship at the primary school level should address the key areas of environmental awareness, environmental knowledge, communication, critical thinking and creativity skills, and values such as responsibility, justice and equity (Monte & Reis, 2021). Emphasising action within learning environments is also essential given the current global environmental challenges (Sass et al., 2020b). However, students' knowledge of possible actions to address socio-environmental issues such as biodiversity loss can be low, and thus educational approaches that enable young people to take effective action within 'their reality' are needed (de Freitas et al., 2023) in promoting environmental citizenship.

Recent empirical research on learning using SSIBL in socio-environmental contexts at the secondary school level has revealed positive impacts on students' learning outcomes (Georgiou & Kyza, 2023) and on the use of SSIBL as a way of promoting secondary school students' environmental citizenship (van Harskamp et al., 2021, 2022). However, although some SSI-based education studies are emerging within the primary education phase (e.g., Evagorou 2011; Zangori et al., 2020), there are no studies yet reported that explore the use of SSIBL as a means towards environmental citizenship within primary education. Equally, there is a need to reorientate children's agency at the time of the Anthropocene (Kouppanou, 2020) to consider what agency children can attain, and to listen to children's voice and their articulation of environmental citizenship (Davis, 2009) to better understand what this looks like in practice for children (Schild, 2016). Our focus in this study on the articulation of dimensions of environmental citizenship by children contributes towards Davis' (2009) and Schild's (2016) recommendations. Valuing and enabling children's articulation of dimensions of environmental citizenship through their experiences is a key aspect of responsible citizenship education (McLeod, 2011) and can help us understand children's experiences and how to support the development of their environmental citizenship through appropriate educational approaches. This study is an empirical exploration of this under-researched area by focusing on primary school children's articulation of environmental citizenship whilst participating in the 'Wild Citizens' programme, underpinned by SSIBL.

4 Study Context

'Wild Citizens' is a biodiversity enhancement educational programme for primary school children co-designed and implemented with primary school teachers, local government ecologists and educators, university student interns with specialisms in Ecology, Biodiversity, Environmental Sciences or Education, and science education researchers. During the Wild Citizens programme, primary school children follow the steps of the underpinning SSIBL pedagogical framework shown in Fig. 1. The approach also models the process of creating and implementing a basic Biodiversity Action Plan (BAP), which includes recording what species/groups of living things are present in the school grounds at the start, deciding how to enhance biodiversity and what to prioritise, and creating a timeline for implementing the BAP. To make the issues directly relevant to children within this

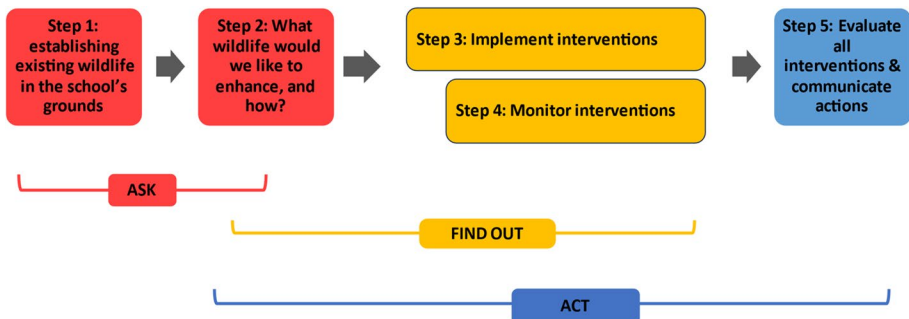


Fig. 1 The Wild Citizens steps and their alignment to the SSIBL stages of ASK – FIND OUT – ACT

study, the focus is on examples of biodiversity loss relating to familiar local species such as hedgehogs, bats and certain wildflowers. We note here that the term 'biodiversity' can be defined variously according to the context. When discussing the term with young children in this study, we have used it in a general sense of referring to the variety of living things, but particularly *wildlife* rather than domesticated animals and cultivated plants. Appendix 1 provides an overview of the Wild Citizens programme and activities in which children participated.

First, during the ASK phase and to create a need to know (Ariza et al., 2021), children explore their school grounds to establish what wildlife there is, taking photos using child-friendly cameras and documenting different types of wildlife they can identify (e.g., types of birds, insects, plants). Then, they review the photos taken and discuss and decide what type of wildlife they would like to focus on and how they can enhance the biodiversity within their school grounds. Step 2 aligns with both the ASK and FIND OUT stages as the overall question of 'What's there?' is addressed through different types of inquiry (e.g., identification and classification of different types of leaves they can find) as part of the children's initial survey of their school grounds, and the emergence through discussion of the issue of biodiversity loss.

Once the children decide what enhancements to make in Step 2 (their BAP), they actively implement their BAP and monitor and review its success through observation and measurement (Steps 3 and 4, Appendix 1). For example, the children planted trees, wildflowers and wildflower seeds and then took responsibility for caring after them and monitoring their growth through measurement and observation. As part of Step 5, children evaluate their interventions (e.g., discussing whether they been successful in having more wildlife), and then communicate their findings within their community (e.g., to children in their school and other schools, to parents) and advocate for the importance of protecting the environment. Communicating the results of their work was achieved by organising a knowledge exchange and celebration event at the authors' institution. Pupil representatives from each school came along with their teachers and some parents and the children presented their actions and explained why they thought it was important to take these actions to tackle biodiversity loss.

The ACT stage of SSIBL is embedded throughout the Wild Citizens programme as children start discussing action possibilities and the need for these actions/enhancements during Step 2. Further, action is an integral part of the FIND OUT stage during Steps 3 and 4 since the children are learning about wildlife as they actively implement interventions (performing direct actions) and as they complete Step 5 where they communicate to others about their findings (indirect actions).

5 Methods and Data Analysis

A qualitative exploratory methodology has been adopted for this study. Approximately 130 primary-aged children (7–10 years old) from five state, inner city primary schools in south-east England took part in Wild Citizens during the 2021–2022 school year. All schools were in socioeconomically deprived areas of the city, with all schools above the national average (25.6%) for free school meal eligibility. 'Wild Citizens' was run in schools either as part of curriculum time in the subject of Science (School 1) or as an afterschool club (Schools 2–5). Participation was on a voluntary basis; if a school and teacher were willing to take part, we then proceeded with gaining parental consent for the children's

participation as well as assent from children for taking part in this study. Semi-structured group interviews were conducted with children to explore how they articulate dimensions of environmental citizenship in the context of biodiversity loss.

A semi-structured interview schedule was developed drawing on Monte and Reis's (2021) framework of education for environmental citizenship at the primary school level, and Sass et al.'s (2020) framework on action competence (Appendix 2). A sub-sample of 77 children (41 boys, 36 girls) were interviewed across two points of the project (at the start of Step 3, and at the end of Step 5, see Fig. 1). Table 1 provides an overview of the duration of Wild Citizens in each school as well as key sample characteristics.

Group interviews were chosen over individual interviews due to the study participants' age and the purpose of the study. Being interviewed in a group setting is appropriate when a wider range of ideas is sought after, as in our exploratory study, and when participants are already familiar with each other and 'have been working together with some time on a common purpose' (Watts & Ebbutt, 1987, p.32). Additionally, the group configuration facilitates children's engagement as children feel more at ease and more comfortable sharing their ideas, views and experiences in a safe and familiar environment (Denscombe, 1995), allowing for richer responses (Lewis, 1992). This approach was aligned with our qualitative research approach and the research question posed, as the aim is to explore children's articulation of dimensions of environmental citizenship based on their collective Wild Citizens experiences; thus, we are not aiming to gain insight to individual knowledge, values or attribute effect in individual children.

Group interviewing requires for all participants' ideas to be explored and expressed, for example, by asking children to take turns considering and answering key interview questions, as opposed to more widely used focus group approaches where overall themes are explored. Most interview groups consisted of 3–4 children; one group of 5 and one group of 6 children were interviewed due to practical constraints such as time limitations and child absence. Group composition and selection was decided by class teachers, based on the following criteria: children's familiarity with each other, frequency of attending Wild Citizens (some children were not able to attend all sessions) and parental consent gained for being interviewed.

