The impact of a biodiversity focussed outdoor learning programme in school grounds on primary school children's mood, wellbeing, resilience, connection to nature, knowledge, and perception of nature

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Declaration of authorship

I, Louise Neilson Montgomery, hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

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Abstract

A connection with nature is largely established during childhood and children are more inclined to build a connection to what is familiar to them. However, the opportunity for children to familiarise themselves with local wildlife has reduced due to urbanisation and classroom-based lessons. Natural habitats within school grounds can house a variety of species but there is a gap in knowledge on the advantages that direct exposure to nature during outdoor education within school grounds can have on children's wellbeing and environmental attitudes.

Investigations involving 1,253 primary school children (8-12 years old) were carried out to explore the impact of weekly hands-on nature engagement activities in school grounds on children's mood, wellbeing, resilience, connection to nature, knowledge and perception of nature. The activities focused around discovering and monitoring species, and creating new habitats and food sources. The activities were designed to be carried out in school grounds regardless of size and ecological quality and focussed on invertebrates and vertebrates.

Questionnaires, focus-groups, quizzes, personal meaning maps and drawings were completed by the children before and after the set of activities to assess their wellbeing, resilience, connection to nature, knowledge and perception of nature. I identified that children who participated in these activities had significant improvements in their mood and wellbeing, which were sustained throughout the academic year. Additionally, children who started with low wellbeing, resilience or connection to nature were positively impacted; while control children who did not participate in the activities showed no significant improvement. Moreover, children's knowledge and perception of nature were found to significantly change. Negative perceptions and false knowledge of taxa were found to decrease following the activities and children developed more accurate identification skills and understanding of local biodiversity. Finally, children and teachers shared the positive impacts the outdoor sessions had on teaching confidence, learning experience and their relationship with nature.

Integrating nature engagement into school curriculum could improve children's educational experience and provide a low-cost method for improving their psychological wellbeing and resilience while allowing children to develop a greater awareness and connection to the natural environment around them.

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1.1 Introduction

The natural environment and biodiversity have played important roles throughout human history (Mayer et al., 2009). For centuries, not only have we gathered natural resources to carve out our modern way of living, but art, poetry and religion recognise that nature is at the forefront of our wellbeing (Bratman et al., 2012). Nature underpins human productivity and fecundity (Díaz et al., 2006; Hanski, 2005). Previous research has focused on the benefits that the natural world can provide to our wellbeing through the supply of resources such as the provision of freshwater; plants for nourishment, medicines and climate stability; filtering the air that we breathe and pollute; and providing economic value from ecosystem services (Díaz et al., 2006). Yet, as humans have had a close affinity to nature throughout evolutionary history (Maller & Townsend, 2006), modern scientific research is shifting to the benefits the natural environment offers for human wellbeing in its preserved state (Millennium Ecosystem Assessment, 2005).

Following the desolation of natural areas for agricultural production, urbanisation and fuel, the Earth's ecosystems are increasingly degraded (Bratman et al., 2012.; Newbold et al., 2016). Through these anthropogenic activities, biodiversity and ecosystem services- what makes human life possible and enjoyable- are at considerable risk (Alves & Rosa, 2007). Genotypes, populations and species are vanishing at an alarming rate (Cardinale et al., 2012; Díaz et al., 2006) driving a global biodiversity decline which is one of the most urgent issues facing modern life (Fiebelkorn & Menzel, 2013; Hanski, 2005; Newbold et al., 2016). Currently, over 58% of global terrestrial land cover has lost over 10% of biodiversity. Thus, it is below the recommended safe levels of biodiversity for ecological systems to function effectively (Newbold et al., 2016) with the current rate of species extinctions estimated to be between 100 and 1000 times higher than the natural rate of extinction (identified through fossil data) and continues to grow (May et al., 1995).

The United Kingdom (UK) is one of the 'most nature-depleted countries in the world' with 56% of all species researched in the 'State of Nature' report to have declined over the past four decades (Hayhow et al., 2016) as a result of agricultural management, pollution, woodland management, hydrological change and invasive non-native species (Hayhow et al., 2019). Within this staggering decline, 40% of researched species show an extensive reduction in numbers and 15% of species on the current International Union for Conservation of Nature Red List are now recorded as extinct or threatened with extinction (Hayhow et al., 2016). As the UK has lost significantly more natural area than the global average, this may result in the ecosystem services struggling to meet modern resource demands and support human wellbeing (Newbold et al., 2016). Although urban areas make up only 7% of land space in the UK, 80% of the population live in this area leaving little space for wildlife to flourish and decreases the frequency children can directly interact with local biodiversity (Eastwood et al. 2017; UK National Ecosystem Assessment, 2011; Soga et al., 2018). Therefore, encouraging rewilding and nature enjoyment in urban areas such as parks, gardens and school grounds can promote the protection of these fast diminishing regions while engendering an appreciation of nature and benefiting human health (Lin et al., 2018; Maller et al., 2009).

Although humans value natural resources and landscapes for their economic and cultural value (Rea & Munns, 2017), nature also has an intrinsic value independent of humans in its preserved state (van den Born et al., 2018). The instrumental and hedonic value of nature continues to direct conservation efforts (European Commission, 2011). Educating the public on anthropogenic harm to the natural environment and the human health benefits received over the long term through the protection of ecosystems may slow the decline of biodiversity loss (Sousa et al., 2016). However, this approach can be inefficient to motivate change, with current educational outreach programs often preaching to the already ecocentric adults (Miller, 2005). Research suggests that humans demonstrate altruistic behaviour if they feel connected to someone or something (Frantz & Mayer, 2014). Therefore, it has been proposed that building a connection to nature at a young age can provide the foundation to slow the pace of biodiversity loss and reverse the environmental impacts over the long term (Arendt & Matthes, 2014; Fiebelkorn & Menzel, 2013; Frantz & Mayer, 2014). This development of an emotional affinity of nature can preserve it for nature’s sake, as well as humans.

It is well established that physical activity is essential for physical and psychological health, such as avoiding cardiovascular diseases (Roe et al., 2013) and mitigating anxiety and depression (Gascon et al., 2015; Penedo & Dahn, 2005). However, modern life of long sedentary desk hours and low physical activity resulting from technological advances have resulted in poor mental and physical health (Huybrechts, De Bourdeaudhuij, & De Henauw, 2011; Inyang, & Okey-Orji, 2015). Previous research has identified that low physical exertion, such as walking within natural surroundings can produce positive effects to wellbeing over as short a time frame as fifteen minutes. Thus, combining nature and low physical activity has more benefits for wellbeing synergistically as opposed to when carried out individually (Barton, Griffin, & Pretty, 2012; Han, 2017), highlighting the need to preserve urban natural areas for human health.

Similarly, informal direct contact with nature, such as living in rural environments, can lead to enhanced biological knowledge development (Longbottom & Slaughter, 2016). Additionally, outdoor education has been identified to help consolidate information learnt within the classroom (Kuo, Browning, & Penner, 2018). Despite this, children are embracing nature less due to parental outdoor safety fears, time constraints of curricula, and the lack of teacher confidence in outdoor education (Dillon et al., 2006; Leather & Quicke, 2010; Lindemann-Matthies et al., 2010). Childhood play within nature has been suggested to indicate whether people are more likely to participate in outdoor recreational activities as they get older (Bixler et al., 2002). Moreover, nature engagement from a young age has been found to support ecocentric beliefs and ecological values to preserve the environment and view the natural environment as calming (Ewert, Place, & Sibthorp, 2005; Lohr & Pearson-Mims, 2005). Hence, developing a connection to nature can aid overall wellbeing for both the planet and humankind (Navarro et al., 2020).

The objective of this literature review is to explore how reinstating a connection to nature in modern life can benefit humans on an emotional, physical, and educational level while ensuring the future for declining wildlife. The various means humans have become disconnected from nature will be discussed, and the benefits of nature engagement to mental and physical health and overall wellbeing. Further to this, the advantages of outdoor education will be explored, and how children’s academic performance is impacted through instilling a connection to nature, as well as a critique on the confounds involved with research on people and nature. Finally, it will assess how preserving and engaging with nature is an asset for humans and the natural world alike.

1.2 Human Detachment from Nature

Currently, over half of the world’s population live in urban areas dominated by anthropogenic objects and depleted natural elements. People living in towns and cities are expected to increase to two-thirds of the world population by 2050 (United Nations, 2014). Yet, many developed countries have already surpassed this figure, with 80% of the UK population living in urban areas (Eastwood et al., 2017). As the number of inhabitants in built-up areas grow, urban expansion drives the decline in wild space resulting in habitat loss and threatening native biodiversity (Dallimer et al., 2012; Seto, Güneralp, & Hutyra, 2012), reducing the contact humans have with nature.

At the same time, population growth has resulted in deforestation, water pollution, carbon emissions, rapid agricultural intensification and climate change (Bradshaw et al., 2010; Weber & Sciubba, 2019) which has added to the impact on biodiversity loss due to disruption of areas for suitable habitats. Habitat loss results in minimal green areas remaining for species in these high-density urban areas, which are often highly fragmented; ultimately limiting species dispersal (Hanski, 2005; Hayhow et al., 2016), feeding and breeding (Benton et al., 2003). An example of this is the skylark (*Alauda arvensis*) which have small territory density in urban areas and such low reproductive productivity that they require multiple nesting attempts annually to maintain their population (Loretto, Schöll, & Hille, 2019; Wilson et al., 1997). Furthermore, a homogenising effect on biodiversity in urban areas takes place in these human-dominated areas due to few locations remaining for native species to thrive. These human-inhabited areas are often dominated by non-native species (Dearborn & Kark, 2010; Miller, 2005) as only 8% of native bird species, and 25% of native plant species are found remaining in built-up areas (Aronson et al., 2014). This highlights that nature degradation leads to a decline in the opportunity humans have to interact with a diverse natural world.

Alongside the urban expansion, humans are commonly disconnected from nature, referred to as the ‘extinction of experience’ (Pyle, 1993) due to the rise of sedentary lifestyles (Soga & Gaston, 2016); following the development of technology and smartphones (Hughes et al., 2018; McCurdy et al., 2010; Wen et al., 2009), busy schedules, and safety fears (O’Brien & Murray, 2007). The extinction of experience may result in each generation passing on less experience and knowledge of the natural environment, resulting in ‘generational amnesia’ (Kahn, 2002). This can lead to future environmentalists and policymakers depreciating the value of the natural environment and shifting baselines (Bird, 2007; Dearborn & Kark, 2010; Papworth et al., 2009).

The extinction of experience in the younger generations has resulted from the most common nature experience taking place indoors through technological entertainment (Dorward et al., 2016; Hughes et al., 2018; Moss, 2012). A study conducted in southern England found that only 32% of the population spent time in the natural environment (Cox et al., 2017). Further to this, previous research by Wen et al. (2009) identified that 37% of children spent (Cox, Shanahan, et al., 2017) less than thirty minutes playing outside after school, while 43% spent more than two hours a day in front of televisions or computers. The screen time identified in this study is higher than the amount recommended by the American Academy of Paediatrics (Council on Communications and Media, 2016) and of particular concern following the World Health Organisation (WHO) (2018) classification of video gaming addiction as a mental health disorder. These studies strengthen research carried out by the Royal Society for the Protection of Birds (RSPB) that suggests only 21% of 8 to 12-year-old children in the UK have a connection to nature deemed appropriate. This target level of children's nature connection is based on the average nature connection of children visiting nature reserves and who have an RSPB junior membership (RSPB, 2013).

These previous studies also highlight a large discrepancy between generations, as Natural England identified only 10% of children frequently play in natural areas, compared to 40% in the 1970s (Natural England, 2009b). Children's play environments have changed greatly compared to previous generations due to parental and social fears of strangers and road traffic (Gill, 2007; Pretty et al., 2009). These fears have led to an increase in supervised outdoor play, which takes place mainly in synthetic playgrounds, resulting in the diminishment of spontaneous, direct contact with nature and opportunity to develop independence, teamwork and language through imaginative and creative play (Brussoni et al., 2015). However, through evolution, humans have an innately emotional affiliation to other living organisms and plants, referred to as biophilia (Wilson, 1984). Children require these first-hand experiences of seeing, touching and smelling nature to develop an emotional bond in their early years, as well as foster an understanding of it (Tunnicliffe & Reiss, 2000).

Modern education of young children further reflects the loss of interaction with nature, as the publishers of the Oxford Junior Dictionary have removed nature words, such as 'acorn', 'buttercup' and 'conker' with 21st-century terms, such as 'attachment', 'blog' and 'chatroom' (Lowman & Randle, 2009; Robbins, 2015). Dictionaries enable knowledge expansion, but with nature terms dismissed in children's dictionaries, further extinction of experience will be observed in younger generations (Soga & Gaston, 2016). If people do not grow up engaging with and learning about nature, they may not want to spend time in, nor protect what they do not know (Frantz & Mayer, 2014; Keniger et al., 2013; Soga & Gaston, 2016).

Nature engagement has additionally been marginalised from children's education as urban areas expand due to city councils selling-off school playing fields for redevelopment (Education & Skills Funding Agency, 2018). This has resulted in smaller school grounds with predominantly concrete areas and little vegetation (Bilton, 2014a; Paddle & Gilliland, 2016), which further facilitates a reduction in children connecting with nature. As children spend a great deal of time in school during their childhood, it is key to ensure that the remaining areas in schools can become greener to reconnect children with the natural world and provide a sustainable future (Dearborn & Kark, 2010; Leonard, 2010; Maller et al., 2009). Previous research has shown that there is a positive correlation between nature connectedness and conscious pro-environmental behaviours. In contrast, implicit nature connectedness was positively correlated with environmental actions that were spontaneous (Geng et al., 2015).

Many organisations have developed activities and awards to encourage schools to include nature engagement in school time. Examples of these include the RSPB Big Schools' Birdwatch (RSPB, 2019); The Wildlife Trusts 30 Days Wild and Nature-Friendly Schools (Richardson et al., 2016; The Wildlife Trust, 2019); and the Woodland Trust Green Tree Schools Award (The Woodland Trust, 2019). These activities and awards are designed to encourage teachers to inspire pupils about nature alongside the curriculum. If the disconnection from the natural world continues in the younger generations, this extinction of experience may exacerbate the decline in the state of nature worldwide (Miller, 2005) without positive environmental behaviour adopted for adulthood (Kuo et al., 2018).

Ultimately, the 'extinction of experience' can lead to 'nature deficit disorder' (NDD); a metaphor to describe young people's detachment from the natural world (Louv, 2008). Although NDD is not a medical diagnosis, NDD is stemmed from attention deficit disorder (ADD). Nature engagement can be used as a method to reduce symptoms of ADD as nature disconnection can lead to the curtailed use of senses, and thus emotional, cognitive, and physical difficulties as children develop (Bragg et al., 2013; Louv, 2008).

The diminishment of innate curiosity resultant from NDD and the extinction of experience, has led to many children now unable to identify common animals and plants such as a magpie (*Pica pica)* and buttercup (*Ranunculus acris*); yet can identify popular television characters and company logos (Balmford et al., 2002; Moss, 2012). Nevertheless, research conducted by Balmford et al. (2002) identified that despite the decrease in identification skills of native wildlife in the UK, children still have great abilities to learn about new creatures and identify them. Balmford et al. (2002) discovered that children from 109 UK schools were able to identify an average of 78% of cartoon Pokémon species at age 8, up from 7% at age 4. While, for wildlife species, correct identification increased from 32% at age 4 to only 53% at age 8. This suggests that children spend more time engaging with nature at a younger age, reflective in nursery free play and forestry schools (Muñoz, 2009). However, as children get older, technology becomes more accessible, and children have a more structured and scheduled lifestyle. This has resulted in children growing up with a lack of free time to explore the outdoors causing isolation from nature and a loss of knowledge of the natural environment; and so children only develop interests and concern for what they are aware of and are frequently exposed to (Frantz & Mayer, 2014; Keniger et al., 2013; Soga & Gaston, 2016).

Children are inclined to build an emotional attachment to what they understand as well as what is familiar to them (Bilton, 2014b). If the 'extinction of experience' continues in younger generations, a fear of nature termed 'biophobia' (Ulrich, 1984), will be more common than a love for nature, 'biophilia' (Wilson, 1984). Adults and children develop fears of nature and venturing outdoors when they are not able to experience nature frequently (White, 1998), and this can be passed down generations (Soga et al., 2020). Previous large-scale research in Japan on biophobia towards invertebrates (through the use of photographs) has suggested the phenomenon among children will increase as more generations grow up in urban areas lacking these daily nature interactions, and lead to a continued cycle of negative feelings towards nature in the future generations (Soga et al., 2020).