A total of 40 group interviews were conducted; 20 interviews near the beginning of the programme when children started discussing what they have observed and what actions to take (Round 1, 77 children), and 20 more interviews with the same children in the same groups at the end of the programme (Round 2, 65 children). Collecting data at these two points allowed us an insight into how children articulate their participation in Wild Citizens as active environmental citizens during different stages of the SSIBL framework (see Fig. 1), and when the Wild Citizens programme had different action foci — at Round 1 the focus was on taking ownership and designing their own enhancement interventions, and starting to implement them; at Round 2, the focus shifted to actions relating to monitoring enhancements and communicating actions.

The majority of interviews were conducted by the first author (36 in total), allowing for high consistency in the data collection process, with 2 interviews conducted by the second author, and further 2 interviews by a university student intern supporting Wild Citizens in that school. All interviews were conducted at the children's schools, in quiet rooms, or quiet open spaces near the children's classroom. Thematic analysis (Braun & Clarke, 2006) was used with a combination of deductive and inductive data analysis approaches used based on searching for key conceptual themes through children's articulation of environmental citizenship according to the work of Monte and Reis (2021) and Sass et al. (2020), but also allowing for new themes to emerge from the data. Since data

Table 1 A summary of study participant information in each school

	School 1	School 2	School 3	School 4	School 5
Free school meal eligibility in the last 6 years	33%	32%	47%	56%	38%
Duration	Once weekly, March – July 2021	Once weekly, April – July 2021	Once weekly, January – July 2021	Once weekly, March – July 2021	Once weekly, March – July 2021
Age range	7–9 years old (Years 3–4)	7–8 years old (Year 3)	7–9 years old (Years 3–4)	7–9 years old (Years 3–4)	6–10 years old (Years 1–5)
Total number of children participating	Approx. 20 children	Approx. 30 children	Approx. 40 children	Approx. 20 children	Approx. 20 children
Number of groups in each interview round	3 groups in April 2021 and 3 groups in July 2021	6 groups in May 2021 and 6 groups in July 2021	6 groups in February 2021 and 6 groups in July 2021	2 groups in May 2021 and 2 groups in July 2021	3 groups in May 2021 and 3 groups in July 2021
Number of children interviewed in Round 1	12 (4 boys and 8 girls)	21 (15 boys and 6 girls)	23 (11 boys and 12 girls)	10 (5 boys and 5 girls)	11 (6 boys and 5 girls)
Number of children interviewed in Round 2	11 (4 boys and 7 girls)	17 (12 boys and 5 girls)	20 (9 boys and 12 girls)	7 (4 boys and 3 girls)	10 (6 boys and 4 girls)

were collected through group interviews, our unit of analysis was the group; accordingly, in our findings, we discuss children's articulation of environmental citizenship dimensions at the group level rather than individual level (Cohen et al., 2011). The Nvivo software for qualitative analysis was used to facilitate the process (Leech & Onwuegbuzie, 2011). To develop our coding framework, we first independently read and coded in separate Nvivo files three transcripts using open coding, discussed emerging open codes and literature-based codes, and resolved any differences through discussion; we then merged all codes into one Nvivo file and developed working definitions for each code. We followed the same process with six further transcripts using our initial list of codes, discussing and resolving differences in our application of codes until reaching full agreement and refining our definitions. A constant comparative analysis process was used to organise our codes into overall themes and sub-themes (Leech & Onwuegbuzie, 2011). The resulting coding framework (see Supplementary materials for framework including themes, sub-themes, definitions and example extracts) was then reapplied to all 40 transcripts by the first author, ensuring maximum consistency during the data analysis process.

6 Findings

Three overarching themes representing environmental citizenship dimensions articulated by children were identified in our dataset. These themes (Environmental Awareness, Values and Action Competence) and sub-themes are presented in Fig. 2 and discussed in the following sections. Where direct quotes are used from the interview transcripts R denotes the interview Round (i.e Round 1 or Round 2), S denotes the School (e.g., School5) and G denotes the Group (e.g. G3).

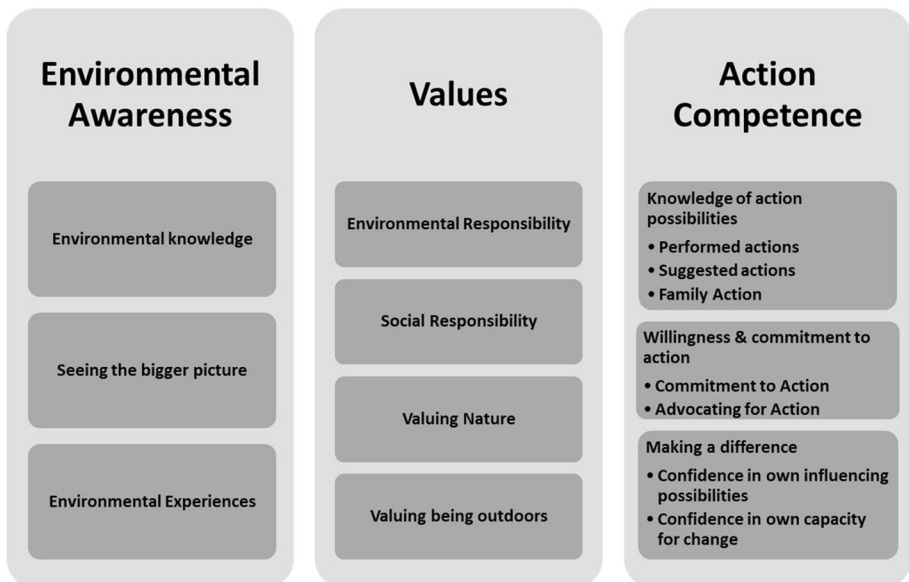


Fig. 2 An overview of key themes and sub-themes identified

6.1 Environmental Awareness: Knowledge, Seeing the Bigger Picture, and Experiences

The *Environmental Awareness* theme included instances where the children purported to know or understand about nature and the environment (whether scientifically accurate or not) and consider aspects that impacted the environment (Hawthorne & Alabaster, 1999). We group 'environmental knowledge' under the overall theme of Environmental Awareness as it was not our aim to measure or assess children's knowledge about the environment. '*Environmental Knowledge*' was used by children when asked to list what types of wildlife they have in their school grounds. Children were able to list a range of plants, birds, insects, and other living things showing they were able to link the overall concept of 'wildlife' and the Wild Citizens activities to what they knew, as summarised in Table 2. Table 2 includes all types of wildlife children mentioned in both rounds, and additional types of wildlife that were mentioned in Round 2 but not in Round 1. Some of these additional types of wildlife were species included in the activities with the children, such as having a representative from a local charity group working on the protection of swifts in the area.

Subject knowledge was used by children in their reasoning about why the Wild Citizens activities were important. Scientific terminology such as 'predators' and 'habitats' were also mentioned by children. In children's articulation of the importance of protecting nature and wildlife the theme of 'seeing the bigger picture' was identified. Children were able, and willing, to discuss the 'bigger picture' when asked why such activities are needed, or their role within them as shown in the extract below:

-
- 105 I: Do you think that's important [helping wildlife]?
- 106 S1: Yeah, because if we do keep polluting the world, it will soon die and we won't be able to live on the Earth so we have to take care of it. And in order to take care of it we need to keep growing in a nice way, encouraging animals, making it a nicer planet
- 107 I: Brilliant, what do you think S2? Was it important for you to take part in these activities?
- 108 S2: Yeah, because technically the Earth is like a human, because it feeds on healthy and unhealthy things and it grows, and it gets more population so why shouldn't it be treated the same as any other person? Because every person gets to be whatever they want to be, and I bet the Earth just wants to be a healthy planet
(R2_S3_G6)
-

Children in this group articulate their role in relation to nature, noting that they need to treat the Earth 'the same as any other person' (line 108) and warn against pollution, whilst at the same time being able to move between local and global scales of environmental citizenship (line 106, 108). Other instances of articulating environmental citizenship through the use of this theme ('Seeing the bigger picture') were in relation to (a) *how nature supports humans*, either through oxygen or food, (e.g., 'trees give us oxygen [...] and] when we get oxygen it means we can still breathe', R1_S1_G2), (b) *warning against the extinction of endangered species* because pollution or deforestation (e.g., 'the bees, they're going extinct somehow, and they pollinate most of the flowers and without insects there would be no life on earth', R1_S5_G2), (c) *helping the planet* (e.g., 'save the planet from going brown', R1_S2_G1), (d) *acting against pollution* because 'human pollution like throwing the trash in the river is actually hurting the ecosystem' (R1_S5_G2), and (e) *mitigating against climate change* (e.g., 'it's to help the climate change so we don't die, and we don't get sick, [...] because most parts of the planet have been, um, built [up] with loads of stuff and we need more wildlife and, and it's to help us from getting extinct', R1_S2_G4).