Despite the growing concern of the extinction of experience, it is believed that due to human's evolutionary close bond with nature, children are born with an inherent nature-based genetic coding and a natural sense of relatedness to nature (Kellert & Wilson, 1993). This instinct needs to be nurtured throughout their early development and education to ensure empathy and a sense of oneness with nature grows throughout their childhood and maintained into adulthood (Barthel et al., 2018; Chawla, 2007; Wilson et al., 1997).

1.3 Reforming a Bond with Nature

Individuals are unlikely to care for nature if they do not understand it, nor help it if they are not passionate about it (Dearborn & Kark, 2010). Instilling a connection to nature before the age of eleven has been identified to be a reliable indicator of growing up as environmentally responsible (Wells & Lekies, 2006); as well as actively engaging with nature to fulfil a healthy lifestyle (Chawla, 2007; Thompson et al., 2008), whilst being attuned to the beauty of nature (Zhang et al., 2014). Connection to nature describes the degree to which one feels close to nature and to what extent individuals view themselves as a component of the natural world (Arendt & Matthes, 2016; Schultz, 2002). There is a growing need for wildlife education in young people to reinstate a passion for nature due to their lack of first-hand experience with biodiversity (Dearborn & Kark, 2010) and predominantly classroom-based learning to accommodate a demanding curriculum (Dillon et al., 2006; Leather & Quicke, 2009; Lindemann-Matthies et al., 2011). Previous research through tests and questionnaires have identified that a connection to nature is essential for pro-environmentalism (Geng et al., 2015) as if humans regard themselves as part of nature, they are less inclined to negatively impact the environment (Leopold, 1949). Surveys carried out in America by Mayer and Frantz (2014) support the suggestion that if humans feel a sense of empathy with nature, this will lead to more concern for the natural environment by possessing anti-consumerism values for a more ecological lifestyle.

Although technology has been criticised for further detaching people from engaging with nature (Wen et al., 2009), it has been debated that it can also allow those that may be unable to easily access natural environments or have different interests and abilities, to observe and learn about wildlife and habitats through online citizen science projects (Montgomery, 2017), while gaining acute health responses (Shanahan et al., 2015). Additionally, studies have found that watching videos of natural settings can improve concentration, mood and aid with reflecting on problems (Mayer et al., 2009). Previous studies suggest that nature documentaries positively impact the environmental attitudes of students (Barbas et al., 2009) and the recent nature documentaries have led to an increase in public concern of plastic pollution devastating our oceans (Marine Conservation Society, 2018) as well as increased tendency to donate towards animal and environmental organisations (Arendt & Matthes, 2014).

Moreover, the recent augmented reality (AR) smartphone game, Pokémon Go, has been suggested as an insight into using AR as a conservation opportunity (Dorward et al., 2016) as well as a tool to improve wellbeing and physical activity in the younger generations who are deemed poorly connected to nature (LeBlanc & Chaput, 2017; Yang & Liu, 2017). The game requires players to walk a distance of between 2 km and 5 km to explore new places and succeed in progressing in the game. This urged thousands of people to go outside and explore natural sites in search of the fictional Pokémon creatures. However, as the Pokémon creatures are centred around real species and their natural history concepts, such as being associated with different aquatic and terrestrial habitats and variations in abundance (Dorward et al., 2016), this enthusiasm can help people build a nature connection who would typically have no interest in venturing outside. Rangers in parks and reserves have been offering tours where both Pokémon and real species are searched for, observed, and talked about (Zachos, 2016) while also contributing to natural history citizen science projects and building an interest in exploring the natural environment.

Particular nature connections, for example with trees, have been noted to build a greater community bond and nature connection in urban developments (Wells, 2000) compared to areas that have few residential trees and more barren green areas. It is believed that the presence of residential trees can promote social interaction and reduce unwanted aggression and violence (Sullivan & Kuo, 1996). Trees in neighbourhoods have also been identified to support childhood play (Taylor et al., 2001) to a greater level than green areas without trees, presenting children with the opportunity to explore the outdoors more, critical for children's growth and development.

The level of neighbourhood green space available is also positively associated with the length and frequency people engage with nature due to increased opportunity (Soga & Gaston, 2016). Natural England, therefore recommended that everyone should have easy access by foot to high-quality natural greenspaces of at least 2 hectares in size within 300 m (5 mins walk) of their home (Natural England, 2010). Stigsdotter et al. (2010) identified in the 2005 Danish Health Interview Survey that respondents who lived in areas less than 300 m away from accessible green space were 1.42 times less probable to suffer from stress and more likely to visit green areas, than those living more than 1 km away. Therefore, close proximity to green space can improve health and wellbeing, whilst facilitating the development of an emotional attachment to outdoor activities (Neuvonen et al., 2007; Soga & Gaston, 2016; Soga et al., 2016). Natural environments local to residential areas can also lead to a spill over effect by encouraging species to colonise new areas through development of wildlife corridors and allowing people to connect more with nature, which can consequently lead to benefits for conservation as well as reducing extinction of experience and improving wellbeing (Dearborn & Kark, 2010; Pyle, 1993; Soga & Gaston, 2016).

1.4 Nature as a Buffer for Health & Wellbeing

Progressively, there has been a perception shift in the way the natural environment can impact on human health. Nature previously had a reputation of causing a health risk, for example from insect-borne diseases or allergens causing hay fever and asthma (Traidl-Hoffmann et al., 2003; Wilson, 2000). However, it is increasingly recognised that nature is an asset and acts as a buffer to long-term mental and physical health implications from environmental diseases caused by anthropogenic activities (Dearborn & Kark, 2010; Frumkin, 2001; Shanahan, et al., 2015). There is a wealth of research on how observing blue surface water (e.g. lakes, rivers and coastal waters); and green terrestrial areas (e.g. forests and parks), referred to as Blue Health (Grellier et al., 2017) and Green Health (Roe et al., 2013), can benefit human health and wellbeing (Gascon et al., 2015; Wells, 2000).

Spending more time in nature can often prevent people from remaining stationary (Muñoz, 2009). Obesity affects 25% of people in developed countries (Pretty et al., 2009) with younger generations more at risk, as one in every three children are classed as obese (Ludwig, 2007) following a rise in children spending more time in front of a screen and being less active outdoors (Wen et al., 2009). It has been suggested that contact with the natural world allows the synergistic health benefits of physical activity and nature contact to buffer mental ill-health and stress by allowing mental recuperation from work (Cox, et al., 2017; Dallimer et al., 2012; Han, 2017), whilst promoting low level activity for good physiological health.

Although long periods of screen time following the technology expansion have dramatically influenced a poor state of health in developed countries (George et al., 2018; Ludwig, 2007), the development of apps have also enabled researchers to explore natural and urban environments impact on wellbeing of participants through the use of the global positioning system (GPS) in smartphones. MacKerron and Mourato (2013) developed an app as a data collection tool which allowed 20,000 participants to log their momentary subjective wellbeing when they are randomly requested to answer a short questionnaire. This innovative method of data collection for large scale wellbeing research identified that on average the participants were significantly happier in outdoor green and natural environments compared to urban environments.

Green exercise has gained popularity in recent years following doctors successfully prescribing ‘green prescriptions’ in New Zealand (Hamlin et al., 2016). Due to the long-term success on patient’s health up to three years later following the green prescription, there is the petition to develop minimum-dose recommendations of nature, similar to that of fruit and vegetable consumption and physical exercise advice to produce flexible cost-effective health policies that suit a range of communities (Cox et al., 2017; Shanahan et al., 2015). This is due to research identifying that exercise in the presence of the natural environment can improve mood and self-esteem more so than those who exercise in artificial and uninspiring environments (Barton et al., 2012; Karmanov & Hamel, 2008) whilst simultaneously tackling physical ailments such as obesity and heart disease. Our Natural Health Service (ONHS) programme is currently in partnership with the National Health Service (NHS) Scotland to support health and wellbeing across communities and schools through transforming outdoor spaces for environmental engagement and green exercise (Nature Scot, 2020).

Prescribing green prescriptions within the UK has been identified to lead to 63% of patients being more active six to eight months after the initial prescription. Of these patients, 46% lost weight through the promotion of physical activity. This can lead to a reduction in hospital and GP visits, as an inactive person spends 37% more days in hospital and visits a doctor 5.5% more frequently (The Centre for Sustainable Healthcare, 2019). Therefore, promoting green prescriptions to supplement medical treatments (Robinson & Breed, 2019) can save time and money for the NHS, as it has been acknowledged that for every £1 spent on developing healthy walking schemes to support green prescriptions, then the NHS could save £7.18 through the prevention of mental and physical ailments (Natural England, 2009a).

Increasing green spaces in urban environments, particularly the number of trees, is a cost-effective initiative to improve public mental and physical health while reducing pollution in urban areas (Dearborn & Kark, 2010; Shanahan et al., 2015). Trees have a higher impact on carbon uptake in towns and cities compared to those outside urban areas. Encouraging the planting of trees in and around school grounds can reduce the toxic pollutants such as nitrogen dioxide (NO_2) which has been noted to be reaching unsafe levels within close proximity to Scottish schools. Further to this, NO_2 levels around schools have been identified to increase by 85% during term time compared to when schools are on holiday (Macaskill, 2017) as a result of school traffic. This highlights the benefits to younger generations for rewilding school grounds and retaining green urban areas in school playgrounds not only for nature engagement but to tackle major health complications from respiratory illnesses (Janssen et al., 2003).

The Woodland Trust has aided the rewilding of school grounds with the Food from Woods Partners which has resulted in many schools planting trees in their school grounds across

England. Through this project the Woodland Trust explored the impact of tree planting activities on the wellbeing of young people between ages 11 and 16 (Puttick & Hughes, 2012) with 113 children. The research identified that young people felt a self-transcendent purposefulness above any other wellbeing benefit through tree planting. Alongside this, the young people felt pro-environmental feelings and a sense of care for the natural world which had a positive impact on their wellbeing.

Similarly, through empirical studies, nature has been found to reduce stress and anxiety; and improve cognitive function and overall self-reported health (Groenewegen et al., 2012; Maas & Verheij, 2007). Health complications can be negated as nature can relax individuals resulting in a lower heart (Laumann et al., 2003) and respiratory rate; improve work performance by providing engaging stimuli without the requirement of mental effort and lead to a reduction in muscle tension due to improved mood. This, in turn, can lead to an improved immune system due to relaxing the sympathetic nervous system, referred to as the Psychophysiological Theory (Irvine et al., 2013). Research carried out by Tyrväinen et al. (2014) identified physiological and psychological improvements over the short term following visits to natural environments which had a positive impact on stress levels. This was identified through the reduction in salivary cortisol levels and perceived stress levels when compared to those in urban areas with less green space.

Throughout evolution, humans have had as much dependence on the natural world as they have with other humans (Hawkley & Cacioppo, 2010). Through the use of MRI scans, it has been noted that social rejection triggers the same sensory areas in the brain as physical pain (Kross et al., 2011). Humans are obligatorily social in order to survive, however having a connection to nature is also essential for self-care. Following studies into social and nature experiences, it was recognised that nature can counteract social rejection (Frantz, unpublished), as a connection to the natural world can provide a sense of belonging and buffers the feeling of ostracism through improving emotional wellbeing (Lovell et al., 2014; Poon et al., 2016). Fiske (2010) identified five fundamental core motives for human behaviour as a sense of belonging, understanding, control, esteem, and trust. When these fundamental motives are met through the natural environment and interaction with animals (Frumkin, 2001), the same sense of belongingness is felt as when in human social situations. This can enable a higher connection to nature through instilling a sense of belonging and fulfilling the five fundamental motives of human behaviour. Cox & Gaston (2018) found that those who fed garden birds recurrently felt more relaxed and felt a sense of belongingness to nature whilst feeling a sense of invested time was beneficial for the bird's welfare. This supports the idea that nature can reduce a sense of social isolation and improve overall mental and physical wellbeing.

Depression is now regarded as the leading cause of disability worldwide and can be the precursor of other chronic diseases (Reddy, 2010). Through previous research, it is accepted that the presence of public green urban environments, such as parks, can improve public health not only through encouraging exercise and mitigating the effect of pollution in cities (through the uptake of particles and gases), but it also provides a pleasant area for relaxation and socialising to benefit mental health and well-being (Cox et al., 2017a; Fuller et al., 2007; Keniger et al., 2013), as previously discussed. Increasing green areas in neighbourhoods can be a cost-effective method to reduce stress, anxiety and depression and relieve pressure on the NHS with annual mental health costs at £14.08 billion to NHS England (National Mental Health Development Unit, 2011); which will likely rise with the policy brief on the need for action on mental health from the United Nations following the impact of COVID-19 (United Nations, 2020).

Mental health issues affecting young people can impact on development and educational attainment (Patel et al., 2007; The Childrens Society, 2017). Over the past twenty-five years, rates of depression have soared in teenagers (Collishaw et al., 2004) with 40,000 children reported to be on antidepressants following a sharp rise in their use (Bird, 2007) alongside the technology expansion with easy access to the internet (Morrison & Gore, 2010) and increasing stress in young people from money concerns and exams (Andrews & Wilding, 2004; Collishaw et al., 2004; Maller et al., 2009). As there is a decrease in nature connectivity and increase in poor mental welfare, studies have identified that natural environments with a diversity of flora and fauna in public spaces leads to an increased well-being by allowing time for reflection and recuperation of cognitive function from mental fatigue and stress while drawing attention away from negative thoughts, referred to as the Attention Restoration Theory (Cox et al., 2017; Dallimer et al., 2012; van den Berg et al., 2010). However, as previously discussed, contact with nature at a young age does not merely affect immediate health and wellbeing but can be beneficial throughout a lifetime. Many social and environmental factors in childhood can influence later life and predict adult health and wellbeing (Bragg et al., 2013).

In past surveys conducted in Denmark, Italy and England, individuals have shown a positive response to increased levels of biodiversity, as the perceived number of bird, butterfly, and plant species have been identified to lead to positive wellbeing with reduced depression, anxiety and stress. Moreover, individuals have stated that the flora and fauna are an incentive to visit local green areas (Dallimer et al., 2012; Manzo & Devine-Wright, 2014; Schipperijn et al., 2010). Investigation shows individuals who spend less time embracing nature had worse cases of depression and anxiety compared to those who actively venture into the outdoors; however, this is hard to determine as this may be also due to depression influencing the likelihood of seeking out nature (Cox et al., 2017).

Whilst research has suggested that a higher perception of fauna and flora richness may lead to better wellbeing; biodiversity and abundance data also suggested an increase in wellbeing may be associated with a higher number of bird species and available natural habitats (Dallimer et al., 2012; Schebella et al., 2019; Shanahan, Fuller, et al., 2015). Research carried out by Cox et al. (2017) has identified that birdsong has the perception to aid attention restoration and stress recovery, and a level of 20-30% of vegetation cover in urban environments can limit anxiety and stress. It was noted that a higher level of vegetation and bird abundance was found to minimise mental illness (Cox et al., 2017; Dallimer et al., 2012; Keniger et al., 2013). In addition to these observations, students have commented that natural environments are seen as "restorative", enabling them to "forget[ing] worries" and has been regarded as "therapeutic" to help with sleep and gastro-related problems during childhood (Carrus et al., 2015; Korpela et al., 2001; Muñoz, 2009). These findings are consistent with later studies that identified young people with poor and disruptive behaviour benefitted the most from nature engagement activities due to the restorative values and reflection of personal goals (Roe & Aspinall, 2011) and led to the students having longer attention spans and less disruptive behaviour outside the classroom following a reduction in hyperactivity (Szczytko et al., 2018).

1.5 Impact of Nature on Educational Attainment

Wellbeing plays a large role in children's academic performance (Public Health England, 2014) as children who have a higher level of physical and mental health are likely to achieve better academic results. Associated with wellbeing concerns for younger generations, it has been identified that green space can reduce anxiety related to education and that young people may have a greater requirement to receive mental health benefits from green environments more than older age groups (Beyer et al., 2014; Cox et al., 2017; Keniger et al., 2013). Keniger et al. (2013) identified that activities developed around nature in schools have been established to have a positive impact on students' self-esteem and academic performance alongside their overall mental wellbeing. Children who also engage with natural environments regularly have more diverse motor fitness, coordination, balance and agility, and take less sick days from school (Fjørtoft, 2001), therefore indirectly improving their educational attainment due to missing fewer school days.

Regular contact with natural areas is vital for children to develop social, emotional, cognitive and motor skills (Groenewegen et al., 2012; Soga & Gaston, 2016) as well as aid classroom attention. In a recent study by Kuo et al. (2018), it was identified that classroom engagement improves following lessons carried out in nature resulting in improved classroom participation and academic performance due to teachers spending less time redirecting children's attention back to the lesson and enabling them to teach indoors for twice as long. In addition, physically engaging with different elements of the natural environment has been established to aid with brain development of young children, with outdoor recreation noted to positively impact educational attainment through improvement in problem-solving skills, core muscle strengthening and writing dexterity (Fjørtoft, 2001; McCurdy et al., 2010).

This view is similarly supported by a study conducted in Sweden, which found children who attended a day school and were allowed to play in areas surrounded by nature, such as woodlands, had better motor skills and concentration when compared to those that had a primarily human-made surrounding (Grahn et al., 1997). This suggests that there are many benefits to rewilding schools and ensuring children can engage with nature throughout their education. Further to this, views of nature from student housing have also been recognised to improve attention and self-discipline when compared to those in built-up areas (Wells, 2000). A long-term study looking at the pre-move and post-move of low-income urban children identified that those children who had an improved natural area immediate to the new location had the highest levels of cognitive functioning (Wells, 2000). Moreover, children's self-discipline is believed to play a key role in a student's academic performance (Taylor et al., 2001). Duckworth & Seligman (2006), suggest that grade eight girls outperformed boys across their core subjects due to higher levels of self-discipline, which was identified to be positively related to natural views they experienced nearer the home. A lack of self-discipline in boys related to the local green areas may be a result of boys typically spending more time playing further away from the home (Taylor et al. 2001).

Further to nature leading to improved cognitive functioning and self-discipline, nature engagement can benefit people with Attention Deficit Hyperactivity Disorder (ADHD), as symptoms have been found to significantly decrease when surrounded by the natural environment and enables ADHD children to concentrate better after nature contact, compared to outdoor urban environments (Beyer et al., 2014; Cox et al., 2017; Paddle & Gilliland, 2016). Furthermore, Taylor et al. (2001), identified that a walk in a natural park for a period of twenty minutes was comparable to the attention improvement observed when taking ADHD extended-release methylphenidate medication, which was not seen when walking in an urban environment.

As previously discussed, engaging children with nature before the age of eleven is important to ensure environmental responsibility as it is less successful to alter environmental attitudes as children mature (Wells & Lekies, 2006; Clayton, 2003). Research by Braun and Dierkes (2017) conducted in primary and secondary schools in Singapore with pupils aged between seven and eighteen identified that children of the ages of seven to nine achieved the most improvement in connectivity to nature after a direct experience with nature. It was also established that children of younger age groups responded best to continuous nature interventions (nature engagement activities) while teenagers responded best to a one-day intervention.

It is a widely held view that daily contact with nature in young people decreases as they progress through their education due to micromanagement of time and intense curriculum (Soga & Gaston, 2016). Past studies have noted that schools do not provide children (particularly younger ages) with understanding of the natural world (Patrick & Tunnicliffe, 2011) and children develop outdoor understanding mainly due to daily direct contact exploring the outdoors. Williams & Smith (2006) have identified that children who have grown up in more rural areas, with daily contact to the natural environment, have a deeper understanding of biological concepts compared to their peers in more urban areas. Therefore, it is important to consider that outdoor school interventions for children who spend less time outdoors than previous generations may directly gain knowledge and understanding from exploring nature (Longbottom & Slaughter, 2016), particularly for those in more built-up urban areas.

Californian schools have observed a 72% increase in school attainment following outdoor learning experiences which may be the result of greater cognitive abilities developed compared to those learning in the classroom (Dillon et al., 2006). In addition to this, the school attendance was higher which directly influences improved academic performance (Richardson et al., 2015). Klemmer et al. (2005) previously identified significantly higher test scores in science from pupils who partook in outdoor learning compared to those that had a traditional classroom-based experience. A study by Quibell et al. (2017) further supports these findings following a comparative study of a conventional classroom-based approach to an outdoor learning approach. The results show that those children involved in lessons in the natural environment had a significant improvement in their reading, writing and mathematics following these ‘hands on’ practical outdoor activities.

Outdoor education is increasing across the UK by means of Forest Schools (O’Brien & Murray, 2007a; Swarbrick et al., 2004). Forest School is a specialised outdoor learning approach with hands-on experiences in woodlands or natural environments with trees to increase contact and awareness of the natural environment (Forest School Association, 2019). However, while outdoor education has received more attention over recent years, the national curriculum has resulted in school schedules becoming increasingly busy (Dillon et al., 2006; Leather & Quicke, 2010; Lindemann-Matthies et al., 2011), taking time away from learning through the natural environment. This is in spite of research conducted on the benefits of forestry school and outdoor learning through engagement with nature ensuring cognitive and emotional restoration more so than learning in the classroom (Roe & Aspinall, 2011) while developing confidence, physical skills, knowledge and understanding (Fisher, 2001; O’Brien & Murray, 2007). Similarly, the national curriculum has removed a great deal of scientific fieldwork as well as the awareness of sustainable living , which has led to a reduced understanding the impact humans have on the environment and is particularly threatening for the field of ecology and future environmentalists.

There is the opportunity with outdoor education to consolidate information learnt in the classroom as research conducted by Natural England identified that different subject areas can be covered through outdoor education (Rickinson et al., 2012). An environmental focused curriculum has also been shown to lead to higher attainment in mathematics, languages, science and arts following outdoor experiences (Quibell et al., 2017). Additionally, research conducted in Ireland found that outdoor science learning days focused on invertebrates, habitats and food chains aided in children’s scientific knowledge (Kerr, 2016). However, despite these opportunities, the lack of support for teachers through training to enable their confidence have restricted them from using outdoor learning (Kuo et al., 2018; Passy et al., 2019), as well as restraints such as timetabling and risk assessments. Risk assessment fears are sometimes overemphasised and can be counterproductive as a result of children now believed to be suffering from a lack of ability to confidently explore new domains, however, outdoor education such as in Forest Schools encourages children to assess the likelihood of risk themselves (Gill, 2007; Savery et al., 2017).

The use of citizen science projects and materials can aid teachers to connect children to the natural world while contributing to education (Kobori et al., 2016; Wals et al., 2014), as well as instil teachers with confidence to use the natural environment as an educational tool to consolidate information that may be difficult to deliver in the classroom, as done through some forestry school training (Fisher, 2001; O'Brien & Murray, 2007). Using citizen science apps and materials, it can enable children to become more aware of nature and appreciate wildlife through the ability to identify species in their school grounds and neighbourhoods with the use of interactive apps that resonate with the younger generation. Further to this, engaging in these activities can promote subjective awareness and confidence in their knowledge of the natural environment to foster future environmentalists and ecocentric behaviour (Wyles et al., 2017).

1.6 Confounds in the Literature

Many studies discussed in the literature review lack appropriate controls and much involve observational and correlational studies (Paluska & Schwenk, 2000; White Eberstein, & Scott, 2018). Although variables may be correlated, it is possible that a confounding factor is responsible for the apparent result. A variety of confounds have the potential to influence the outcomes of research discussed in the literature review, and authors have attempted to address these in a variety of ways. Authors have acknowledged that the relationship between nature and people's health, wellbeing, attitudes, and educational attainment could be explained by confounds between the amount of time spent outside external to the studies, the social environment, the amount of physical activity, the types of activity, preference for nature, verbal and written ability and socio-economic and cultural background (Perrin & Benassi, 2009; Ulset et al., 2017; Mayer & Frantz, 2004).

Researchers have also used a combination of between and within-subject comparisons and controlled for demographic factors such as age, sex, and ethnicity, socio-economic status, as well as weather, daylight, crime, companionship, time and day (Cervinka, Röderer & Hefler, 2012; MacKerron & Mourato, 2013; Mueller at al., 2019). Furthermore, studies carried out investigating the impact of urban natural environments on health and psychological wellbeing controlled for visitor characteristics. Additionally, research conducted on children and within schools took into consideration the demographics of the children, socio-economic status, as well as the quality of the school and children's harmony with family. When considering children's connection to nature, the impact of nature engagement on children's behaviour, and attitudes; the researchers assessed the confounds of parental use of nature, and frequency parents visit natural environments with and without their children. Moreover, factors such as the availability of outdoor space in schools and time spent outdoors at schools were controlled for by authors. The researchers have considered the effect of these through a variety of techniques. These include selective sampling by ensuring the participants meet selection criteria, randomization, and statistical modelling; such as, including sociodemographic variables and predictors in the model (White, Eberstein, & Scott, 2018; Han, 2017; Howell et al., 2011).

1.7 Summary of Literature

Humans have never been more disconnected from the natural environment as much as they are now. Through the degradation of the natural environment for natural resources, it has impacted ecosystems and biodiversity, as well as our own wellbeing. To ensure a healthy future for humans and the environment, it is necessary to ensure the remaining wild areas are preserved and there is an effort into rewilding built-up urban environments. Humans value the resources that nature provides us through ecosystem services, yet it is vital to safeguard the natural world in its preserved state to allow humans to benefit through the means of a daily dose of nature and maintain our natural affinity for the environment and wildlife within.

As discussed in the literature, there is a plethora of benefits nature can provide to human health and wellbeing as well as educational attainment. As humans are innately interested in nature and benefit holistically throughout a lifetime, it is essential that children are immersed in exploring the natural world during their childhood to adopt a pro-environmental attitude for the future and avoid a disconnection with nature to prevent the value of the natural world from diminishing. Daily contact in local areas and promoting nature interaction through outdoor education can help tackle some of the major issues facing the environment and modern life; from educational attainment and wellbeing of younger generations, to physical health, social interactions and resilience throughout a lifetime. Using technology as a tool to promote and enable people to explore natural areas and the wildlife within can ensure that the extinction of experience is limited, whilst tackling the declining state of nature and human wellbeing in a way that will resonate throughout the modern generations.

1.8 Underlying Principle

This research explores children's and teachers attitudes to local wildlife and outdoor education while focussing on the mood, wellbeing, resilience, connection to nature, perception of nature and knowledge gain of the children and how they change through participation in an outdoor learning programme carried out in the school grounds.

Natural habitats within school grounds can house a variety of species. Still, there is a gap in knowledge on the advantages that direct exposure to nature during outdoor education within school grounds can have on children's wellbeing and environmental attitudes. Previous studies that have investigated human-nature relationships in children have involved activities centred around adventure games, forming positive group relationships without control groups, and focussing on the presence of neighbourhood nature, as opposed to interactions with it. However, the research in this thesis has concentrated primarily on first-hand engagement with nature and can more reliably infer this has been the benefit of nature engagement.

The primary reasons for considering the impact of nature engagement on wellbeing and education in younger generations is due to the current crisis in child wellbeing and global biodiversity. There is lack of outdoor education in schools and reduction in engagement with the natural environment in younger generations. As previously discussed in the literature, a connection to nature is largely forged during childhood. However, opportunities to explore the natural environment alongside the school curriculum are declining in England (Barker & Slingsby, 2002), leading to a reduced connection to nature as children progress through school (Tilling, 2018). This may result in reduced uptake of natural sciences later in children's school careers (Childwise, 2019), which some suggest has previously resulted in reduced economic growth and wellbeing (Grice and Hymans, 1994).

Fieldwork in the environmental sciences has particularly decreased in recent years (Tilling, 2018) resulting in children being 'turned off' science (Murphy and Beggs, 2003), particularly ecology (Tilling, 2018), when at school. The use of outdoor learning can consolidate information learnt in the classroom and allow children to foster an interest for the natural world whilst becoming aware of the importance of biodiversity. Additionally, through outdoor learning, children can gain species recognition skills and develop tools and an understanding to improve and maintain ecosystems for a sustainable future.

The loss of biodiversity is coincident with children's declining mental and physical wellbeing and reduced time spent interacting with the outdoors (Bragg et al., 2013). The impact of a lack of nature in our daily lives is well researched, focussing on the benefits of nature engagement on public health, wellbeing and environmental attitudes (for a review see Twohig-Bennett & Jones, 2018). If public connection to nature is to improve and ameliorate modern-day problems such as depression, obesity, and biodiversity loss, then the understanding and perspectives of younger children and their nature interactions with the outside world should be considered.

As research has suggested that attitudes influence children's understanding and interest in the natural world (Longbottom & Slaughter, 2016; Williams & Smith, 2006); it is vital to ensure children's pro-environmental perspectives are fostered during their school years in order for their interest and knowledge of the natural world to prosper in later life while supporting their wellbeing. School children are the future custodians of the natural environment; therefore, it is essential to encourage the younger generations to become interested in nature to ensure that environmental degradation does not continue (Hughes et al., 2018). The importance of considering children's attitudes towards nature and the knowledge gained from interacting with the outdoors is vital to ensure interest in the biological world for future pro-environmental behaviours and policymakers to protect ecosystem services for both nature and human's future wellbeing.

1.9 Research aims and questions

The main aim of the study was to explore how children's mood, resilience, wellbeing, knowledge and perception of wildlife and connection to nature change as the biodiversity in the school grounds is monitored through interactive biodiversity activities tailored to the curriculum. Detailed analysis on the children's demographics (such as gender, age cohort, year, and school) were included to investigate possible factors that may influence the findings.

The main research objectives were:

1) To determine if interactive biodiversity-focussed outdoor education activities improve children's mood, wellbeing, and connection to nature over the short and long term.
2) a) To determine children's perception of local biodiversity and explore whether their perception becomes more accurate with outdoor education.

   b) To determine whether children's perception of biodiversity influences their wellbeing, resilience, and connection to nature.

3) a) To determine children’s species identification skills, knowledge and perspectives of British taxa and whether outdoor education activities influence them.

b) To determine if the outdoor education programme influences teachers approach to teaching and has a ripple effect on the children’s educational experience.

4) To determine if children who have an education focussed around nature have better knowledge, attitude, connection to nature and wellbeing compared to children in the mainstream school system and are less impacted by invertebrate-focussed activities.

It was hypothesised that:

1) Engagement with nature would have psychological benefits with immediate short-term improvements in mood, and longer-term improvements on children’s wellbeing and connection to nature.
2) a) Children would initially have an inaccurate perception of local biodiversity through perceiving more vertebrates than invertebrates, however, after biodiversity focussed outdoor education activities, they would have a more accurate perception of local flora and fauna.

   b) Children who perceive high levels of biodiversity would have higher wellbeing, resilience, and connection to nature.
3) Children would have initially poor species identification skills and knowledge of British taxa, but to a greater degree for invertebrates and plants compared to vertebrates. Additionally, children would have more negative perceptions of invertebrates and plants compared to vertebrates before the biodiversity activities. However, perspectives and knowledge would become more positive and accurate after the outdoor education for all investigated taxa due to a reduction in biophobia.
4) Children from mainstream schools would have a lower connection to nature and wellbeing, as well as poor knowledge and more negative attitudes towards invertebrates; and as a result, would have greater beneficial impacts to their knowledge, attitude, connection to nature and wellbeing.

1.10 Study context

1.10.1 Defined terms

Throughout this thesis, mood, wellbeing, resilience, connection to nature, knowledge and perceptions are explored. Wellbeing is defined as the state of being in complete physical, mental, and social wellbeing. Mood can be deemed to come under the overarching term of wellbeing; however, within this thesis, the term mood explores how children felt at a particular time by measuring their emotions before and after each session. This allowed one to investigate the short-term impact of the outdoor education programme through measurement of mood as well as investigate long-term impact with wellbeing measurements. Resilience is important to examine with wellbeing as resilience demonstrates an individual's capacity to recover quickly from difficulties and therefore, is strongly linked to an individual's wellbeing.

The term connection to nature is defined as the closeness one feels to nature, the extent nature impacts them and how they view themselves as apart of nature. Connectedness to nature is closely linked to children's knowledge and perceptions of nature. Knowledge is defined as awareness or familiarity of a fact gained by experience or a situation. Perception is defined as the way in which something is regarded, understood, or interpreted. Therefore, these aspects were used to investigate the children's understanding and awareness of species and habitats and their attitudes to the natural environment.

1.10.2 Educational theory

A postpositive, social constructivist approach was adopted during this research as children's knowledge, perceptions and understanding of themselves and nature were not only measured but collected with the understanding that every child has their own individual experiences and learnings. Previous educational research has explored the cognitive elements of learning through observational and measurable actions. Analysis of cognitive and psychological research are expressed in a similar manner to that of scientific laws gathered from observations of natural phenomena (Cohen, Manion, & Morrison, 2000). The postpositivist perspective acknowledges that there is little to no objectivity with regards to researching people, as both the researchers and the participants are part of a construction of social reality; however, social reality is built in different ways by different people (Gall, Borg, & Gall, 2003). Therefore, an essential principle of postpositivist research is the value of using both qualitative and quantitative methods. Social constructivist perspectives additionally include the idea that as children have preconceived notions and understandings, developed from their personal experiences, they are actively fundamental to how they learn; and therefore build upon prior knowledge and experience (Falk, 2009). These social constructivist perspectives that developed throughout this research were, thus, inclusive of the prior knowledge and experience of the children.