Table 2 Range of wildlife children refer to across the two interviews

	Round 1 and Round 2	Round 2 only (additional)
Mammals	hedgehogs, foxes, badgers, squirrels, bats	
Birds	robins, crows, magpies, kingfishers, pigeons, bluebirds, swans, seagulls, blackbirds, owls, hawks, starlings, blue tits, sparrows	swifts, eagles, ravens
Reptiles	snakes	
Amphibians	tadpoles, newts, axolotls, frogs	
Invertebrates ('bugs')	slugs, snails, butterflies, spiders, ants, bees, woodlice, ladybirds, worms, beetles, caterpillars, shield bugs, wasps, flies, hornets, centipedes, dragonflies, glow worms, fire ants, red ants	flying ants, leopard slugs
Plants	daisies, grass, oak trees, bluebells, dandelions, roses, palm trees, apple trees, blackberries, poison ivy, stinging nettles, buttercups, lilies, cherry blossom, sunflowers, strawberries	lavender, willow trees, foxgloves

'Environmental experiences' emerged when children articulated examples of interacting with nature either at home or at school. Children referred to environmental experiences when asked to consider actions they can take to support wildlife, and at times, raised the issue of *absence of experiences* ('I don't normally see them', R1_S2_G4, line 77). Children's articulation of environmental experiences related to actions they had taken at home or at school, and with environmental values, are discussed in the following sections.

6.2 Values

Children's environmental value orientations were articulated when discussing the importance of their work in Wild Citizens for them and for the environment. Four sub-themes were included: environmental responsibility, social responsibility, valuing nature, and valuing being outdoors.

6.2.1 Environmental Responsibility

In discussing the important role of the environment, all children across both rounds of interviews were able to articulate their own *environmental responsibility*, indicating an awareness of their civic duties and responsibilities in relation to the environment. Whilst doing this, children articulate a mixture of anthropocentric and biocentric positioning towards nature (Kopnina, 2013). Children articulate their responsibility towards nature by pointing out the need to 'help wildlife' more generally, and linking it to values such as respect, as shown in the following extract:

-
- 59 I: So What have you gained from doing these activities?
 60 S1: I've been...I don't know why, but I've, like, been a lot kinder and, like, more... *I've been less harmful to animals*
 61 I: Yeah, can you give me an example of that, S1?
 62 S1: Like, if I saw a butterfly, I wouldn't try and catch it, I would leave it be
 63 I: Why do you think you're doing that?
 64 S1: So I'll just let it, like, live its life
 65 I: Yeah, why is that important though?
 66 S1: Because if you think of it, like, if someone just came and took you away, it would feel very scary. And that's probably the same for, like, animals
 67 I: [...] Anyone else who wants to say something about what they have gained from doing these activities?
 68 S2: *I've gained, like, a sense of respect for all the animals*, and if I see loads of beautiful flowers, I won't try and pick them, so I'll just leave them be and won't touch them (R2_S3_G1)
-

Children note themselves that they have developed a sense of respect and kindness towards wildlife, and importantly, they are able to exemplify this through desirable pro-environmental actions, such as being less harmful to wildlife (lines 60, 62, 68). Here, children are able to attribute intrinsic value to nature articulating biocentric values. Environmental responsibility was articulated in relation to the importance of nature for human survival (e.g., 'growing trees makes us breath better', line 66, R1_S1_G1) but also for well-being, such as 'if we don't let the environment grow all we'll have is like a giant wasteland in our school and if we go out for break or lunch then *it's going to be boring*' (Line 89, R1_S2_G5) indicating an anthropocentric value orientation towards nature.

6.2.2 Social Responsibility

Children were able to articulate their ‘social responsibility’, that is being responsible members of society and acting in the best interests of their school as their social setting. Children’s articulation of social responsibility was combined with their environmental duties and responsibilities as citizens when discussing what they can do within their school’s grounds, as shown in the following extract:

we need to take more care of the school grounds and stuff because people are littering and that sort of stuff and they’re not taking care of it. We want birds to come down but like well actually if they come down and they think “oooh, the plastic looks a bit like food” they could choke on it
(line 60, Round 1_S5_G1)

Children note the importance of ‘taking care’ of their school by litter-picking, but also consider this action in relation to their environmental responsibility and ensuring that they are protecting birds around their school setting.

6.2.3 Valuing Nature

‘Valuing Nature’ included both anthropocentric and biocentric values. We created a separate theme for this as children did not always articulate these values in relation to their duties or responsibilities as environmental citizens (Environmental Responsibility) but at times they articulated an appreciation for the importance of nature more generally. Within this, biocentric views were articulated when children reflect that ‘[I have learned] we should treat everything with respect, no matter what’ (line 97, R2_S1_G3) and ‘we should be treating the wildlife as we always treat everyone else’ (line 127, R1_S2_G5). Anthropocentric views were articulated when children’s appreciation for nature included benefits to themselves, such as ‘I love going on the, like, making the trees bigger, because without trees, there’s no oxygen, and without oxygen, you’ll die’ (line 83, R2_S1_G2).

6.2.4 Valuing Being Outdoors

When children discussed environmental experiences, they also articulate their appreciation for being outdoors through noting the benefits it has on their health and wellbeing. Interestingly, children valued the experience of being outdoors as an alternative to using on electronic devices indoors, as commented on in the extract below:

They’re [Wild Citizens] really fun to, because we don’t just get to go home and watch our tablets we get to stay [afterschool] around wildlife and be more calm and stuff
(line 110, R1_S2_G6)

Further, the value of being outdoors was articulated by children in relation to a lack of environmental experiences within their home settings, as noted by Group 5 in School 2:

It’s important to me because really, I don’t have much wildlife in my garden, so it’s important to me because I’ve got...we’ve got the garden over there where we can, like, do this stuff, and, like, we’re lucky to have that
(line 44, R2_S2_G5)

6.3 Action Competence

6.3.1 Knowledge of Action Possibilities: Suggested, Performed and Family Action

To explore how children understand and articulate the action dimension of environmental citizenship, we asked them to discuss what they already did within their school grounds, and what else they could do, both within school and outside school to support wildlife (Appendix 1). The children's performed and suggested actions across the two rounds of interviewing are summarised in Table 3. Suggestions for actions (knowledge of action possibilities) are discussed by children in the *public sphere* and at the *local scale* of influence within their school grounds, based on the actions and enhancements their school's BAP included, such as '[we] made bird feeders for feeding the birds' (line 136, R1_S4_G2), and 'we've put different flower seeds [...] so they can grow flowers' (lines 84–86, R2_S1_G1). These are articulated as *collective actions* indicated by the use of 'we', as the children work together during Wild Citizens, as well as due to the group interview configuration.

Importantly, children were able to consider action beyond the local scale of their school grounds to consider other local scale contexts both in the *private and public sphere*. For example, when prompted to discuss what they could do outside of school to support wildlife, they provided suggestions for action at home, at the park, or within their social groups (Table 3). The most common context in which children were able to transfer their considerations of taking action was at home with family members (*Family Action*, Fig. 2). Children referred to actions they had already taken or could take at home, such as 'at home, when we're not at gardening club and we're back at home on a Saturday, I planted some flowers with my dad' (line 191, R1_S2_G4). Further, children were able to articulate ways in which they could support nature outside of school with their families. For instance, at the start of a Round 2 interview, Group 2/School 5 children asked whether the Wild Citizens programme would be continued, and when prompted to explain why they would like it to continue they discussed how the actions taken at school, were also discussed and performed at home, as shown in the extract below:

I've got to see my friends enjoy just being around in nature, getting fresh air, and when I came home, every Tuesday afternoon, I would be, like, "Mum, dad, I did this, this and this today," and then I used to just sit down with my sister, be talking to her about it, being, like, "Ooh, this, this and this," and then I've also encouraged her to do it'
(Line 9, R2_S5_G2)

In this extract actions taken with family also take the form of sharing their performed actions and experiences as well as a commitment to action, through encouraging other family members to take action themselves. Environmental citizenship is articulated here in the private sphere, indicated by the use of first person ('I did this') demonstrating environmental agency by focusing on advocating for environmental protection, rather than the most commonly used references of suggested or performed actions in the public sphere (e.g., school context).