1.10.3 Research approach

A pre-test, post-test approach was carried out to collect the data required to address the research questions. A mixture of quantitative and qualitative methods was used throughout the research involving established questionnaires, drawings, quizzes, personal meaning maps, semi-structured interviews, and focus groups. The use of mixed methods for the research of children's wellbeing, connection to nature, knowledge and perceptions allowed for triangulation (Patton, 1999) to increase the validity through verification from converging results (Heale & Forbes, 2013).

All data collected in this thesis was gathered over two years (September 2017 – June 2019) with a team of post-graduate and undergraduate volunteers. The data collection involved a total of 1359 primary aged children from 24 state and private schools in the South East of England. Across the UK overall, 7% of children are privately educated; however, this varies by region. For example, 25% of children are privately educated in Edinburgh, and over 12% of children are privately educated in the South East of England (Guide to Independent Schools, 2020). Of all independent schools, 54% of their pupils are educated in South Eeast England (*ISC, 2019*). Due to this, it is essential to include both state and privately educated children in the research, with 33% of children from private schools and 67% of children from state schools.

1.11 Structure of the thesis

This chapter presents an overview of the existing literature on the link between people and nature through four aspects. It considers how, as a society, we are detached from the natural environment more so now compared to previous generations; debates and outlines how people can become more connected to nature through various methods; presents an overview of how nature can benefit people's health and wellbeing across all age groups; and explores the benefits of nature contact for children and young people's educational attainment. Additionally, the chapter introduces the underlying principle of the research and discusses educational theory. Finally, the research aims, questions and study content are presented.

Chapter 2 presents an outline of the studies research methods employed to collect the data and justification of the approaches used, school participations, ethical considerations and educational theory behind the methodologies. Additionally, an overview of the studies undertaken are presented to summarise the time scales and dates the studies took place, the participants and school types involved as well as the activities carried out and the measures and analysis involved. Finally, the pilot studies carried out throughout the research are summarised to give an overview of the different pilot measures and findings.

Chapter 3 presents a published study with primary school children aged 8-11 years old, on whether a nature engagement programme within school grounds impacts their mood, wellbeing, and nature connection. The nature engagement programme was carried out weekly for one hour per week over 7 seven sessions per term, equating to 21 sessions throughout the academic year (September 2017 – June 2018). The study was a pre-post intervention design with data collected at the start and end of the academic year using established questionnaires to measure the three areas of interest. A control group of children were also involved and completed the wellbeing and connection to nature surveys at the start and end of the academic year but did not participate in the outdoor engagement programme.

Chapter 4 presents findings gathered over a full academic year (September 2018 – June 2019) involving primary school children aged 8-12 years of age. The children participated in outdoor biodiversity focussed nature engagement programme over a full academic year, which involved seven weekly one-hour sessions over the three terms. The study explores the children's perception of their school's biodiversity at the start and end of the academic year. The study investigated the accuracy of the children's awareness of biodiversity and how it relates to their wellbeing, resilience, and connection to nature. The children's biodiversity perception was assessed with the use of drawings and a biodiversity survey of the school grounds. The children's wellbeing, resilience and connection to nature was measured with the use of established questionnaires. A control group of children completed the established wellbeing, resilience, and nature connection questionnaires, as well as the biodiversity perception drawing before and after the academic but did not participate in the nature engagement programme.

Chapter 5 presents the results gathered over a full academic year (September 2018 – June 2019) involving primary school children aged 8-12 years of age. The children participated in a nature engagement programme in their school grounds. The programme ran over a full academic year, over 21 weeks with each session lasting a full hour. The sessions were carried out seven sessions per term to ensure the children were exposed to species across all seasons. The study explores the children's knowledge and attitudes towards charismatic and non-charismatic taxa groups, specifically mammals, birds, plants, and insects. The data was collected with the use of personal meaning maps and quizzes at the start and end of the academic year. The results explore the children's knowledge and attitudes towards the taxa at the beginning and end of the academic year and investigate how it changes after participating in the outdoor engagement programme. The results also present an evaluation that children and teachers completed post-intervention to explore how they felt the nature engagement programme impacted the pupils and teaching.

Chapter 6 presents a short-term case study of three different schools, a Froebelian ethos school, a mainstream state school and a mainstream private school. The Froebelian school integrates nature engagement and outdoor education throughout the curriculum, whereas the mainstream schools have a predominately classroom-based education. The investigation explored children's mood, wellbeing, connection to nature, knowledge, and perceptions of insects before and after a seven-week intervention over the summer term involving invertebrate activities. The data was gathered using established wellbeing, nature connection and mood surveys, and personal meaning maps to explore children's knowledge and perceptions of insects and how they changed following the intervention. Focus groups were also carried out with the children to explore how the children felt about nature and insects through an open question format to investigate avenues that could not be identified with closed answer questionnaires. Additionally, interviews were carried out with the teachers of each class to explore how they felt the intervention and outdoor education impacted their pupils and teaching.

Chapter 7 discusses the findings obtained from the short and long term studies, and how it has helped to fill gaps in understanding on children's knowledge and perception of nature and the impact outdoor education can have on their mood, wellbeing, resilience, nature connection, and knowledge and perception of local biodiversity. Conclusions are drawn and discussed in relation to previous research and the future of outdoor education. Finally, the strengths, contributions and limitations of the research are discussed and suggestions for future research are presented.

Chapter 2 : General Methods
Study system and participants

2.1 Outline of studies

To gather the data required to address the research objectives, qualitative and quantitative methods were used (questionnaires, semi-structured interviews, drawings, quizzes, and personal meaning maps (PMMs)). Multiple methods of data collection and sources of data for the study were gathered to build an understanding of the children's mood, resilience, wellbeing, knowledge, as well as perception and attitudes towards nature (See Appendices 4-14 for data collection measures used examples).

A mixed method approach is particularly important as children are all individual and learn in a variety of ways. Therefore, it is important to consider different methods to measure children's wellbeing, connection to nature, knowledge, and perceptions of nature through questionnaires, evaluation surveys, drawings, personal meaning maps and discussions. The way in which children learn, is an important aspect of this research. Social constructivism theory suggests that positive teaching and learning is dependent on the interpersonal experiences outside the classroom. Children can build upon their experiences and previous knowledge to develop ideas and ways of thinking about scientific concepts (Falk, 2009; Jafari Amineh & Davatgari, 2015). The methods of outdoor education within the thesis and methods used to investigate children's knowledge and perceptions allow the children to build on their prior knowledge and awareness by actively engaging with nature.

Table 2.1 displays an overview of the research studies undertaken from September 2017 to July 2019 to provide information on the timeline, participants, activities, measures, and analysis involved.

Table 2.1 An overview of the research studies undertaken

	Study			
	1 (Chapter 3)	2 (Chapter 4)	3 (Chapter 5)	4 (Chapter 6)
Dates	September 2017 to June 2018	September 2018 to June 20019	September 2018 to June 2019	May 2018 to July 2019
No. of participants	• 549 pupils: - 459 action pupils - 90 control pupils	• 752 pupils: - 509 action pupils - 243 control pupils	• 410 pupils • 15 teachers	• 58 pupils • 3 teachers
No. of schools and type	• 7 state • 4 private	• 7 state • 3 private	• 7 state • 4 private	• 1 state • 2 private
Activities	Seven sessions per term, for one hour each week, equating to 21 sessions in the full academic year. The activities focussed on major taxonomic groups including trees and other plants, fungi and lichens, mammals, birds, insects, other invertebrates, and amphibians.	Seven sessions per term, for one hour each week, equating to 21 sessions in the full academic year. The activities focussed on major taxonomic groups including trees and other plants, fungi and lichens, mammals, birds, insects, other invertebrates, and amphibians.	Seven sessions per term, for one hour each week, equating to 21 sessions in the full academic year. The activities focussed on major taxonomic groups including trees and other plants, fungi and lichens, mammals, birds, insects, other invertebrates, and amphibians.	Seven sessions over the summer term, for one hour each week, equating to 21 sessions in the full academic year. The activities focussed on the major taxonomic group of insects and involved monitoring and discovering invertebrate species.

Measures	• Mood survey: positive and negative effect schedule (PANAS) with seven positive and seven negative emotions on a Likert scale (α = 0.88). • Wellbeing questionnaire: Kidscreen-27 with 27 Likert questions (α= 0.80 to 0.84). • Connection to nature questionnaire: RSPB Connection to Nature Index with 12 Likert questions (α= 0.82).	• Wellbeing questionnaire: Kidscreen-27 with 27 Likert questions (α= 0.80 to 0.84). • Connection to Nature questionnaire: Nature Relatedness- 6 with six Likert questions (α= 0.77). • Biodiversity perception drawing: draw schools' biodiversity with larger size of item representing greater abundance.	• Wellbeing questionnaire: Kidscreen-27 with 27 Likert questions (α= 0.80 to 0.84). • Personal meaning maps of mammals, birds, insects, and plants. • Quizzes of mammals, birds, insects, and plants. • Evaluation questionnaire for teachers and children.	• Mood survey: positive and negative effect schedule (PANAS) with eight positive and eight negative emotions on a Likert scale (α = 0.88). • Wellbeing questionnaire: Kidscreen-27 with 27 Likert questions (α= 0.80 to 0.84) & Good Childhood Index with 16 Likert questions (α = 0.84). • Connection to nature questionnaire: RSPB Connection to Nature Index with 12 Likert questions (α= 0.82).

				• Insect personal meaning maps. • Focus group with children. • Interview with teachers.
Analysis	The effects of school type (private and state), sex (male or female), year group (year 4, 5, 6) and collection point (before and after) on children's mood, wellbeing, and nature connection (and subsections) questionnaires were examined with generalised linear mixed models to account for influential random effects of individual and school to identify the full simplified	The effects of school type (private and state), sex (male or female), year group (year 4, 5, 6) and collection point (before and after) on children's wellbeing, resilience and nature connection questionnaires, as well as taxa group drawings, were examined with generalised linear mixed models to account for influential random effects of individual and school to identify the full simplified	Before and after correct scores of quizzes were analysed with paired Wilcoxon signed-rank tests with Bonferroni correction with adjusted p-values (to control for multiple testing) for all children within themes and between themes. Generalised linear mixed models with Poisson error structure were used to assess the impact of demographic factors of year and school	The effects of school, gender and collection point (before and after) on the children's mood, wellbeing, connection to nature (and subscales), and PMM scores were analysed using generalised linear mixed models with Poisson error structure to account for influential random effects of individuals. Tukey post hoc tests were used to test

	model. Tukey post hoc test were done.	model. Mann-Whitney-Wilcoxon tests were used to explore the difference between before and after results of the control and intervention groups compared to actual biodiversity with Bonferroni correction and adjusted p-values cited (to control for multiple testing).	type on the fully correct quiz scores and PMMs.	the significance of each pairwise comparison.

2.2 School participation

Schools were recruited to take part in the project through headteachers and class teachers to have seven one-hour sessions per term. Schools were recruited from South East England in Surrey, Berkshire, Middlesex, and East Sussex. During September 2017 – July 2019, 23 schools were selected to participate throughout the academic years. The participating cohorts included co-educational state, independent and international schools.

The school year groups that participated were all within Key Stage 2 (KS2; school years 3 to 6 in England, aged between 7 and 11) and ranged from year 4 (age 8) to year 6 (age 11). KS2 is part of the National Curriculum in England which directs teachers on what topics to teach and to what level.

2.3 Ethical considerations

The study was conducted in adherence with the Data Protection Act (DPA) in 2017 and the new EU's General Data Protection Regulation (GDPR) from 2018 onwards. The ethical considerations in these investigations relate to conducting research with children in terms of parental consent, anonymity and privacy as well as preventing discomfort and maintaining the right to withdraw at any time.

2.3.1 Consent

Informed consent was given for the research gathered during the investigations. Prior to the law change in 2018 the participants (the children) gave consent through the 'opt-in' format (Appendix 3), while parents and guardians provided consent through the format of the 'opt-out' method (Appendix 2). The 'gatekeepers' (headteachers and teachers) provided written and verbal consent following the project being thoroughly discussed and outlined.

Following the GDPR coming into effect in 2018 for new schools and participants, 'opt-in' consent was gathered from all children, parents, and gate keepers. The level of detail in the information provided was appropriate for the age range of the participants (the children) and guardians to understand. The information provided (e.g. the parental consent form) was correct, appropriate, and accessible due to feedback and advice gathered from data protection and research specialists. The information provided included the research aims, an outline of the research method, the benefits of participation and confirmation that a research ethics committee has approved the project. Additionally, legal rights and safeguards were provided to the participants and how their personal information and data would be stored. Parents/ guardians were asked to consent to their child's participation in the research.

The children's consent can be challenging to gather if they do not understand what they are consenting to (Miller & Bell, 2002). Consequently, the project was explained to them in the terminology they could understand in both writing and verbally. The children were continuously advised they did not have to participate in any part of the research or activities if they did not want to and were able to ask any questions they may have at any time.

2.3.2 Anonymity and privacy

To ensure anonymity and privacy throughout the investigations, the children were assigned a unique identification (ID) code composed of their first and last initial, the day of their birth and their class (e.g. LM025C). The children were reassured throughout that nobody in the school or their parents would see what they said. The only people that would know the information were the researchers and codes would only be shared with teachers if there was the exception of detrimental information that breeched the child protection rights of a child. Headteachers, teachers, parents and children were reassured that each child, school, and data record would remain anonymous, stored, and destroyed in keeping with the DPA (1998), and later GDPR (2018).

2.3.3 Preventing discomfort and maintaining the right to withdraw

Throughout the research, every attempt was taken for the children to feel at ease. It was stated that the surveys the children were completing were not a test, and they did not have to complete any surveys if they 'did not want to'. The children were also told there were 'no right or wrong answers' throughout or if they 'did not know' an answer or were 'unsure' they could fill in what they thought was most suitable or leave the question blank. The researchers were also vigilant about non-verbal cues that may have suggested the children were feeling uncomfortable, did not want to continue or felt frustrated. Where any child did not want to complete surveys, they were reassured that they were still able to participate in the activities if they desired.

The children were also told they did not have to participate in any of the activities or could move away from an area that had any organisms that made them feel uncomfortable. It was also explained that the children were not in danger from any organisms that they were in contact with, and they were safe when carrying out any of the activities planned.

2.3.4 Biodiversity activities

The outdoor education activities were aimed at engaging pupils with local species and habitats in their school grounds through monitoring local wildlife and building new habitats and food sources (see Appendix 1). The activities were developed to be appropriate for all participating schools, irrespective of the environmental quality or size of the school grounds and allowed different themes to be explored through interlinking activities (e.g. planting wildflowers explored the theme of plants and pollinators; pond dipping explored invertebrates and amphibians). See Appendix 1 for weekly activities and further details.

The nature engagement activities began with a short PowerPoint presentation in the classroom to introduce the pupils to what they would be doing over the next hour and to ensure the intervention was standardised across activity leaders before starting the activity. The programme was delivered to the schools by the researchers with undergraduate student volunteers as support. All volunteers were Biological Science students who were trained prior to the sessions.

An outline of the different biodiversity engagement activities that were explored within the various categories (trees & other plants, lichens & fungi, mammals, birds, insects & other invertebrates, and amphibians) during the academic year are described below.

Trees & Other Plants: Tree surveys (Figure 2.1a) were conducted by the children over the different seasons to investigate different species and how they change over the seasons. Surveys were carried out specifically on tree health, height, girth, and the features of trees: the bark, deciduous or evergreen, buds, catkins, leaf structure (OPAL, 2019 Figure 2.1b). Native and non-native bluebells were studied to examine the difference in pollen and flower structure. Daffodil and lavender bulbs and wildflower seeds were planted to explore the life cycle of a plant and support pollinators.

(a) (b) (c)

Figure 2.1: Trees and other plants activities: (a) children conducting a tree survey on a common oak tree, measuring the girth, drawing around leaves and doing bark rubbings; (b) children conducting tree survey looking at buds and fruits on trees to identify the species; (c) daffodil bulbs planted in pots and secured onto stakes to make a vertical garden.