Table 3 Summary of children's knowledge of action possibilities across two rounds of interviewing in and outside of school

	Round 1 Interviews	Round 2 Interviews
At school		
Performed actions	<ul style="list-style-type: none"> ● Made animal shelters (e.g., bug hotels, bird boxes/houses, hedgehog tunnels) ● Created posters or signs for protecting plants; warned others to not step on flowers/plants they planted ● Provided food & water (e.g., birdfeeders) ● Cleaned school pond 	<ul style="list-style-type: none"> ● Planted new plants/trees/wildflower seeds ● Created animal shelter (bird nest/houses; swift boxes; bat boxes, bug houses) ● Created a hedgehog highway ● Provided food and water to plants, animals, insects, birds ● Welcomed them and made them feel comfortable ● Created a 'wildlife garden' ● Litter picking ● Littering less at school
Suggested actions	<ul style="list-style-type: none"> ● Grow/plant flowers, grass, trees ● Create animal shelters (e.g., bug hotels, bird houses, bee houses, tunnels for small animals) ● Create habitats ('more leaves down for caterpillars'; create a pond) ● Provide food & water (e.g., bird feeders, water fountain, flowers for bees and butterflies) ● Warn people not to step on flowers; create posters; signage ● Create pathways around wildflower areas ● 'See other schools' gardens for improving our school' ● Raise more money for 'more stuff into our garden' ● Clean the school's pond ● 'Make the garden bigger; ask the government to expand the school' ● 'Make cars by school's grounds go slower' ● Pick up rubbish around the school ● Create a recycling centre at school ● More recycling/rubbish bins 	<ul style="list-style-type: none"> ● Grow/plant/water more flowers, trees ● More wildlife areas (e.g., make more gardens around the school; make a forest for the animals, create a pond, have more flower beds) ● Add vegetable plants ● More tunnels for hedgehogs ● More food (e.g., continue refilling the birdfeeders) ● More shelter for animals (e.g., more bird boxes, more bee houses) ● Litter picking ● Recycling ● Mini greenhouses for plants ● Protect the plants when playing football ● More signs saying 'Come to our school', 'Beware of hedgehogs' ● 'See what other schools are doing and maybe try and extend it to our school'

Table 3 (continued)

	Round 1 Interviews	Round 2 Interviews
Outside school		
Performed action	<ul style="list-style-type: none"> ● Grow plants and trees in their garden ● Water flowers ● Provide food to insects, birds (e.g., bird feeders, squirrel feeders) ● Help birds at home ● 'Make an urban garden'; 'Turn your garden into a helping station' 	<ul style="list-style-type: none"> ● Grow plants at home & look after them ● 'I bought some plants and I planted them at home and I water them every day' ● Made hedgehog houses ● Birdfeeders ● squirrel feeder
Suggestions for action	<ul style="list-style-type: none"> ● Grow plants and trees in your garden ● Stop cutting down trees ● Plant tree seeds when out walking ● Plant more flower seeds/flowers at home ● Pick up rubbish ● Create animal shelters at local parks ● Put food for badgers, deer, and foxes in the forest 	<ul style="list-style-type: none"> ● Make my own bug hotel ● Become 'gardeners', make a wild garden somewhere near ● Make our [home] garden better ● Bird feeders ● Plant flowers [at home] 'so then we know more about what to do when we come to gardening club ● Repurposing waste for making animal shelters (e.g., bird nests) ● Litter picking; 'Cleaning up the pollution' ● Don't disturb nature ● Don't kill it [wildlife] ● 'we can say to other people around the world, "Please help us make more, to help us stay alive in the future"'

6.3.2 Willingness and Commitment to Contribute to Action

‘Commitment to Action’ and ‘Advocating for Action’ were the two sub-themes within this dimension of action competence identified in our interviews. Children’s commitment and willingness to contribute to action was articulated as transference from within school contexts to their homes, not only in terms of sharing their actions with family members (as shown in the extract from R2_S5_G2, line 9) but also performing direct actions at home such as:

actually, it inspired me to do some growing at my house [...] I got strawberry and tomato plants [...] I put the tomatoes and strawberries in different pots so we don’t get confused, watered them, then keep watching them every weekend or every school day after school
(R2_S2_G3, lines 61-69)

‘Commitment to Action’ was further articulated by children through wanting to continue taking part in Wild Citizens in the following school year, and by their participation in a sharing and celebration event at the authors’ institution where the children were given the opportunity to share their performed actions and explain why these were important (Step 5, Fig. 1). For instance, at the end of their interview, when prompted if they would like to add anything further before stopping, children in School 3 articulated their commitment and passion for action by noting that ‘all of us should continue planting and continue helping wildlife [...] because, like...well, because there’s, like, loads of countries that, like, don’t have all these things so, like, we need, like, to try and make other places better’ (lines 168–170, R2_S3_G1). In this extract, environmental responsibility is also articulated through their willingness to continue ‘helping wildlife’ and a move from within their school grounds to other local and even global scales of influence.

‘Advocating for Action’ was identified when children articulated their willingness to act through a particular focus on *influencing others* as an action possibility (Jensen & Schnack, 2006; Sass et al., 2020b), illustrating how knowledge of action possibilities and willingness to act interrelate in children’s articulation of environmental citizenship dimensions. Influencing others was suggested at the local/school scale by encouraging ‘other people to join us [...] like we can encourage different people to come and help the wildlife’ (lines 175–177, R1_S4_G2). Influencing others is also articulated on a global scale of influence, such as ‘we could put what we’ve been doing on, like, social platforms where everyone can see what we’ve been doing and *we could influence people to do the same all over the world*’ (line 237, R2_S5_G2).

6.3.3 Confidence in Own Influencing Possibilities and Own Capacity for Change

In exploring children’s confidence in own influencing possibilities, we asked children to consider whether they were making a difference to wildlife through their performed actions (Sass et al., 2020a) in the context of biodiversity loss. At both rounds of data collection, children articulated their confidence in making a difference and were able to note simple actions they can take within and outside school. During Round 1 interviews, and as children were at the stage of designing or starting to implement their BAPs (Stage 3, Fig. 1) they justified their impact at a hypothetical or abstract level. They noted that ‘if we didn’t make flowers around school, bees wouldn’t come, so if we do have flowers then bees will come like in Spring’ (R1_S5_G1), or discussed the impact they had on their

school's environment in more general terms (e.g., 'we are changing the environment at our school', R1_S3_G1), or by referring to their performed actions, such as '[we're making a difference] because we're planting more flowers' (R1_S2_G4). Providing examples of performed actions to justify confidence in making a difference indicates that children viewed these actions as *relevant* for achieving such change.

During Round 2 interviews, after children had implemented and monitored their enhancements within their schools' grounds (Step 5, Fig. 1) they were able to articulate their confidence in making a difference at three levels of influence beyond the hypothetical level: (a) making a difference to wildlife, (b) making a difference by influencing others to take pro-environmental action, and (c) making a difference at a global level of influence. When children discussed how they impacted wildlife, they draw on comparisons between before and after their interventions, again indicating that they perceived their actions as *relevant* for enhancing wildlife at their school grounds and importantly, *impactful*. For example, children in one school noted the difference between what the school grounds looked like previously, and how their interventions were improving their school's outdoor space, as shown in the extract below:

S1: Yeah, because before, we just had, like, a plain field and everyone just kept going in there for football and that. [...] Because there used to always be, so before the wildlife [interventions], there were little daisies there, and they were fully grown, and then all the boys just, when people were playing basketball, they kicked them over the daisies. And then we had the wildlife, then there's, like, they put signs up saying, "Don't go in here," and, "Go in here with teachers' permission."
(line 117, R2_S1_G1)

In making such comparisons, children articulate their confidence in their own influencing possibilities by drawing on *observable evidence* and *performed actions* that demonstrate their influence on the wildlife around their school's grounds. They use the fact that they have to keep refilling the birdfeeder stations they put in place, and the fact they have 'put more flowers in' (R2_S3_G4) as evidence of having more birds in their school grounds. Their confidence in the positive outcomes of their actions is also noted at *seeing more* wildlife such as butterflies and bees (e.g., 'we've been seeing more butterflies. We've been seeing lots of different types of birds I've never, ever seen', line 44, R2_S2_G2).