Lichens & Fungi: Deadwood and trees were investigated to look for fungi (Figure 2.2a) and lichen (Figure 2.2b) and to specifically investigate the fungi gill and lichen frond structures with phonescopes (mini microscopes attached to tablets; Figure 2.2c), and organisms that live within them. Cultivated mushrooms were placed in school grounds to investigate colonisation from organisms and explore fungi as a habitat. Different species of lichen were identified with OPAL guides and investigated as indicators of pollution and how they deter predators and avoid sunlight damage (OPAL Air Centre, 2005).

(a) (b) (c)

Figure 2.2: Lichen & Fungi activities: (a) bracket fungi growing on deadwood; (b) lichen fronds under phonescope; (c) children using phonescopes to look at structures closely.

Mammals: Hedgehog homes (Figure 2.3a) and hair and footprint tunnels (Figure 2.3b Background) were built to explore which species may have visited it. A mammal feeder (Figure 2.3b Foreground) was built with recycled materials to explore which species visited and fed on the different sources of food and to explore the different adaptation of mammalian skulls. Camera traps (Figure 2.3c) were put up to investigate native and invasive species in different areas of school grounds.

(a) (b) (c)

Figure 2.3: Mammal activities (a) hedgehog home built with waterproof plastic and insulated with soil and dry leaves on the outside and straw on the inside; (b) Background: Mammal footprint and hair tunnel made from recycled folded plastic and sticky back plastic to collect fur and foot prints; (b) Foreground: Mammal feeder made from recycled plastic dishes and hangers with different food sources; (c) camera trap footage of badger.

Birds: Bird tables (Figure 2.4a) and feeders (Figure 2.4b) were built by pupils with recycled materials. Using a camera trap, different food sources and colours were added to explore the difference in food preference and beak structure. Bird homes (Figure 2.4c) were made and hung up to create habitats. Bird aerodynamics were explored by looking at different wing structure and building their own paper birds. Point count bird surveys (Lynch, 1995) were carried out to look at the different species in their grounds. Bird calls of different species was investigated through call and response by playing species calls through speakers. Owl pellets (Figure 2.4d) were dissected to explore food chain structure.

(a)  (b) 

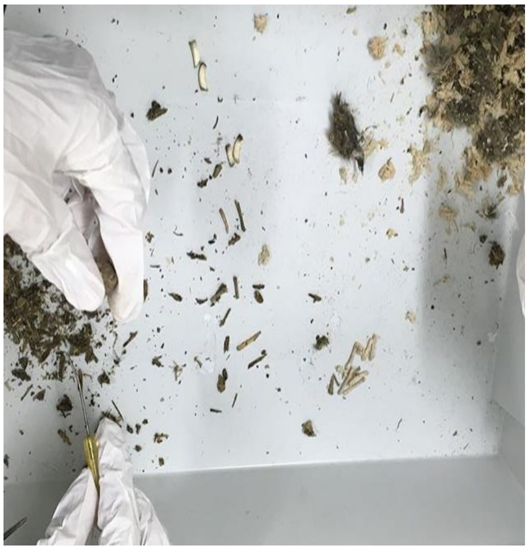
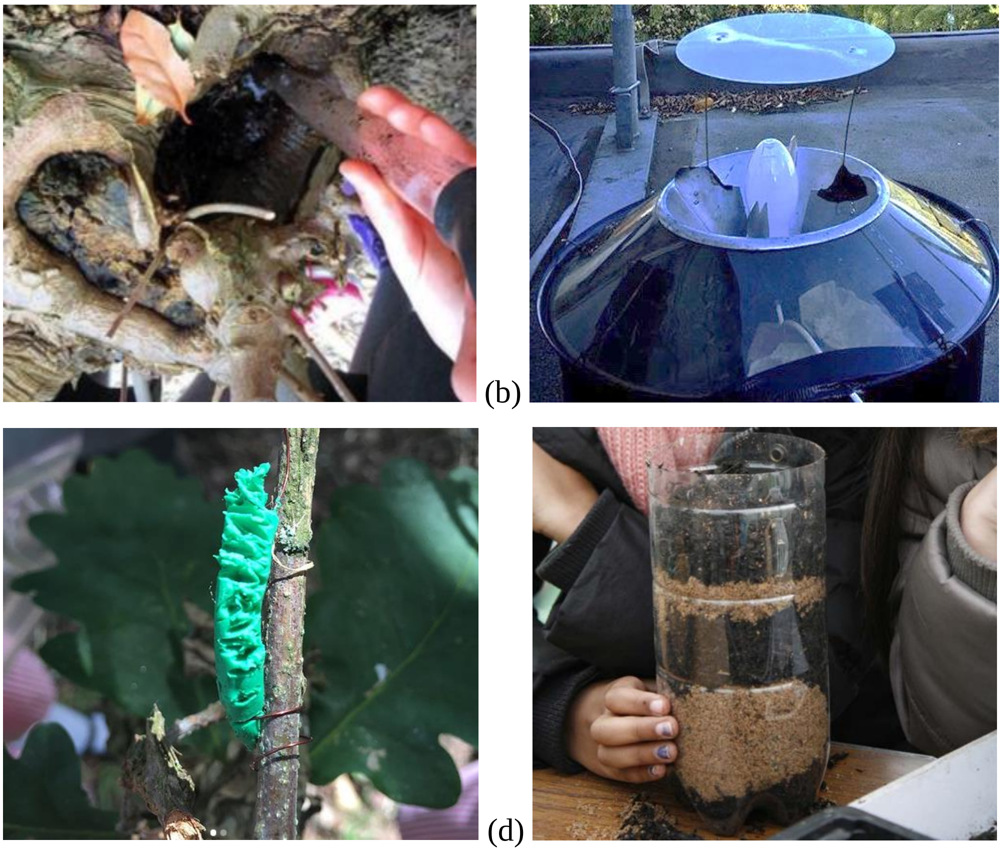
(c)  (d) 

Figure 2.4: Bird activities: (a) Bird table built from recycled plastic board, plates and broomsticks with different food sources on each plate (meal worms, seed, berry suet pellets, insect suet pellets; (b) Bird feeder made from recycled bottles with holes drilled through with food colouring coloured seeds (red/ blue/ yellow/ green) and a stick pushed through for a perch; (c) Built wooden bird boxes with nesting blue tit chicks inside; (d) Owl pellet (mass of undigested items of a birds food that has been regurgitated) dissection to explore different bone structures, fur and feathers inside.

Insects & Other Invertebrates: Tree wet holes (Figure 2.5a) were investigated to observe organisms that live in them such as mosquito fly larvae and rat-tailed maggots. Pond dipping with nets, foraging through leaf litter, pitfall traps, tree beating, and sweep netting were carried out to look at aquatic and terrestrial invertebrates with identification keys. Moth lightbox traps (2.5b) and sweep nets were used to survey day and night-flying moth species. Predation rates on plasticine dummy caterpillars (Figure 2.5c) (Castagneyrol et al., 2019) were explored (see Chapter 6, Section 2.2.1, Table 1 for further details of pitfall traps, tree beating, sweep nets, moth traps and dummy caterpillars). A wormery was built to explore invasive worm species and the function of worms in the soil (Figure 2.5d; Royal Horticultural Society, 2020).



(a) (b) (c) (d)

Figure 2.5: Insects & Other Invertebrates activities: (a) Sourcing water from tree wet holes to explore organisms inside; (b) Lightbox moth trap to investigate night flying moth species; (c) Plasticine dummy caterpillar made and put on common oak tree branches with wire to observe predation rates; (d) Photo sourced from Royal Horticultural Society (2020): Wormery built with recycled plastic bottle and alternating damp layers of sand, soil, sand, compost. Earthworms were added and dried leaf litter on top. Outside was covered with black card and kept in warm place while ensuring contents remained damp. Card could be removed to observe burrowed worms and layers mixing.

Amphibians**:** Metamorphosis was investigated with frogspawn, and tadpoles looked at in ponds or brought into schools (Figure 2.6a). Amphibian morphology was investigated when pond dipping or frogs were brought in to observe the features and how they differ from reptiles. Sink ponds (Figure 2.6b) were made to investigate how organisms colonise and move in the water

(The Royal Society for the Protection of Birds, 2020). Water testing (Figure 2.6c) of pond water was carried out to explore the effects of eutrophication and the impact on organisms.

(a) (b) (c)

Figure 2.6: Amphibian activities: (a) tadpoles and duckweed from pond dipping; (b) Photo sourced from The Royal Society for the Protection of Birds (2020): Sink pond built in school grounds without ponds available; (c) Water testing kit to test pH, ammonia and phosphate levels of pond water.

2.4 Pilot studies

Several pilot studies (detailed in Table 2.2) were carried out to determine the suitability of personal meaning maps, quizzes, and drawings to gather children's knowledge and perceptions. These were specifically tested to ensure children understood the tasks, to explore the way the personal meaning maps and quizzes should be scored and explore the length of time suitable to carry out these activities. Pilot studies were also carried out to determine the most appropriate manner to interview teachers and children and evaluate the biodiversity outdoor education programme.

Table 2.2 Details of pilot studies between 2017 and 2018

Pilot instrument	Date(s)	No. of participants	Findings
One-to-one interviews	October 2017	5 children	• Questions asked were too leading and led to children having short one worded answer. • Very difficult to make notes and interview at same time- audio recording would be better. • Interviews lasted too long and children seemed shy on

			their own- focus groups may be better.
	May 2018	4 teachers	• Questions asked were too leading. • Should interview teachers when have free time so not distracted by pupils needs. • Interviews require 30-45 minutes to collect all information. Likert questionnaires may be better to avoid social bias and to enable teachers to answer more quickly with limited free time available.
Evaluation questionnaire	May 2018	10 teachers	• Too many questions led to it being too time consuming for teachers. • Open ended questions led to little information gained due to teachers skipping questions. • Should be anonymous to ensure teachers answer how they truly feel.
Personal meaning maps	January 2018 and June 2018	86 children (year 4 – 6)	• The children in all years grasped the task very easily due to the similarity to mind maps. • Five minutes was a long time for the task as children completed the task after few minutes. • A clear marking scheme of themes should be developed between two markers to avoid differences between time points and subjectivity.
Quizzes	January 2018 and June 2018	86 children (year 4 – 6)	• The children understood the two-stage process in the quizzes of proving answer as well as species name. • Teachers advised numbers should be added to each picture to ensure the children do not get lost.

			• Marks should be given for each individual section following a clear marking scheme to avoid differences between time points.
Biodiversity drawings	July 2018	16 children (year 3 – 6)	• The children did not understand the term biodiversity; therefore, a simple explanation was needed of how to do the task. • Teachers advised providing an example for the children to understand the task, therefore a marine example was spoken through. • Ten minutes was too much time for the children to draw. • Children should be reminded to only draw the natural elements of their schools' grounds and not buildings, artificial structures, and people. • Grass should be excluded. • Children should be asked to label diagrams to identify drawings. • Children should be told not to colour in to ensure task is fully completed.

Chapter 3 : Psychological benefits of a biodiversity-focussed outdoor learning program for primary school children

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Outline

Psychological benefits of a biodiversity-focussed outdoor learning program for primary school children

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Abstract

This investigation sought to discover whether engaging school children (aged 8-11) with nature could produce sustained improvements in mood and wellbeing in the long-term. We designed a program of biodiversity-focused activities carried out over one academic year in the school grounds. Participation in this program produced significant improvements in children's mood and wellbeing, which were sustained across the academic year. Improvements in wellbeing were not found in a control sample of children who did not take part in the activities. Children with initially low feelings of connection to nature became more connected over the course of their participation. Building engagement with nature into school curricula could therefore be a low-cost way to improve children's psychological wellbeing.

Keywords

outdoor education; biodiversity; mood; primary education; wellbeing; biophilia

3.1 Introduction

Poor mental health is one of the most significant economic and social challenges of the 21st century, estimated to cost over £100 billion per year in England alone (Centre for Mental Health, 2010). It is associated with a range of negative life outcomes including higher absenteeism from school, lower educational attainment, fewer personal relationships, and reduced life expectancy (Department of Health, 2011). Declines in mental health and wellbeing over the past 25 years are evident particularly in younger age-groups, with one recent report suggesting a six-fold increase in the proportion of children and young people diagnosed with a long-term mental health condition since 1995 (Pitchforth et al., 2018). Many factors may be contributing to this trend including economic uncertainty and the rise of social media (Pitchforth et al., 2018). However, one factor which is often overlooked is the pattern of rising urbanisation and disengagement from the natural world. This study aimed to address this gap, through exploring whether engaging children in the natural world results in positive psychological outcomes.

In Great Britain, 90% of the population lives in built-up urban environments (Miller, 2005). Such urbanisation drives the decline in wild space, resulting in habitat loss and threatening biodiversity (Dallimer et al., 2012; Seto, Güneralp, & Hutyra, 2012). As a result, the UK is now considered one of the "most nature-depleted countries in the world" (Hayhow et al., 2016). The 2019 State of Nature Report (Hayhow et al., 2019) stating 'that the abundance and distribution of the UK's species has, on average, declined since 1970 and many metrics suggest this decline has continued in the most recent decade'. Other consequences of urbanisation include a decrease in the relationship that children enjoy with the natural environment (Seto et al., 2011), since they grow up with little day-to-day contact with green areas and native wildlife, representing a move towards a more indoor lifestyle. Wen et al. (2009) identified that 37% of children spent less than thirty minutes playing outside after school, while 43% spent more than two hours a day in front of televisions or computers. This is despite researchers identifying numerous benefits for children spending time outdoors and interacting with nature (Mcdowell, Macdonncha, & Herring, 2017) and has been suggested as one reason for a general decline in wellbeing (Louv, 2008).

According to a report for the Royal Society for the Protection of Birds (Bragg et al., 2013), children growing up in the UK today are more disconnected from the natural environment than any previous generation. The benefits of engaging with the natural environment on physical health and wellbeing are well documented (Wells, 2000). Alongside improvements in physical health (e.g., obesity; Bell et al., 2008; Sebire et al., 2011), other benefits include increased happiness, feelings of physical and mental energy (Ryan et al., 2010), and increased attention (Huynh et al., 2013), cognitive ability and academic engagement and attainment (Payton et al., 2008). However, the aforementioned research has tended to focus on adult or clinical samples. Furthermore, these conclusions have been based on a loosely-applied definition of engagement with nature, spanning from pet ownership, to passively spending time in natural areas (e.g., walking in rural areas; Capaldi, Dopko, & Zelenski, 2014), to outdoor adventure programs (Lubans, Richards, Hillman, Faulkner, & Beauchamp, 2016). This presents two issues: firstly, and crucially, their application has often focussed on the effect of an isolated program on a specific outcome (such as attention), with relatively little focus on the psychological mechanisms underlying such an improvement. Whilst there have been some compelling theories proposed outlining what these mechanisms could be, these have generally been advanced as theses by environmentalists or educationalists without a strong empirical grounding. One such theoretical account that has become particularly influential in accounting for the beneficial effects of engaging with nature is the biophilia hypothesis, which suggests that humans have an innate tendency to connect with nature and other organisms, which leads us to derive cognitive and emotional satisfaction from them (Wilson, 1984). This study therefore aimed to provide a direct test of this theory. To do this, we measured nature connectivity as a demonstration of affinity and desire to connect to nature, predicting that stronger connection to nature would be associated with greater improvements in mood and wellbeing.

Another issue with previous research is that many of the studies which evaluate an active engagement intervention (e.g. Lubans et al., 2016) have used outdoor adventure programs, which would clearly be too costly to be offered widely and provide a confound insofar as they are designed to provide a novel and exciting experience. In contrast to outdoor adventure programs, Otto and Pensini (2017) carried out a school based project with 358 nine to 12-year-olds; they demonstrated that nature based environmental education increases connectedness to nature. Further research has shown that longer interventions are more likely to have a more positive outcome (Rickinson, 2001). Given the past literature, we aimed to assess the wider impact of taking part in a nature-focussed program, delivered in an everyday school environment, across the course of a full academic year. Through implementing this program within children’s everyday school environment, it minimises the likelihood that the intervention setting, or novelty of the activity might overpower the effects of engagement with nature. Furthermore, if successful in improving mood and wellbeing, this protocol would provide an easily adoptable program that could be embedded into the school curriculum. An additional advantage is that school fieldwork is an ideal vehicle for hands-on learning about nature, as it is known to help contextualise ecology in pupils' minds by taking it out of the textbook and into the environment (Lock, 1998), with benefits for academic attainment. Furthermore, the intrinsically practical nature of fieldwork is supported by research which has found that hands-on interaction with nature maximises the resulting mental health benefits (Maller & Townsend, 2006), possibly via increased self-efficacy (Spencer & Blades, 2005). Finally, children's pleasure in engaging with nature is increased when they are able to shape their environment and interact with the species therein (Barthel et al., 2018; Kyttä, 2004). Despite this, recent reports indicate that opportunities for curriculum-mandated fieldwork are declining (Outdoor Science Working Group 2011; Berks Bucks & Oxon Wildlife Trust 2013; Lambert & Reiss 2015). Most schools have access to at least some outdoor space which could be developed to encompass habitats, with state-funded schools recommended to make provision for this (Department for Education, 2014).