Another level of influence children articulate is *influencing others* to contribute to action interrelating with Commitment and Willingness to Act. For instance, when asked to provide examples of actions performed to support wildlife, a group in School 3 confidently note a change in the actions of other children at school as a result of their work, which they frame as 'making a difference' (line 44), as shown in the extract below:

38 S1: You may not know it, but I think that people have been picking up litter more and doing the litter picking as well a lot and at breaks, and like I think people have been putting litter down less as well
39 I: You think so S1?
40 S1: And I think we're *influencing people to help the environment* with Wild Lab [Wild Citizens]
41 I: Amazing, why do you say that?
42 S1: Because most people *do* know that we're doing it, and they might see what we've been doing, like at break times they might see that we've done some stuff and *that might influence them to help*
43 Interviewer: Yeah amazing...
44 S1: And people used to be like running all over the patch that we did the flowers on, and now no one walks on it
(R2_S3_G6)

In this extract, the children articulate the impact of their actions as they comment on an outcome they have achieved as a result of performed actions. Children's confidence of their own influencing possibilities was articulated at a global level of influence as shown below:

'I think I'm making a difference to the animals, since...the animals here don't really have a place to stay and we're making it for them and *if it's expanding all over the world*, then the extinction, there won't be any of the extinction or the wildlife will have finally get a place to live in' (line 151, R2_S4_G1)

Children being able to visualise how their actions might have a wider impact than just within their school grounds is an important aspect of action competence (Sass et al., 2020a) as having a vision might support children's willingness to act. Articulating links between local and global scales was also discussed in relation to content knowledge such as referring to 'extinction' and 'climate change', as shown below:

-
- 164 S1: [I think it's important to try and make a difference] because global warming is happening and it's getting warmer and also the tides are...
- 165 I: What does that mean for you, to make a difference, S1?
- 166 S1: It feels like I'm making a difference to that (R2_S1_G3)
-

Finally, although unprompted, there were some instances where children articulated confidence in their own capacity for change, that is the extent they thought they had mastered the skills needed for successful action (Sass et al., 2020a). For instance,

-
- 107 S1: I think I've *learnt to be resilient at doing the flowers*, and always helping the flowers, to be the best you can
- 108 I: How do you think you are being resilient?
- 109 S1: Because we're feeding them, doing everything to help them, we're giving them lots when it's starting to be the weekend, and before I go on holiday, well, it's only today, we are going to feed them lots and lots of water
- 110 I: Okay, amazing. S2 and then S3...
- 111 S2: So...
- 112 I: What did you learn S2?
- 113 S2: So, I learned about all the different bugs that were in, because I didn't know a lot of bugs, but now I know what bugs they are, and *now I know, like, how to do stuff in the garden, water plants, and now I know what to do* (R2_S1_G2)
-

Children in this group refer to learning skills that help them persevere with caring for their biodiversity enhancement interventions (line 107) and refer to performed actions when asked to elaborate on their ideas. The importance of knowing *what* to do as well as *how* to perform actions as articulated in line 113 should be an important dimension of any educational programme for environmental citizenship.

7 Discussion

In this study, we explore primary school children's articulation of environmental citizenship dimensions within the context of biodiversity loss. Environmental citizenship and educational approaches that can support its development in young people are recently emerging (ENEC, 2018), creating the need to operationalise this multi-layered concept for primary science education. A key finding is that children articulate environmental citizenship at both local and global scales of influence. Dillon (2018) argues that our current education system fails to support young people see the bigger picture of the science and environmental concepts they are being taught. Yet, the primary school children in our study were able to articulate this bigger picture by considering the implications of their actions not only at the localised school context but also at national and global scales, indicating an emergent understanding that localised actions can have a global impact when performed collectively. This finding expands the work of Sass et al. (2021), who found that 10–13-year-olds were able to represent the interconnected nature of the United Nation's key areas of sustainable development (people, planet, prosperity, peace, partnership).

The ability to articulate both local and global levels of influence in relation to biodiversity loss is particularly important given discussions about eco-anxiety (e.g. Ojala, 2012; Pihkala, 2017), and about the potential limitations that young children have with understanding issues at such scales (Rousell & Cutter-Mchenxie-Knowles, 2020); even if children of this study's participant age group (6–10 years old) cannot understand complex scientific knowledge (e.g., about climate science), they articulate the links between their performed actions and the impact it might have at a global scale, showing their ability to conceptualise and discuss the implications and consequences of issues such as biodiversity loss in simple terms, demonstrating environmental awareness (Hawthorne & Alabaster, 1999).

Importantly, by being able to visualise, experience and observe links between performed actions and the impact these have in their local setting, biodiversity loss as an issue is transformed for the children from a slow, 'invisible' disaster to an observable phenomenon, which they then act to mitigate against. Consequently, teaching about the SSI of biodiversity loss through SSIBL, and embedding authentic scientific practices (biodiversity action plans) does not only support the development of environmental citizenship at the community level (Sarid & Goldman, 2021) but also acts as a form of disasters education that can be embedded within primary science education. This provides an empirical illustration of how an ecological disaster can be framed as an SSI and addressed through the primary science curriculum through an action-oriented approach.

The design of the Wild Citizens programme, underpinned by the SSIBL pedagogy, and with its utilisation of biodiversity action plans as a way of learning about, and acting to mitigate biodiversity loss is an innovative pedagogical approach which has action as an inherent dimension of the learning process. This provides children with the authentic opportunities needed to enact agency (Jansen & Schnack, 2006; Schilds, 2016) through small, manageable actions, which nonetheless can make an *observable* difference. Children refer to the actions taken to justify their confidence in their own influencing possibilities, indicating they perceived their actions as *relevant* for enhancing wildlife at their school grounds and importantly, *impactful* (Section 6.3.3). This in turn strengthens their sense of

respect towards nature and their locus of control (Hawthorne & Alabaster, 1999) and enables them to develop confidence in their own influencing possibilities supporting environmental agency and the development of action competence, key dimensions of environmental citizenship. Thus, we argue that visualising and observing the impact of their collective actions can strengthen children's belief that they can be part of the solution, as a collective.

The majority of children in our study were aged 7–9 years old, yet it is clear through children's articulation of actions taken and confidence in their own influencing possibilities that children at this comparatively young age can engage in meaningful collective action, and are empowered by it. Our findings expand the evidence base in this area (Sass et al., 2020b; Baptista et al., 2018), and strongly indicates that opportunities should be given to primary school children to realise this potential to perform collective actions in addressing relevant SSIs. Otto et al. (2019), having conducted longitudinal studies of young people's environmental attitudes and behaviours, report that children's environmental attitudes consolidate from age 10 to age 14 before they start declining between the ages of 14 to 18. This would suggest that educational programmes aiming at supporting pro-environmental attitudes and agency need to start early to counteract the decline identified during adolescence. Primary education is the time to start empowering children to take responsible action (Chawla, 2020; Monte & Reis, 2021). This is further supported by Sass et al. (2020b) who caution against 'underestimating the richness and level of complexity of actions early adolescents feel they are capable of and willing to take, while acknowledging their need for collective action and collaboration with peers' (Sass et al., 2020b, p. 251).

Another key finding is that children articulate both their environmental duties and responsibilities as well as their *social responsibilities* as environmental citizens, and they are able to contextualise their actions in relation to a setting that is familiar to them, and a setting they have been actively working to improve (i.e., their school grounds). This illustrates empirically that young children are — and should be seen as — 'active citizens' and not as future citizens (Jans, 2004). They should thus be supported in developing their confidence and commitment to taking action as environmental citizens. Commitment and willingness to engage in action was more prevalent in the children's articulation of environmental citizenship during the second round of interviews. This was expressed in relation to wanting to continue taking part in Wild Citizens in the following school year, their participation in a sharing and celebration event at the authors' institution where they shared their performed actions, and explained why they thought these were important to perform. Communication skills are included as important aspects of environmental citizenship more widely (Monte & Reis, 2021), and of action competence (Sass et al., 2020a). We would add to this argument by noting the importance of including *communication as action* as part of educational programmes that aim at supporting children becoming active environmental citizens, since this allows them to move from considerations of influencing others at personal or local scales of influence to higher scales such as their community, families, and other schools, as shown in our study.