The current study therefore aimed to design and evaluate a simple and low-cost program of engagement with nature which, if effective in improving children's mental wellbeing, could be widely adopted to reach almost all children in society. We chose to focus in particular on children in primary schools, aged 8-11, as onset of symptoms of depression and anxiety peaks after the transition to secondary school, between the ages of 11-14 years (Kessler et al., 2005, Joinson et al., 2012), with a preceding decline in wellbeing in 10-12-year olds (Rees, Main, & Bradshaw, 2015). Research has found that to improve mental health, the focus should be on enhancing wellbeing as this promotes resilience (Lamers, Westerhof, Glas, & Bohlmeijer, 2015). In fact, poor wellbeing has been found to predict later depression (Grant, Guille, & Sen, 2013).

We hypothesised that this engagement with nature would have beneficial psychological outcomes for the children who participated in the program, with both immediate improvements in mood and a longer-term impact on wellbeing and connection to nature; in contrast, the control pupils in non-participating classes would show no change in mood, wellbeing and connection to nature.

3.2 Methods

3.2.1 Participants

We recruited 549 pupils, aged 8-11 years, from 11 schools across Surrey, Berkshire and Middlesex; 459 pupils participated in the biodiversity program, whilst an additional 90 children were recruited as controls from non-participating classes within four of the schools (three state-maintained schools and one privately funded school) to complete the surveys.

A literature search revealed no papers in this field which had used our chosen measures in a comparable way, but we calculated that these samples should be large enough to detect a small to medium effect size of 0.3, with statistical power of 80% (minimum required sample size n = 74).

Schools were initially contacted with information about the project. For those who agreed to take part, information letters were sent home to parents. Parents were asked to provide either opt in consent or opt out consent (chose to have their child excluded from the study). Informed consent was acquired from each child. This study obtained ethics approval via Royal Holloway University of London Research Ethics Committee procedures. Datasets for each child were anonymised by assigning a unique ID code. Due to non-completion of surveys and difficulty in matching the unique ID codes for some sessions, 93 participants (16%) had to be excluded from the final analysis, leaving a final sample size of 456. The demographic characteristics of the final sample can be seen in Table 3.1.

Table 3.1: Demographic characteristics of the final sample.

Gender	Participants	Controls
Female	183	48
Male	146	27
No response	37	15
Mean age, years (SD)	9.06 (0.70)	9.62 (0.93)

3.2.2 Procedure

3.2.2.1 Outdoor education program

A series of activities to improve and monitor biodiversity in school grounds was devised and delivered in participating schools. The aim of the program was to teach pupils about the biodiversity in their school grounds, via a series of hands-on projects focussing on major taxonomic groups including birds, amphibians, insects, trees, and mammals. Activities were focused around two themes: 1) discovering and monitoring species, for example using non-harmful mammal footprint and hair traps overnight to monitor which nocturnal species were in and around the school grounds; and 2) building new habitats/food sources, for example making and installing bird boxes in the school grounds. The activities took place across one academic year (September 2017 - June 2018) and comprised seven sessions per term (i.e. 21 sessions in total). The sessions always commenced with a short PowerPoint presentation, to engage the children with the topic in hand and standardise delivery of the material across all activity leaders delivering the program, and, except in exceptionally bad weather, at least part of the activity took place in the school grounds. Each session took one hour, and every school followed the same program of activities. The program of activities was delivered by a team of researchers from undergraduate to post-doctoral level. All undergraduates were Biological Sciences degree students and were given training before the sessions. Throughout the year, where possible the same team delivered the programme in the schools. Each team was comprised of an experienced trained lead (the post-doctoral researcher or a postgraduate research student) and between two to four upper level trained undergraduates (in their final two years of study). The postdoctoral researcher and postgraduate students collectively wrote the material and delivered it to ensure consistency in material delivered across schools. Undergraduate students were present to support children during nature engagement activities. Teachers accompanied the pupils on all sessions and took part to aid in behavioural management where appropriate but did not supervise the activities.

3.2.2.2 Mood, wellbeing, and connectivity monitoring

To measure the impact of the nature activities on wellbeing, mood, and connection to nature, the children completed a series of questionnaires at various points throughout the year. All children completed surveys for wellbeing and connection to nature at an initial pre-program session, and then repeated these surveys after the final nature session was delivered.

Wellbeing was measured using the KIDSCREEN-27 (Ravens-Sieberer et al., 2014), which has been validated for use with children aged 8-18 years. This questionnaire concentrates on the children’s feelings in the previous week leading up to the survey, and has questions divided into five aspects of wellbeing: physical activity and health, general mood and feelings about self, friends, family and free time, and school and learning. Each question is rated from 1-5, with five being the highest positive response. The responses were collated to give each individual an overall score (possible range 27 to 135).

Connection to nature was measured using the Connection to Nature Index (Chen-Hsuan Cheng & Monroe, 2012). This survey was chosen since it had been recommended by Bragg and colleagues (2013) as the best of a range of possible measures for this age group due to its use of age-appropriate language and child and teacher preference. Connection to nature is defined as a sustained awareness of the relation between self and nature, which is reflected both in attitude and behaviour (Chen-Hsuan Cheng & Monroe, 2012). The survey is validated with children aged 8-12 years old and is comprised of 16 questions divided into four sections: enjoyment of nature, empathy for creatures, sense of oneness with nature, and sense of responsibility for the environment. The questions within each section are assessed on a five-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree), with a higher score indicating stronger connectedness (Hughes, Richardson, & Lumber, 2018). Analyses were carried out for the overall average score across these 16 items (the connectivity index; Chen-Hsuan Cheng & Monroe, 2012).

In addition to these pre- and post- intervention measures, the children taking part in the biodiversity programme also completed a mood survey each week at the beginning and end of the nature session. We used an adapted version of the Positive and Negative Affect Schedule for children (PANAS-C) scale (Williamson, Dewey, & Steinberg, 2001) to determine the shorter-term effects of our program on the children. This questionnaire is validated for use with primary-age children and presents a list of eight positive and eight negative emotions that children are asked to rate according to their current mood. In discussion with teachers, it was felt that two pairs of the mood states were too similar for children to be able to understand the difference (active/energetic and sad/unhappy). We therefore omitted *energetic* and *unhappy* from the final scale. Computing Cronbach's alpha for the resulting data showed that the scale still had good internal reliability ($\alpha = 0.88$; comparable to that of the original validation of the full scale $\alpha = 0.85$ by Watson, Clark, & Tellegen, 1988). In order to make the response format more child-friendly, an emoticon-based 5-point rating scale ('Not at all' to 'Extremely') was developed to accompany the survey. Positive and negative mood items were randomised in order to minimise response bias. For scoring, negative mood items were reversed so that a higher overall mood score indicated a less negative mood (i.e. for a negative mood such as 'Annoyed' a score of five would represent a choice of not feeling at all annoyed, whereas for a positive mood such as 'Pleased' a score of five would represent a choice of feeling very pleased). The positive and negative mood scores were then averaged to produce a single mood score encompassing all 14 moods (possible range 1 to 5, with a higher score indicating greater positivity).

Where Wi-Fi access was available in schools, children completed the connectivity and wellbeing surveys using the Qualtrics survey platform (Qualtrics, Prove, UT) on tablets (Amazon Fire 7). Where Wi-Fi was not available, surveys were completed on paper. Throughout the completion of surveys pupils were reassured that they were not being tested, could ask questions about anything that was unclear and leave blank any questions that made them feel uncomfortable. Wellbeing and connection to nature surveys were similarly completed by the control children who did not take part in the nature sessions.

3.2.2.3 Data analysis

Data from all surveys was inputted electronically and checked by two people immediately after sessions. Scores were cleaned by removing incomplete responses and those 2.5 standard deviations above and below the mean score for each measure. This resulted in a loss of 2% of the data for each measure.

All questionnaire measures were scored using the existing protocols as detailed in section 3.2.2.2. All analyses were carried out in R 3.5.2 (R Core Team, 2018).

For the full analyses, we analysed all three measures to compare the children's scores before and after their participation (before and after each individual session for mood, and at the beginning and end of the program for wellbeing and connectivity, as well as the subgroups of 'enjoyment of nature', 'empathy for creatures', 'sense of oneness' and 'sense of responsibility'), using generalized linear mixed models (GLMM) to account for influential random effects of individual and school with Poisson error structure.

GLMMs using the R package lme4 (Bates, Maechle, & Bolker, 2014) was used to examine the scores before and after the activities. The effects of school type (private and state), sex (male or female), year group (year 4, 5, 6) and collection point (before and after) on children's mood, wellbeing, and nature connection questionnaires were examined with generalised linear mixed models to account for influential random effects of individual and school to identify the full simplified model. Interaction and statistical significance were gathered by removing terms sequentially and testing the significance between the models until a minimal model was achieved. Tukey post-hoc tests were additionally used to test the significance of each pairwise comparison to investigate the difference in collections. Finally, we carried out regression analyses to investigate whether connection to nature was able to predict change in average mood or wellbeing; testing both linear and nonlinear (polynomial) models; comparing across linear to fourth-order polynomial models to search for the best fit for the data.

3.3 Results

3.3.1 Wellbeing

Overall, the children's average wellbeing score was 108.5 (SE 0.92); which is in the normal range for children of this age (8-11; KIDSCREEN Group Europe, 2006). Children within the programme group had a significant improvement in their wellbeing scores ($\chi 2$= 13.61, df = 1, $p < 0.001$), whereas the control group of children displayed no significant improvement ($\chi 2$= 3.75, df = 1, $p > 0.05$). The impact that the programme had on the children's wellbeing was not significantly different between school type (df = 1, $p > 0.05$), year (df = 2, $p > 0.05$) or sex (df =1, $p > 0.05$).

Table 3.2 Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's wellbeing scores with individuals and school used as a random effect. Bold values indicate significant terms.

Model Parameter	**Wellbeing**		
	df	LogLik	p-value
Treatment (action/ control) * Time point (before/ after)	**1**	**-1546.3**	**< 0.05**
Year	2	-1546.3	> 0.05
School type	1	-1546.3	> 0.05
Gender	1	-1546.3	> 0.05
Minimal model	Wellbeing score ~ Treatment * Time point + (1|individual) + (1|school)		

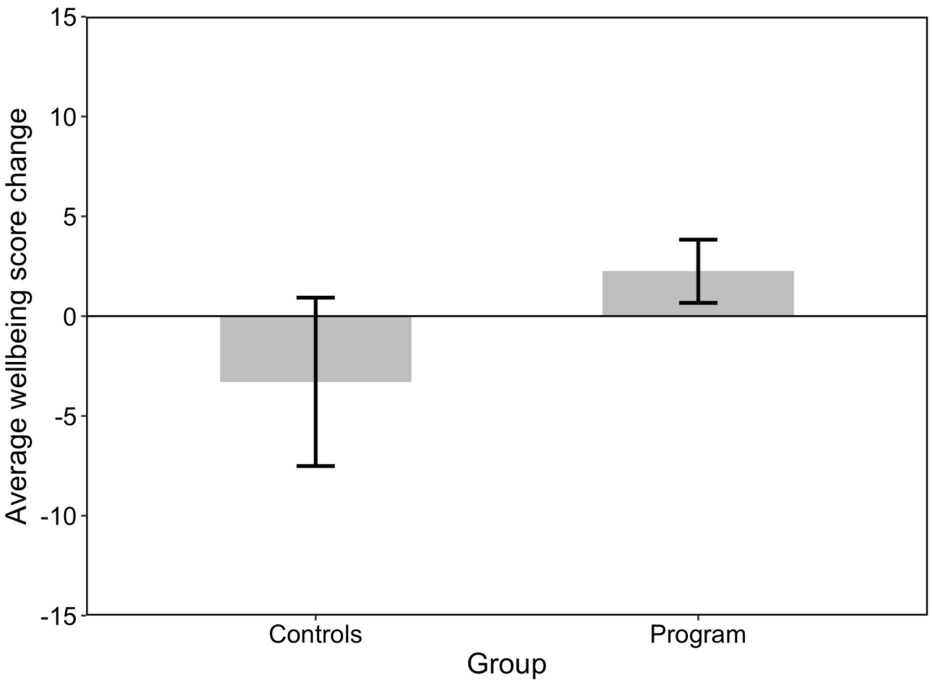

Figure 3.1: Change in KIDSCREEN-27 score from the beginning to the end of the program for controls and children who took part in the nature session (possible range -/+108). A positive value shows an improvement across the project. Bars represent +/- 1 SE above and below the mean here and in all following.

3.3.2 Mood

Mood was assessed before and after the nature activity using the reduced PANAS survey. There were 366 children with complete datasets who took part in the biodiversity programme whose data were included in this analysis (note: unlike for the wellbeing and connection to nature measures, which were completed once at the beginning and once at the end of the project, only children in the active intervention group completed the mood surveys). There was a significant improvement in mood score across the course of the sessions ($\chi 2= 41.7$, df = 1, $p < 0.001$). The post hoc test showed that the children had a higher mood after the sessions compared to before (SE = 0.003, df = 1, z = -6.50, $p < 0.001$). The average mood score before and after the sessions can be seen in Figure 3.2.

Table 3.3 Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's mood scores with individuals and school used as a random effect. Bold values indicate significant terms.

Model Parameter	Mood		
	df	LogLik	p-value
Time point (before/ after)	**1**	**-15834.0**	**< 0.001**
Year	2	-15834.0	> 0.05
School type	1	-15834.0	> 0.05
Gender	1	-15834.0	> 0.05
Minimal model	Mood score ~ Time point + (1|individual) + (1|school)		

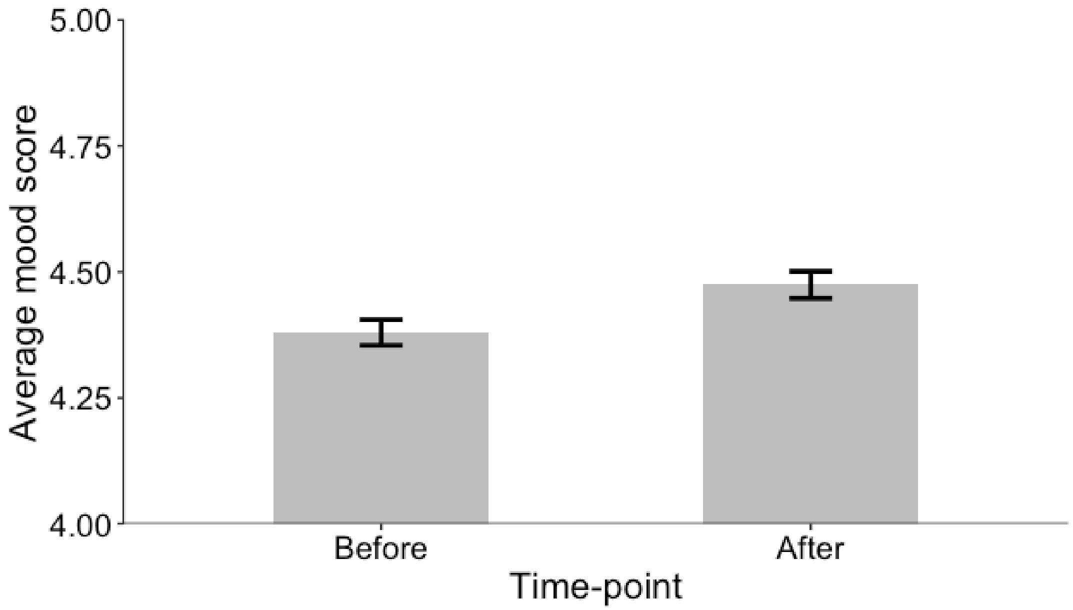

Figure 3.2: Average mood score (possible range 0-5) across all sessions, recorded immediately before and after each session, for children taking part in the biodiversity program. Bars represent +/- 1 SE.