8 Study Limitations

This study draws on data from group interviews to explore children's articulation of environmental citizenship in the context of biodiversity loss. One limitation of our data set and approach is that our interpretations are relying on children's self-reporting of

the impact they think they have had on others and on their school grounds through their actions. Similarly, children report on actions they take at home with family members. We have provided extracts from our transcripts to show in detail the children's choice of words, and to ensure our interpretations are supported through evidence from our dataset. The majority of interviews were conducted by an experienced researcher (first author) with expertise in conducting group interviews with children. Honesty was encouraged throughout and space was given during the group interviews for children to ask questions and clarifications if needed in order to ensure questions were understood. Another limitation to consider is that the Wild Citizens programme was implemented across five different schools and different age groups. This variability in age and school context has been countered by maintaining close contact with schools by visiting Wild Citizens sessions and ensuring the university interns that supported the schools followed a common approach (as described in Appendix 2). The variability in the implementation shows how Wild Citizens can be supported through adaptations across a range of age groups.

9 Conclusions and Implications for Further Research

This study contributes to the fields of SSI-based education and environmental citizenship by illustrating that when given the opportunity and provided with the necessary educational scaffolds, through programmes such as Wild Citizens, primary school children can — and do — take action to protect their environment and advocate for the importance of doing so within and outside their school communities as environmental citizens. This in turn highlights the pivotal role of the SSIBL pedagogy as an action-oriented and responsible citizenship-oriented approach to science education, demonstrating empirically its potential for promoting environmental citizenship in young people. Our study further illustrates how when disasters education is framed through an action-oriented SSI-based approach (SSIBL), space is provided within school subjects such as science to address environmental or ecological disasters such as biodiversity loss. Therefore, in designing, implementing and researching further the use of SSIBL within primary science education, and in addressing other slow disasters contexts, we need to remain fully aware that children of this age can act as young environmental citizens, and we should therefore leverage their ability to (i) see the bigger picture and (ii) recognise that they can make a difference. At the same time, we need to acknowledge and consider tensions between environmental citizenship, disasters education and science education (Iversen & Jónsdóttir, 2019; Park, 2020), and how teachers can be supported in teaching science using socially-responsible inquiries within the primary education phase, whilst also balancing competing educational aims and visions.

The Wild Citizens activities made biodiversity, and biodiversity loss, more visible for the children. Further research in this area should focus on the extent that children through this approach can appreciate the complexity of biodiversity loss as a socioenvironmental issue, and the instructional supports that are required to enable complexity to also become visible for primary school children.

Appendix 1

The interview schedule used for the group interviews

Round 1 Interviews	Round 2 Interviews
<ul style="list-style-type: none"> • What wildlife do we have in the school grounds? • How can we have more wildlife into the school grounds? Can you give some examples of what we can do? • What is the purpose of the activities we are doing? (Why do you think we are trying to have more wildlife? What did you get out of it so far? What do you think you learned so far?) • What do you think about the activities we have been doing with Wild Citizens? • Do you feel that you're making a difference to the wildlife around the school's grounds? If yes, in what way/how are you making a difference? If not, why? • Do you feel there are other things <i>you</i> can do (on your own) to encourage wildlife? • What else do you think you could do outside school to have more wildlife? • Is there anything else you would like to say? 	<ul style="list-style-type: none"> • What wildlife do we now have in the school grounds? • What did you do to have more wildlife into the school grounds? Can you give some examples? • What is the purpose of the activities we have been doing? (Do you think it was important for you to take part in these activities?) • What do you think about the activities we have been doing with Wild Citizens? • Do you feel you've made a difference to the wildlife around your school's grounds? If yes, in what way/how have you made a difference? If not, why? (How does that make you feel? Do you think it's important (to make a difference)?) • Do you feel there are other things <i>you</i> can do (on your own) to encourage wildlife? • Now that the project is finished/schools have closed, is there anything you would like to do more of/to continue doing to help wildlife? • Is there anything else you would like to say?

Appendix 2

An overview of the Wild Citizens programme

SSIBL stage	Wild Citizens steps	Activities
ASK	Step 1. What's there? establishing existing wildlife in the school's grounds	Pupils explore their school grounds taking photos of animals, plants, birds, insects or other wildlife they can identify with cameras/tablets
ASK, FIND OUT & ACT	Step 2. Planning for more wildlife: what wildlife would we like to enhance, and how? <ul style="list-style-type: none"> • What wildlife is there already? • How can we encourage more wildlife? 	<ul style="list-style-type: none"> • Discussion about Step 1 observations and review of photos taken • Make drawing of their ideal school grounds—what the school grounds could look like, including interventions they would like to implement • Create a list of enhancements to implement and group them according to types of wildlife (Biodiversity action plan)
FIND OUT & ACT	Step 3. Plants	<ul style="list-style-type: none"> • Review school grounds and decide where to place wildflowers and why • Sow wildflower seeds and wildflower plugs • Devise a care plan for wildflowers

SSIBL stage	Wild Citizens steps	Activities
ACT	Step 3. Birds	<ul style="list-style-type: none"> • Review school grounds and decide where to place bird feeders, nest boxes and why • Install bird feeders and nest boxes • Devise a care plan and put in place a monitoring team for replenishing water, seeds
	Step 4. Monitoring interventions	<ul style="list-style-type: none"> • Pupils review and monitor their Plants and Birds enhancements, • Pupils collect data on frequency, type and number of birds, measuring plant grown etc., using observation and taking photos
	<ul style="list-style-type: none"> • What's here now and what's changed? • Are we making a difference? • How do we know? 	
	Step 3. Bugs (above and below the ground)	<ul style="list-style-type: none"> • Review school grounds and decide where to place bug hotels, compost bins, butterfly feeders and why • Making and installing bug hotels, butterfly feeders. Installing compost bins and starting composting process
	Step 3. Bigger animals (e.g., hedgehogs)	<ul style="list-style-type: none"> • Make hedgehog footprint tunnels • Make holes in fences to allow passage for hedgehogs
	Step 4. Monitoring interventions	<ul style="list-style-type: none"> • Pupils review and monitor their enhancements across types of wildlife, taking photos and making observations of new birds, plant grown, etc
	Evaluate interventions and communicate actions to different audiences (e.g. school assembly, parents, teachers, other schools)	<ul style="list-style-type: none"> • Pupils taking photos of animals and plants with cameras/tablets • Pupils compare their ideal grounds' drawings with what the grounds now look like • Pupils prepare short videos and posters to explain their actions and their importance for wildlife • Pupils write short letters to describe their experiences in the Wild Citizens programme
	<ul style="list-style-type: none"> • What's here now and what's changed? • Have we made a different to wildlife? • How successful have our actions been? 	

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Data Availability Data not available due to ethical restrictions.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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References