3.3.3 Connection to nature

Complete data sets for those taking part in the biodiversity program included 244 children, for the control group included 43 children. On average, all children reported a high connection to nature score at the beginning of the program (program group M = 4.31, SE = 0.04; control group M = 3.99, SE = 0.08). There was no significant improvement in connectivity index scores across the duration of the program for either the children who took part in the nature activities or the control children within the connectivity total overall, nor the four individual subcategories. However, as the majority of children reported a connectivity index of above 4, we carried out an additional exploratory analysis for the children taking part in the biodiversity programme, to consider whether ceiling effects could be constraining our results here. To do this, we looked only at children with an initially low connectivity index (below 4.06, following Hughes et al., 2018; n = 63, 26% of the sample for this measure) to investigate whether their connectivity improved across the duration of the program. Analysis showed a significant increase in children's connectivity scores between the two timepoints (χ^2= 6.9, df = 1, SE= 0.02, z = -2.64, p < 0.01; initial M = 3.56, SE = 0.06, final M = 3.77, SE = 0.10; see Figure 3.3).

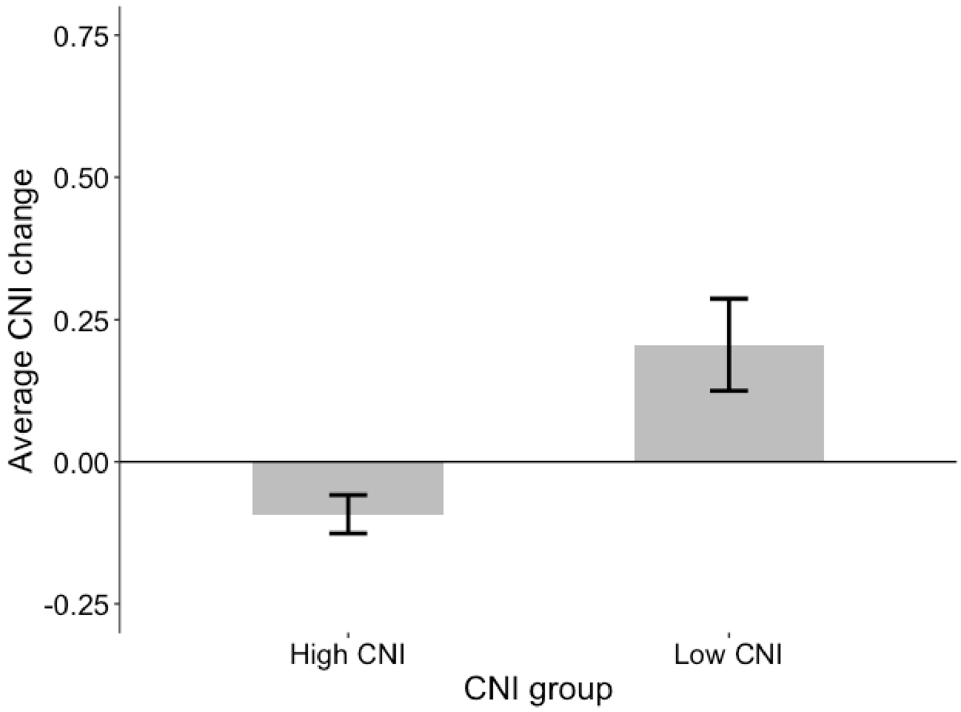

Figure 3.3: Average change in connection to nature index (CNI) for children with an initially higher (>4.06) or lower (<4.06) connection to nature. Error bars show +/- 1 SE around the mean.

Finally, we carried out regression analyses (testing linear and polynomial models as outlined in *Methods)* to investigate whether connection to nature, as a proxy measure for biophilia, could explain the positive psychological impact of the nature program. However, individual differences in connection to nature index scores, averaged across the year, did not significantly predict either outcome measure (mood or wellbeing). To examine the biophilia hypothesis further, we also included the initial connectivity score subgroup (high or low connectivity, based around the same 4.06 cut-off score as previously) into this model. This provided a linear regression model that significantly predicted change in wellbeing scores; $R^2 = 0.04$, $F(3, 180) = 3.43$, $p = 0.02$. This was due to there being a relationship between these two variables for those with low initial connectivity (interaction term $t = 2.42$, $p = 0.02$; $rho = 0.23$ for low connectivity group and $r = 0.002$ for high connectivity group).

3.4 Discussion

This paper presents a longitudinal study to measure the effect on mood, wellbeing and connection to nature of children aged 8-11 years participating in a program of nature-based outdoor activities in their school grounds. We found that taking part in these activities produced both immediate benefits for the children's mood across the course of each session, and longer-term improvements in their wellbeing across the duration of their year's participation in the program; whilst no such improvements were seen in a control group of children who did not take part in the program. Connection to nature only improved for children whose scores were initially low. In line with the predictions of the biophilia hypothesis, these children with initially lower connection to nature scores showed greater improvement in wellbeing. For those with higher initial connection however, we could not test this relationship as there was no significant change in their connection to nature across our study. This may be due to apparent ceiling effects in our chosen measure, with 74% of the sample having mild or strong connection to nature (following Hughes et al., 2018) at the outset of the program.

The benefits of children spending time in nature are well documented (Capaldi et al., 2014; Capaldi et al., 2015; Gill, 2014), with pupil attainment, mental and physical wellbeing showing significant improvements when lessons are taken outside in nature (Bølling, Niclasen, Bentsen, & Nielsen, 2019; Marchant et al., 2019). This is especially important at a time when urbanisation and the loss of green spaces is increasing and more children are living in areas that are dominated by built environments (Vanaken & Danckaerts, 2018). Children living in deprived urban areas have a greater risk of suffering from anxiety and depression and disruptive behaviours (Rudolph, Stuart, Glass, & Merikangas, 2014). Since children's exposure to nature occurs mostly in private gardens (Hand et al., 2017), which not all children have access to and the quality of which varies, interventions in schools have the potential to impact children greatly, since they spend long periods of time there (Kelz, Evans, & Röderer, 2015).

3.4.1 Wellbeing

Time spent in nature increases aspects of children's eudemonic and hedonic wellbeing by providing them with meaning, purpose and increased satisfaction with life (Adams & Savahl, 2017; Kerret, Orkibi, & Ronen, 2014). Furthermore, access to green space, including school grounds, improves memory, attention restoration, self-discipline, reduces stress levels and improves behaviour (McCormick, 2017). This is vital since figures released by the Office for National Statistics (2016) estimated that 13.5% of young people have mental health problems. Analysis by Frith (2016), suggests that there are approximately 720,000 children between the ages of 5 and 16 years who have a diagnosable mental health condition in England alone, with a significant rise in the last five years. Despite these high numbers, only 0.7% of the NHS budget is spent on child mental health. Furthermore, nearly a quarter of children referred to the Child and Adolescent Mental Health Services (CAMHS) are turned away, as their condition is not judged as serious enough, meaning they are not getting the support they need (Frith, 2016). At a time when the Government's plan for the environment for the next 25 years states that its aims are to "help people improve their health and wellbeing by using green spaces including through mental health services" and "encourage children to be close to nature, in and out of school, with particular focus on disadvantaged areas" (DEFRA, 2018), our timely intervention focused on the effects of spending an hour outside a week, in the school grounds for children in both the state and private sector. The aim was to engage children with nature in their school grounds: something that the children will see every day. Although suburban and urban areas contain wildlife, this is often overlooked, since it is perceived as 'not what nature is' (Hanisch, Johnston, & Longnecker, 2019). For children to become connected to nature and for it to have an importance to them, they must see it as something which features as part of their everyday lives and not just something that they can engage with on television, that is far removed from them.

Here, we have shown that taking children outside for an hour a week to engage with their school grounds significantly boosts their wellbeing. This is important for several reasons. Firstly, it demonstrates that relatively little time is required to produce measurable positive results on children's wellbeing. Secondly, this program was implemented in school grounds, thus is achievable at low-cost, could be easily made available to most children, and may also confer educational benefits.

3.4.2 Mood

Previous research with adult participants has demonstrated that engagement with nature has positive effects on mood and this effect is greater when the engagement is outdoors rather than looking at images of nature (Kahn, Severson, & Ruckert, 2009). We demonstrated significant short-term mood improvement in mood over the course of an hour-long nature activity, averaged over the 21 weeks of the program. Moreover, improvement in mood was not related to any particular activity, and there was no evidence that this effect was lessened over the course of the academic year. This is an important finding, as most previous research has been based on an improvement over the course of a single short-term activity, the novelty of which could act as a confound. Furthermore, although sessions across the year focussed on different aspects of biodiversity including both more popular species such as birds and those less charismatic, such as insects (Cox et al., 2017; Lindemann-Matthies et al., 2011), the constancy we observed in improvements in children's mood (no significant interaction between session and mood change) across each weekly session also suggests that the beneficial effect of interacting with nature was not affected by the particular focus of the session. For children to take responsibility for their environment it is expected that they should engage broadly with it.

3.4.3 Connection to nature

To ensure that the environment, as well as the individual child, benefits from an activity to engage them with nature, connection to nature must be high, since this instils a set of pro-environmental behaviours and values within the individual (Giusti, Svane, Raymond, & Beery, 2018). Deep-rooted human connection to nature is nurtured in children by direct interaction (Evans et al., 2007). Therefore, for our final measure, we measured children's connection to nature. There was no significant improvement in connectivity across the program for either the participating children or the control groups; however, this appeared to be due to a ceiling effect, with the vast majority of children in our sample demonstrating a higher connectivity index (above 4.06; following Hughes et al., 2018) at the outset of the study. This meant that we were unable to elucidate whether our program affected the participating children's connection to nature; however, those who started with a connection to nature regarded as low did significantly improve after the intervention. Although there was significant improvement, this may have resulted in a regression to the mean due the later data collection measurement moving closer to the overall mean compared to the first time. Nevertheless, the children with initially low scores remained below the average, and therefore, we can more likely infer there was an improvement due to the programme. We also sought to investigate whether the beneficial effects of engagement with nature could be explained by an innate 'biophilia'; however, a ceiling effect seen in our proxy measure for biophilia for many of the children meant that we were unable to draw any firm conclusions about this theory. It may be necessary to trial alternative measures for this, such as Nature Relatedness-6 (Nisbet & Zelenski, 2013) or the Connectedness to Nature Scale (Mayer & Frantz, 2004), or to develop a more sensitive measure of connection to nature to address these questions in future work.

3.4.4 Limitations

A core limitation of the current study is that we were unable to match the number of children in the control group to those taking part in the experimental program, primarily due to participating schools wanting the program to be accessible to everyone and only committing if it was. Due to this, we aimed to ensure we recruited widely across a range of school types (state and private funding source). Given we found no effect depending on the school funding type for any of our measures, we believe that our findings are robust across these different settings. Importantly, even with the smaller samples we identified that control group children's scores differed significantly from those involved in the program. It would be important for future work to focus on further evaluating the impact of such programs, including a fully matched-control group.

In addition to the above, it would be important to further explore the role of individual differences in connection to nature and how this may be connected to wellbeing. Past evidence has found a link in adults (e.g. Cervinka, Roderer, & Hefler, 2011); however with the measure we used there were ceiling effects. There are a number of measures that we could choose from (e.g. Nisbet & Zelenski, 2013; Perrin & Benassi, 2009), which are suitable for children in this age group, although Bragg et al., 2013 indicated that more children found the language in these surveys difficult to understand than in the Connection to Nature index we used in this intervention.

A further possible limitation of our measurement of connection to nature is the effect of social desirability and common method biases. Social desirability bias results from participants answering questions in a way that they believe the investigators would like them to, and therefore may not reflect their true opinions. This may artificially raise their scores in such a survey as this, possibly contributing to the ceiling effect we suspect in the connection to nature measure. Common method bias arises from over-reliance on introspective attitudinal measures, as used in our investigation here, without a secondary measurement to ensure reliability in respondents' own introspections. One way to ensure that both of these issues are avoided, future investigations could use a behaviour-based and attitudinal reports, as exemplified by Otto, Evans, Moon, and Kaiser (2019), ensuring convergent validity between both types of measurement (Otto, Kröhne, & Richter, 2018).

3.5 Conclusion

In this study, we examined whether engaging with a hands-on nature program delivered in the school grounds would improve children's wellbeing and mood and enhance their connection to nature. We have shown that, even when time spent outdoors in nature is restricted to one hour a week and repeated across the duration of a full academic year, children show an improvement in their mood and wellbeing. Furthermore, this does not require trips away from the school or expensive equipment. We also found some evidence that children with a lower connection to nature score experienced a greater improvement in wellbeing over the course of the program. Such a program could easily be implemented across primary schools in the UK, even in areas where budgets and land available are restricted. By making better use of this existing space, we propose that children could be inspired to explore nature and adopt a healthy lifestyle for a sustainable future (Cooke & Leonard, 2010; Dearborn & Kark, 2010; Maller, Henderson-Wilson, & Townsend, 2009). A similar model could also be adopted for older pupils, and future work could seek to verify whether these findings can be replicated in secondary school-age children (11+ years), and help to make the case for a national program by investigating whether there are concurrent impacts on actual biodiversity in school grounds and children's educational attainment.

Author contributions

DJH, ACG, DW and HH designed the study, DJH recruited the schools and coordinated the data collection, DJH, LM and FH collected the data, DJH, LM and FH planned the projects, DJH, HH and LM wrote the manuscript, DJH, ACG, HH, LM and DW carried out the analysis, ACG, DW, DJH, HH and LM edited the manuscript.

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Chapter 4 : Children's perception of biodiversity in their school grounds and its influence on their wellbeing, resilience, and connection to nature

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Outline

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Keywords

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Discussion

Conclusions

Acknowledgements

Conflict of Interest

Author Contributions

Data Availability Statement

Ethical Approval

Children's perception of biodiversity in their school grounds and its influence on their wellbeing, resilience, and nature connection

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Abstract

1. Children are more inclined to build an emotional attachment to what is familiar to them. However, children's opportunities to explore the local natural environment have diminished following curricular pressures and urbanisation, and there is the danger that certain species could disappear from people's awareness and that these species become more likely to be endangered.
2. Natural habitats within urban areas can be home to a variety of species, and increasingly there is evidence of the benefits that exposure to nature has on wellbeing. However, which taxa specifically aid wellbeing is not known, nor whether an accurate perception of biodiversity is beneficial.
3. An investigation over one academic year was carried out involving 752 pupils (8-11 years of age), on the impact that weekly nature engagement activities in school grounds have on children's perception of biodiversity, wellbeing, resilience (to adversity or risk) and nature connection. These activities focussed around monitoring a range of taxa. Perception of biodiversity was assessed by children drawing what they thought was in their school grounds before and after the activities. Questionnaires were additionally used before and after the activities to assess wellbeing, resilience, and nature connection.
4. We found that although children perceived few organisms in their schools' grounds before the activities, the number of children acknowledging the different taxa increased after the set of activities. Their participation, therefore, resulted in a more accurate perception of biodiversity in their school grounds. An improvement was found in the wellbeing and resilience of children who had initially low scores. Higher wellbeing and resilience were found in those that perceived higher numbers of trees and plants, and higher nature connection was found in children who perceived higher numbers of birds.
5. Integrating nature engagement into the school curriculum could improve psychological wellbeing and resilience over the long term while allowing children to develop a greater awareness of the natural environment around them to reduce the extinction of experience and adopt pro-environmental values for a sustainable future.

Keywords

biodiversity, wellbeing, resilience, nature connection, outdoor education, biodiversity perception, nature, primary education

4.1 Introduction

The natural world and the biodiversity it encompasses have played an important role throughout human evolutionary history (Mayer et al., 2009) as it is at the forefront of our productivity and fecundity (Díaz et al., 2006; Hanski, 2005). In the wake of the destruction of habitats for natural resources, urbanisation and land use, the Earth's biodiversity is becoming increasingly degraded (Newbold et al., 2016). Through these numerous anthropogenic activities, biodiversity is at great risk, ultimately threatening a sustainable future if degradation continues (Hayhow et al., 2016). Species and population abundance are diminishing at a distressing rate, with one million species thought to be at risk of extinction globally (Tollefson, 2019). This worldwide biodiversity decline is one of the most urgent issues facing modern life (Fiebelkorn & Menzel, 2013; Newbold et al., 2016) with population sizes having declined by 60% since 1970 (WWF, 2018).

The United Kingdom has been identified as one of the most nature depleted countries in the world with 56% of all species listed in the 'State of Nature' report found to have declined over the past four decades (Hayhow et al., 2016; WWF, 2018). This ongoing reduction in biodiversity intensifies our already disconnected lifestyle from the natural world through the extinction of experience (Pyle, 1993), with current children in the UK identified to have a low nature connection (Hughes, Richardson, & Lumber, 2018) and poor ability to identify common species (Balmford, Clegg, Coulson, & Taylor, 2002; White, Eberstein, & Scott, 2018). If younger generations continue to decrease their engagement with nature and not develop an awareness of local flora and fauna, it may exacerbate the decline in the state of nature worldwide (Miller, 2005), without positive environmental behaviour adopted for adulthood (Kuo, Browning, & Penner, 2018).