- Amos, R., & Christodoulou, A. (2018). Really workingscientifically: strategies for engaging students with socio-scientificinquiry-based learning (SSIBL). *School Science Review*, *100*(371), 59–65.
- Ariza, M. R., Christodoulou, A., van Harskamp, M., Knippels, M. C. P., Kyza, E. A., Levinson, R., & Age-silaou, A. (2021). Socio-scientific inquiry-based learning as a means toward environmental citizenship. *Sustainability*, *13*(20), 11509. <https://doi.org/10.3390/su132011509>
- Ban, S., & Mahmud, S. N. D. (2023). Research and trends in socio-scientific issues education: A content analysis of journal publications from 2004 to 2022. *Sustainability*, *15*(15), 11841. <https://doi.org/10.3390/su151511841>
- Baptista, M., Reis, P., & Andrade, V. (2018). Let's save the bees! An environmental activism initiative in elementary school. *ViSions for Sustainability*, *9*, 41–48.
- Bencze, L. (2017). STEPWISE: A framework prioritizing altruistic actions to address socioscientific issues. In L. Bencze (Ed.), *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments. Cultural Studies of Science Education* (vol 14). Springer. https://doi.org/10.1007/978-3-319-55505-8_2
- Bencze, L., Pouliot, C., Pedretti, E., Simonneaux, L., Simonneaux, J., & Zeidler, D. (2020). SAQ, SSI and STSE education: Defending and extending science-in-context. *Cultural Studies of Science Education*, *15*(3), 825–851.
- Biesta, G., Lawy, R., & Kelly, N. (2009). Understanding young people's citizenship learning in everyday life: The role of contexts, relationships and dispositions. *Education, Citizenship and Social Justice*, *4*(1), 5–24.
- Bjørker, M. R. (2019). Making invisible changes visible: Animal examples and the communication of biodiversity loss. *Culture Unbound. Journal of Current Cultural Research*, *11*(3–4), 394–414. <https://doi.org/10.3384/cu.2000.1525.191127>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.
- Burns, F., Eaton, M. A., Barlow, K. E., Beckmann, B. C., Brereton, T., Brooks, D. R., et al. (2016). Agricultural management and climatic change are the major drivers of biodiversity change in the UK. *PLoS ONE*, *11*(3), e0151595. <https://doi.org/10.1371/journal.pone.0151595>
- Burns, F., Mordue, S., al Fulaij, N., Boersch-Supan, P. H., Boswell, J., Boyd, R. J., Bradfer-Lawrence, T., de Ornellas, P., de Palma, A., de Zylva, P., Dennis, E. B., Foster, S., Gilbert, G., Halliwell, L., Hawkins, K., Haysom, K. A., Holland, M. M., Hughes, J., Jackson, A. C., ... Gregory, R. D. (2023). *State of Nature 2023*, the State of Nature partnership. Available at: www.stateofnature.org.uk. Accessed 12/09/2024.
- Caro, T., Rowe, Z., Berger, J., Wholey, P., & Dobson, A. (2022). An inconvenient misconception: Climate change is not the principal driver of biodiversity loss. *Conservation Letters*, *15*(3), e12868. <https://doi.org/10.1111/conl.12868>
- Chawla, L. (2020). Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. *People and Nature*, *2*(3), 619–642. <https://doi.org/10.1002/pan3.10128>
- Cheng, J. C. H., & Monroe, M. C. (2012). Connection to nature: Children's affective attitude toward nature. *Environment and Behavior*, *44*(1), 31–49.
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). Routledge.
- Davis, J. (2009). Revealing the research 'hole' in early childhood education for sustainability: A preliminary survey of the literature. *Environmental Education Research*, *15*(2), 227–241.

- de Freitas, A. C., do Nascimento, L. A., de Castro, R. G., Motokane, M. T., & Reis, P. (2023). Biodiversity and Citizenship in an Argumentative Socioscientific Process. *Sustainability*, *15*, 2987. <https://doi.org/10.3390/su15042987>
- Denscombe, M. (1995). Explorations in group interviews: An evaluation of a reflexive and partisan approach. *British Educational Research Journal*, *21*(2), 131–148. <https://doi.org/10.1080/0141192950210201>
- Department for Education (DFE). (2022). Sustainability and climate change strategy. *Policy Paper*. Published 21 April 2022, Available online: <https://www.gov.uk/government/publications/sustainability-and-climate-change-strategy>. Accessed 12/09/2024.
- Dillon, J. (2018). Towards convergence of science and environmental education to address wicked problems. *Education in Science*, *27*(4), 14.
- Dobson, A. (2007). Environmental citizenship: Towards sustainable development. *Sustainable Development*, *15*(5), 276–285.
- European Commission, Directorate-General for Research and Innovation. (2015). *Science education for responsible citizenship – Report to the European Commission of the expert group on science education*, Publications Office. <https://data.europa.eu/doi/10.2777/12626>. Accessed 12/09/2024.
- European Network for Environmental Citizenship – ENEC. (2018). Defining “Environmental Citizenship”. Available at: <http://enec-cost.eu/our-approach/enec-environmental-citizenship/>. Accessed 12/09/2024.
- Evagorou, M. (2011). Discussing a socioscientific issue in a primary school classroom: The case of using a technology-supported environment in formal and nonformal settings. In T. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (Vol. 39, pp. 133–159). Springer.
- Evans, G. W., Otto, S., & Kaiser, F. G. (2018). Childhood origins of young adult environmental behavior. *Psychological Science*, *29*(5), 679–687. <https://doi.org/10.1177/0956797617741894>
- Georgiou, Y., & Kyza, E. A. (2023). Fostering chemistry students' scientific literacy for responsible citizenship through socio-scientific inquiry-based learning (SSIBL). *Sustainability*, *15*(8), 6442. <https://doi.org/10.3390/su15086442>. MDPI AG.
- Hadjichambis, A. C., Reis, P., Paraskeva-Hadjichambi, D., Činčera, J., Boeve-de Pauw, J., Gericke, N., & Knippels, M. C. (2020). *Conceptualizing environmental citizenship for 21st century education* (p. 261). Springer Nature.
- Hamlin, I., & Richardson, M. (2022). Visible garden biodiversity is associated with noticing nature and nature connectedness. *Ecopsychology*, *14*(2), 111–117.
- Harvey, D. J., Montgomery, L. N., Harvey, H., Hall, F., Gange, A. C., & Watling, D. (2020). Psychological benefits of a biodiversity-focussed outdoor learning program for primary school children. *Journal of Environmental Psychology*, *67*, 101381. <https://doi.org/10.1016/j.jenvp.2019.101381>
- Hawthorne, M., & Alabaster, T. (1999). Citizen 2000: Development of a model of environmental citizenship. *Global Environmental Change*, *9*(1), 25–43. [https://doi.org/10.1016/S0959-3780\(98\)00022-3](https://doi.org/10.1016/S0959-3780(98)00022-3)
- Herman, B. C., Clough, M. P., & Rao, A. (2022). Socioscientific issues thinking and action in the midst of science-in-the-making. *Science & Education*, *31*, 1105–1139. <https://doi.org/10.1007/s11191-021-00306-y>
- Iversen, E., & Jónsdóttir, G. (2019). ‘We did see the lapwing’ – Practising environmental citizenship in upper-secondary science education. *Environmental Education Research*, *25*(3), 411–421. <https://doi.org/10.1080/13504622.2018.1455075>
- Jans, M. (2004). Children as citizens: Towards a contemporary notion of child participation. *Childhood*, *11*(1), 27–44.
- Jensen, B. B., & Schnack, K. (2006). The action competence approach in environmental education. *Environmental Education Research*, *12*(3–4), 471–486. <https://doi.org/10.1080/13504620600943053>
- Knippels, M. C. P., & van Harskamp, M. (2018). An educational sequence for implementing socio-scientific inquiry-based learning (SSIBL). *School Science Review*, *100*(371), 46–52.
- Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310.
- Kolstø, S. D. (2008). Science education for democratic citizenship through the use of the history of science. *Science & Education*, *17*, 977–997. <https://doi.org/10.1007/s11191-007-9084-8>
- Kopnina, H. (2013). Evaluating education for sustainable development (ESD): Using ecocentric and anthropocentric attitudes toward the sustainable development (EAATSD) scale. *Environment, Development and Sustainability*, *15*(3), 607–623. <https://doi.org/10.1007/s10668-012-9395-z>
- Kouppanou, A. (2020). Environmental education and children's agency at the time of the Anthropocene. *Journal of Philosophy of Education*, *54*(4), 944–959.

- Kowasch, M., Cruz, J. P., Reis, P., Gericke, N., & Kicker, K. (2021). Climate youth activism initiatives: Motivations and aims, and the potential to integrate climate activism into ESD and transformative learning. *Sustainability*, *13*, 11581. <https://doi.org/10.3390/su132111581>
- Lawy, R., & Biesta, G. (2006). Citizenship-as-practice: The educational implications of an inclusive and relational understanding of citizenship. *British Journal of Educational Studies*, *54*(1), 34–50. <https://doi.org/10.1111/j.1467-8527.2006.00335.x>
- Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using NVivo. *School Psychology Quarterly*, *26*(1), 70–84. <https://doi.org/10.1037/a0022711>
- Levinson, R. (2022). Teaching SSIs: An epistemology based on social justice through the meta theory of critical realism. In Y.-S. Hsu, R. Tytler, & P. J. White (Eds.), *Innovative Approaches to Socioscientific Issues and Sustainability Education*. (pp. 367–379). Springer Nature.
- Levinson, R. (2018). Introducing socio-scientific inquiry-based learning (SSIBL). *School Science Review*, *100*(371), 31–35.
- Levinson, R., & The PARRISE Consortium. (2017). Socio-scientific inquiry-based learning: Taking off from STEPWISE. In L. Bencze (Ed.), *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments*. *Cultural Studies of Science Education* (vol. 14). Springer. https://doi.org/10.1007/978-3-319-55505-8_22
- Lewis, A. (1992). Group child interviews as a research tool. *British Educational Research Journal*, *18*(4), 413–421.
- Mackey, G. (2012). To know, to decide, to act: the young child's right to participate in action for the environment. *Environmental Education Research*, *18*(4), 473–484. <https://doi.org/10.1080/13504622.2011.634494>
- McCorristine, S., & Adams, W. M. (2020). Ghost species: Spectral geographies of biodiversity conservation. *Cultural Geographies*, *27*(1), 101–115.
- McLeod, J. (2011). Student voice and the politics of listening in higher education. *Critical Studies in Education*, *52*(2), 179–189. <https://doi.org/10.1080/17508487.2011.572830>
- Monte, T., & Reis, P. (2021). Design of a pedagogical model of education for environmental citizenship in primary education. *Sustainability*, *13*(11), 6000. <https://doi.org/10.3390/su13116000>
- Montgomery, L. N., Gange, A. C., Watling, D., & Harvey, D. J. (2022). Children's perception of biodiversity in their school grounds and its influence on their wellbeing and resilience. *Journal of Adventure Education and Outdoor Learning*, *1–15*, 1. <https://doi.org/10.1080/14729679.2022.2100801>
- Morin, O., Simonneaux, L., Simonneaux, J., Tytler, R., & Barraza, L. (2014). Developing and using an S3R model to analyze reasoning in web-based cross-national exchanges on sustainability. *Science Education*, *98*(3), 517–542. <https://doi.org/10.1002/sce.21113>
- Natural England. (2020). Nationally important wildflower grasslands get increased protection. Available at: <https://www.gov.uk/government/news/nationally-important-wildflower-grasslands-get-increased-protection>. Accessed 12/9/2024.
- OECD. (2023). PISA 2025 Science Framework (draft), May 2023. Available at: <https://pisa-framework.oecd.org/science-2025/>. Accessed 12/09/2024.
- Ojala, M. (2012). Regulating worry, promoting hope: How do children, adolescents, and young adults cope with climate change? *International Journal of Environmental and Science Education*, *7*(4), 537–561.
- Otto, S., Evans, G. W., Moon, M. J., & Kaiser, F. G. (2019). The development of children's environmental attitude and behavior. *Global Environmental Change*, *58*, 101947. <https://doi.org/10.1016/j.gloenvcha.2019.101947>
- Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, *47*, 88–94. <https://doi.org/10.1016/j.gloenvcha.2017.09.009>
- Park, W. (2020). Beyond the 'two cultures' in the teaching of disaster: Or how disaster education and science education could benefit each other. *Educational Philosophy and Theory*, *52*(13), 1434–1448. <https://doi.org/10.1080/00131857.2020.1751126>
- Park, W., Lee, H., Ko, Y., & Lee, H. (2023). "Safety" and "integration": Examining the introduction of disaster into the science curriculum in South Korea. *Journal of Curriculum Studies*, *55*(5), 580–597. <https://doi.org/10.1080/00220272.2023.2239887>
- Pihkala, P. (2017). Environmental education after sustainability: Hope in the midst of tragedy. *Global Discourse*, *7*(1), 109–127. <https://doi.org/10.1080/23269995.2017.13004>
- Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship: Teaching socio-scientific issues*. McGraw-Hill Education (UK).
- Rousell, D., & Cutter-Mackenzie-Knowles, A. (2020). A systematic review of climate change education: Giving children and young people a 'voice' and a 'hand' in redressing climate change. *Children's Geographies*, *18*(2), 191–208. <https://doi.org/10.1080/14733285.2019.1614532>

- Sadler, T. D., Barab, S., & Scott, B. (2007). What do students gain by engaging in socioscientific inquiry? *Research in Science Education*, 37(4), 371–391.
- Sarid, A., & Goldman, D. (2021). A value-based framework connecting environmental citizenship and change agents for sustainability—Implications for education for environmental citizenship. *Sustainability*, 13(8), 4338.
- Sass, W., Boeve-de Pauw, J., Olsson, D., Gericke, N., De Maeyer, S., & Van Petegem, P. (2020a). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education*, 51(4), 292–305. <https://doi.org/10.1080/00958964.2020.1765132>
- Sass, W., Quintelier, A., Boeve-de Pauw, J., De Maeyer, S., Gericke, N., & Van Petegem, P. (2020b). Actions for sustainable development through young students' eyes. *Environmental Education Research*, 27(2), 234–253. <https://doi.org/10.1080/13504622.2020.1842331>
- Schafer, L., Jorks, P., Seck, E., Koulibaly, O., & Diouf, A. (2021). Slow-onset processes and resulting loss and damage—An introduction. *Berlin: Germanwatch eV Retrieved January, 9, 2022*. Available at: https://www.germanwatch.org/sites/default/files/FINAL_Slow-onset%20paper%20Teil%201_20.01.pdf. Accessed 12/09/2024.
- Schild, R. (2016). Environmental citizenship: What can political theory contribute to environmental education practice? *The Journal of Environmental Education*, 47(1), 19–34. <https://doi.org/10.1080/00958964.2015.1092417>
- SDSN & IEEP. (2019). *The 2019 Europe Sustainable Development Report. Sustainable Development Solutions*. Network and Institute for European Environmental Policy: Paris and Brussels. Available at: <https://sdgghub.com/project/2019-europe-sustainable-development-report/>. Accessed 12/09/2024.
- Selby, D., & Kagawa, F. (2013). Climate change in the classroom. Paris: UNESCO. Available at : <http://unesdoc.unesco.org/images/0021/002197/219752e.pdf>. Accessed 12/09/2024.
- Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of Bildung. In Y. J. Dori, Z. R. Mevarech, & D. R. Baker (Eds.), *Cognition, Metacognition, and Culture in STEM Education. Innovations in Science Education and Technology*, vol 24. Springer, Cham. https://doi.org/10.1007/978-3-319-66659-4_4
- Sjöström, J., Eilks, I., & Zuin, V. G. (2016). Towards eco-reflexive science education. *Science & Education*, 25, 321–341. <https://doi.org/10.1007/s11191-016-9818-6>
- United Nations Framework Convention on Climate Change. (2012). Slow Onset Events - Technical Paper. Available at: <https://unfccc.int/resource/docs/2012/tp/07.pdf>. Accessed 12/09/2024.
- Väliverroinen, E., & Hellsten, I. (2002). From “burning library” to “green medicine”: The role of metaphors in communicating biodiversity. *Science Communication*, 24(2), 229–245. <https://doi.org/10.1177/107554702237848>
- Valladares, L. (2021). Scientific literacy and social transformation. *Science & Education*, 30, 557–587. <https://doi.org/10.1007/s11191-021-00205-2>
- van Harskamp, M., Knippels, M. C. P. J., & van Joolingen, W. R. (2022). Sustainability issues in lower secondary science education: A socioscientific, inquiry-based approach. In Y. S. Hsu, R. Tytler, & P. J. White (Eds.), *Innovative Approaches to Socioscientific Issues and Sustainability Education. Learning Sciences for Higher Education*. Springer. https://doi.org/10.1007/978-981-19-1840-7_11
- van Harskamp, M., Knippels, M.-C.P.J., & van Joolingen, W. R. (2021). Secondary science teachers' views on environmental citizenship in The Netherlands. *Sustainability*, 13(14), 7963. <https://doi.org/10.3390/su13147963>
- Watts, M., & Ebbutt, D. (1987). More than the sum of the parts: Research methods in group interviewing. *British Educational Research Journal*, 13(1), 25–34. <https://doi.org/10.1080/0141192870130103>
- WWF (2022) *Living Planet Report 2022 – Building a naturepositive society*. In R. E. A. Almond, M. Grooten, D. Juffe Bignoli, & T. Petersen (Eds.). Switzerland. Available at: <https://livingplanet.panda.org/en-GB/>. Accessed 12/09/2024
- Zangori, L., Ke, L., Sadler, T. D., & Peel, A. (2020). Exploring primary students causal reasoning about ecosystems. *International Journal of Science Education*, 42(11), 1799–1817. <https://doi.org/10.1080/09500693.2020.1783718>