Strong connections with nature are not only associated with environmentally sustainable behaviour but also with greater happiness (Nisbet & Zelenski, 2013). A connection with nature is generally established during childhood when children are more inclined to build an emotional attachment to what they recognise and appreciate (Bilton, 2014b). It has previously been suggested that the public can only miss a species if they have previously developed a connection to it, and an understanding of them (Weilbacher, 1993). However, as the opportunities to explore the natural environment have diminished, there is a possibility certain species could disappear from the public's awareness before they become endangered (Hayhow et al., 2019).

The opportunity for children to explore native species within school lessons has reduced over recent generations (Barker, Slingsby, & Tilling, 2002; Lindemann-Matthies, 2002). Fieldwork in environmental sciences has notably decreased in recent years (Tilling, 2018) with more textbook-based education leading to children developing a prototypical view of nature (Shepardson, Wee, Priddy, & Harbor, 2007; Tay, 2016). This view of nature does not encompass green areas in urban environments but is purely for plants and animals with no human interaction. Children growing up today, therefore, have an unclear perception of nature surrounding their places of living (Payne, 1998; Rickinson, 2001). However, it has recently been suggested that school grounds are an under-used asset that would be optimal for environmental education (Harvey, Gange, & Harvey, 2019).

Children's awareness of nature has further disconnected from their native species due to technological advancements (McCurdy, Winterbottom, Mehta, & Roberts, 2010; Richardson & McEwan, 2018), notably the internet (Ballouard, Brischoux, & Bonnet, 2011). It has been identified that children are more drawn to exotic (Lock, 1995) and 'charismatic' species which are more commonly discussed in the media (Genovart, Tavecchia, Enseñat, & Laiolo, 2013; Lindemann-Matthies, 2005) due to biases in published research gaining funding from 'flagship' species for conservation (Genovart, Tavecchia, Enseñat, & Laiolo, 2013; Lindemann-Matthies, 2005; Titley, Snaddon, & Turner, 2017). The charismatic and flagship species are typically mammals, which do not represent global biodiversity, with 95% of global species being invertebrates (Titley, Snaddon, & Turner, 2017), and it is therefore expected that these biases are reflected in children's perceptions of local biodiversity.

This distorted perception of nature supports the concept of shifting baseline syndrome, in which as awareness of biodiversity changes, previous conditions are forgotten (Papworth et al., 2009). Various studies have identified the knowledge of common native species, understanding and awareness of local biodiversity are very poor in the general public (Balmford, Clegg, Coulson, & Taylor, 2002; Lindemann-Matthies & Bose, 2008). Consequently, as the public is not well aware of the state of nature in the UK while biodiversity continues to decline over the generations, referred to as 'generational amnesia' (Kahn, 2002), this loss will go unnoticed and will lead to serious implications for conservation (Soga & Gaston, 2018) and human health (McCormick, 2017).

The decline in mental health and psychological wellbeing in young people has been of great concern in recent years (Bird, 2007; Pitchforth et al., 2018). However, nature focussed studies have suggested a reduction in depression, anxiety, and stress when individuals perceive high numbers of flora and fauna in their local environment (Dallimer et al., 2012; Schipperijn et al., 2010); and, engagement with green space has been found to positively influence emotional and behavioural resilience (Flouri, Midouhas, & Joshi, 2014). Additionally, outdoor education has been shown to have a positive impact on the psychological wellbeing of children (Harvey et al., 2020), at a time when average life satisfaction in children in England aged 10-15 has been decreasing since 2010 (Department of Education, 2019). Wellbeing and resilience are important to investigate together as wellbeing captures a psychological state at a given time, whereas resilience considers past and future experiences to cope with a problem (Mguni, Bacon, & Brown, 2012).

In this study, we investigated whether children's perceptions of local biodiversity within their school grounds reflect what is present and whether their perception of biodiversity is associated with their wellbeing, resilience, and nature connection. Additionally, we recorded whether children's perception of biodiversity changes after taking part in a hands-on outdoor education programme that engaged children with the biodiversity in their school grounds over one academic year (hereafter referred to as 'intervention group'). Children's perceptions of biodiversity were evaluated from their drawings of what organisms they thought were present in their school grounds to identify preferences in taxa, and how this related to the actual biodiversity present in their school grounds. Questionnaires were also used to gain an understanding of the children's wellbeing, resilience, and nature connection before and after the intervention.

It was hypothesised that children would draw few species, and be more likely to draw mammals and birds in their school grounds before the activities began due to them being considered charismatic groups. However, after the intervention, it was hypothesised that children who participated in the hands-on biodiversity activities would be more likely to draw less charismatic organisms, such as invertebrates. As a check to ensure that any changes in perceptions and feelings were as a result of the intervention activities, within the study, we had a group of children who did not take part in the intervention activities (the control group), but where before and after measures were taken with similar time gaps. Additionally, it was hypothesised that there would be a positive association between a high perception of flora and fauna and the children's wellbeing and resilience. Furthermore, we hypothesised that children who participated in the hands-on activities would have an improvement in their nature connection after the one year set of activities due to exploring the biodiversity in the school grounds, and would have a more accurate perception of the biodiversity at the end of the academic year.

4.2 Methodology

4.2.1 Participants

A total of 752 children, ages 8-11 years old, from 10 schools (seven state and three private) across South East England (Surrey, Berkshire, and Middlesex) were recruited for the study. In total, 509 children participated in the intervention activities (intervention group), and 243 children were in the control group. Informed consent was obtained for every child participating in the study, from both child and gatekeepers, as approved by the institutional ethical review process at Royal Holloway, University of London. Datasets for each child were anonymised. Table 4.1 displays the number of children in the intervention group and control group within each age cohort.

Table 4.1:Intervention and control group pupils.

Year group	Age cohort (years)	Intervention group (n)	Control group (n)
4	8-9	222	98
5	9-10	260	62
6	10-11	27	83

4.2.2 Outdoor Education Programme

The outdoor education programme was completed by the intervention group and aimed to teach children about the biodiversity in their school grounds, through a series of hands-on activities focussing on major taxonomic groups including tree and other plants, lichens and fungi, mammals, birds, insects, other invertebrates, and amphibians. The hands-on activities were focussed around discovering and monitoring species (see Appendix 1 for activities). A programme of activities was developed to be appropriate for all participating schools, regardless of their size and ecological quality and linked to the primary science curriculum (Harvey et al., 2020).

The activities took place across one academic year (September 2018 - June 2019) and comprised seven sessions per term, over three terms, equating to twenty-one sessions. Each session took one hour, and every school followed the same programme of activities. The sessions commenced with a short PowerPoint presentation delivered in the classroom to engage the children with the topic of the week and to ensure the delivery of the programme was standardised across activity leaders, who were the researchers, before going outside.

4.2.3 Biodiversity Perception

Children's perception of the biodiversity in the school grounds was recorded at the beginning of the study by instructing them to draw the organisms they thought were in their school grounds, over five minutes, with a larger size to indicate greater abundance (see Appendix 11). To ensure the children understood the instructions, an example of drawing marine organisms was discussed by stating that although a whale is far larger than a fish, there are more fish in the ocean than there are whales, and so a fish would be drawn larger than a whale. The biodiversity perception drawing exercise was repeated approximately nine months later, at the end of the academic year, once the outdoor education programme activities had been completed by the intervention group.

The children's perception of school biodiversity drawings would be used to compare to actual biodiversity in their school grounds after carrying out a biodiversity survey of their school grounds (outlined in section 4.2.5). During the process of classifying the organisms in the children's drawings, grass was excluded from the children's drawings, as well as in the biodiversity survey of school grounds since it might be affected by mowing and fertilisers, which undermines the representation of the true biodiversity.

Each organism drawn was measured along the longest length, and to generate the children's perception of abundance for each taxonomic category (trees and other plants, lichens and fungi, mammals, birds, insects, other invertebrates, and amphibians), percentage size was calculated relative to the largest organism drawn. The inverse percentage difference between actual biodiversity and children's perception of biodiversity was used to determine the accuracy of their perception. The number of items were counted within each investigated category to account for species diversity. This method has been proven to be a quick, simple and enjoyable method to gather children's perception of the environment in previous studies (Drissner, Haase, Wittig, & Hille, 2014; Prokop, 2008).

4.2.4 Wellbeing, Resilience & Nature Connection

To measure wellbeing, resilience, and nature connection, questionnaires were answered by each child at the start of the study. These were then repeated at the end of the academic year, once the intervention group had completed the set of activities. The wellbeing questionnaire comprised of the Kidscreen-27 (KS-27) (The KIDSCREEN Group Europe, 2004; The KIDSCREEN Group Europe, 2006; Ravens-Sieberer et al., 2007; Ravens-Sieberer et al., 2014) and the resilience questionnaire compromised of the Child and Youth Resilience Measure 12 (CYRM-12) (Ungar & Liebenberg, 2011; Liebenberg, Ungar, & LeBlanc, 2013). Nature connection was measured using the Nature Relatedness Scale 6 (NR-6) (Nisbet & Zelenski, 2013).

The KS-27 questionnaire was completed to gather an understanding of the children's perception of their physical wellbeing, psychological wellbeing, autonomy, relationship with parents and peers, the children's social support and school environment, and finally the children's overall life satisfaction at a given time. The Kidscreen-27 is a series of 27 questions on a five-point scale from strongly disagree (1) to strongly agree (5), broken into five subsections to give an overall assessment of wellbeing: physical activities and health; general mood and feelings about yourself; family and free time; friends; and school and learning.

The CYRM-12 explores the resources (individual, relational, communal, and cultural) available to aid in the children's resilience by overcoming adversity and sustaining wellbeing over time. It is a series of 12 questions on a three-point scale: (1) no; (2) sometimes; (3) yes.

The NR-6 measures the connection that individuals feel to nature, with the ability to predict happiness associated with nature, environmental concern and contact with nature (Nisbet & Zelenski, 2013). The NR-6 has a series of six Likert statements across a five-point scale, from (1) disagree to (5) agree, to generate a single score for nature relatedness. The NR-6 was chosen due to the short number of questions for children to complete quickly and as it has been reported that it is easy for children to understand (Bragg, Wood, Barton, & Pretty, 2013).

The validated questionnaires have demonstrated good reliability to assess wellbeing, resilience, and nature connection of young people 8-12 years old (KS-27 α= 0.80 to 0.84; CYRM α= 0.84;

NR6 α= 0.86; Education Endowment Foundation, 2011; Nisbet & Zelenski, 2013; Ravens-Sieberer et al., 2014). The total scores were calculated for each individual by summing the individuals' scores for KS-27 (range 27 - 135), CYRM-12 (range 12 - 36), and NR-6 (range 6 - 30) with a higher score representing better overall wellbeing, resilience or nature connection.

4.2.5 Biodiversity surveys of school grounds

Surveys of the school grounds were carried out using direct and indirect monitoring methods to record different taxa (as described in Appendix 17). These were completed within one month of the children's biodiversity perception measures (i.e., their before and after drawings), to estimate the biodiversity present for each school, allowing us to compare the survey findings to the children's biodiversity perception drawings. To ensure the biodiversity surveys of the schools' grounds were comparable to the children's drawings, species and abundance within each category were recorded (to produce percentage size of each category) with the use of biodiversity monitoring techniques that were introduced to the children throughout the academic year. This ensured the children were exposed to all taxa identified within the surveys. The biological categories selected for monitoring were trees and other plants, fungi and lichens, mammals, birds, insects, other invertebrates, and amphibians because of focusing on these over the academic year.

4.2.6 Data analysis

All questionnaire measures were scored using the existing protocols as detailed in section 4.2.3-4.2.4 for both control and intervention groups. Before and after scores for biodiversity perception, wellbeing, resilience, and nature connection were compared in the intervention and control groups.

Table 4.2 displays the number of children who filled out each questionnaire before and after the intervention. The number of children that filled out the questionnaires varied due to children choosing not to fill out the questionnaire, child absences, or classes dropping out due to curricular pressures.

Table 4.2: Number of children in the intervention and control groups that filled out the individual questionnaires before and after the study.

Data	Intervention (n)		Control (n)	
	Before	After	Before	After
Biodiversity perception drawing	429	400	120	121
Wellbeing questionnaire	509	473	120	113
Resilience questionnaire	509	476	120	113
Nature relatedness questionnaire	489	477	123	111

Table 4.3 displays the number of questionnaires that were incomplete due to answers missing and the number of unpaired questionnaires due to child absences or children using different unique identification codes in the before and after questionnaires. On average, within the incomplete questionnaires, wellbeing had 3.3 answers missing with the number of missing answers ranging from 1 to 27; resilience had 2.2 answers missing, ranging from 1 to 11; and nature relatedness had 4.0 answers missing, ranging from 1 to 5.

Table 4.3: Number of questionnaires in the before and after collection that had answers missing (incomplete) or had no matching code in the before and after questionnaires (unpaired).

Data	Intervention (n)		Control (n)	
	Incomplete	Unpaired	Incomplete	Unpaired
Biodiversity perception drawing	-	106	-	25
Wellbeing questionnaire	529	114	84	21
Resilience questionnaire	81	114	22	21
Nature relatedness questionnaire	24	92	1	27

The inclusion criteria for final analysis was that paired (before and after) questionnaires were fully complete. Table 4.4 displays the final number of children included in each analysis.

Table 4.4: Number of remaining children in intervention and control groups for statistical analysis.

Data	**Intervention (n)**	**Control (n)**
Biodiversity perception drawing	294	96
Wellbeing questionnaire	103	47
Resilience questionnaire	345	90
Nature relatedness questionnaire	395	99

All statistical analysis was carried out using R 3.5.3 (R Core Team, 2019) and graphs were made on GraphPad Prism 5 (GraphPad Software, 2010). The biodiversity perception data were analysed with generalised linear model with Poisson error structure using R package lme4 (Bates, Maechle, & Bolker, 2014) to examine the change in drawn taxa before and after the activities. Interaction and statistical significance were gathered by removing terms sequentially and testing the significance between the models until a minimal model was achieved. Tukey post-hoc tests with Benjamini-Hochberg correction (to control for multiple testing) were additionally used to test the significance of each pairwise comparison. The effects of school type, age cohort, sex, taxa group and collection point (before and after) were examined with generalised linear mixed models to account for influential random effects of individuals and school. We further examined the difference in the children's perception of biodiversity compared to actual biodiversity coverage before and after the activities. Mann-Whitney-Wilcoxon tests were used to explore the difference between before and after results of the control and intervention groups with Bonferroni correction and adjusted p-values cited (to control for multiple testing). Spearman rank correlations were also used to explore whether there was any association between the children's wellbeing, resilience, or nature connection and the taxa groups they perceived within their school grounds.

A generalised linear model with Poisson error structure using the R package lme4 (Bates, Maechle, & Bolker, 2014) was used to examine the change in the number of children identifying a given group of organisms, before and after the activities. Interaction and statistical significance were gathered by removing terms sequentially and testing the significance between the models until a minimal model was achieved. Tukey post-hoc tests were additionally used to test the significance of each pairwise comparison to investigate the difference in trials. Only drawings of trees and other plants, lichen and fungi, mammals, birds, insects, other invertebrates, and amphibians were included in the relative analysis.

The effects of school type, age cohort, sex and collection point (before and after) on children's wellbeing, resilience, and nature connection questionnaires were examined with generalised linear mixed models to account for influential random effects of individuals and school with Poisson error structure using the R package lme4 (Bates, Maechle, & Bolker, 2014). Interaction and statistical significance were gathered by removing terms sequentially and testing the significance between the models until a minimal model was achieved. Additionally, Wilcoxon signed-rank tests were performed on those children with low baseline scores to change in wellbeing and resilience scores. Finally, Spearman rank correlation coefficient was used to investigate whether there was an association between the categories of organisms investigated and their scores from each questionnaire before and after the activities.

4.3 Results

4.3.1 Perception of biodiversity

The total number of relevant drawn items by the intervention group significantly increased (χ^2= 273.98, SE = 0.10, df = 1, z = 16.92, p < 0.001) after the intervention was completed, regardless of whether the school was private or state. However, the number of items drawn by the control group did not change between the before and after drawings (χ^2= 0.68, df = 1, p > 0.05), as seen in Figure 4.1.

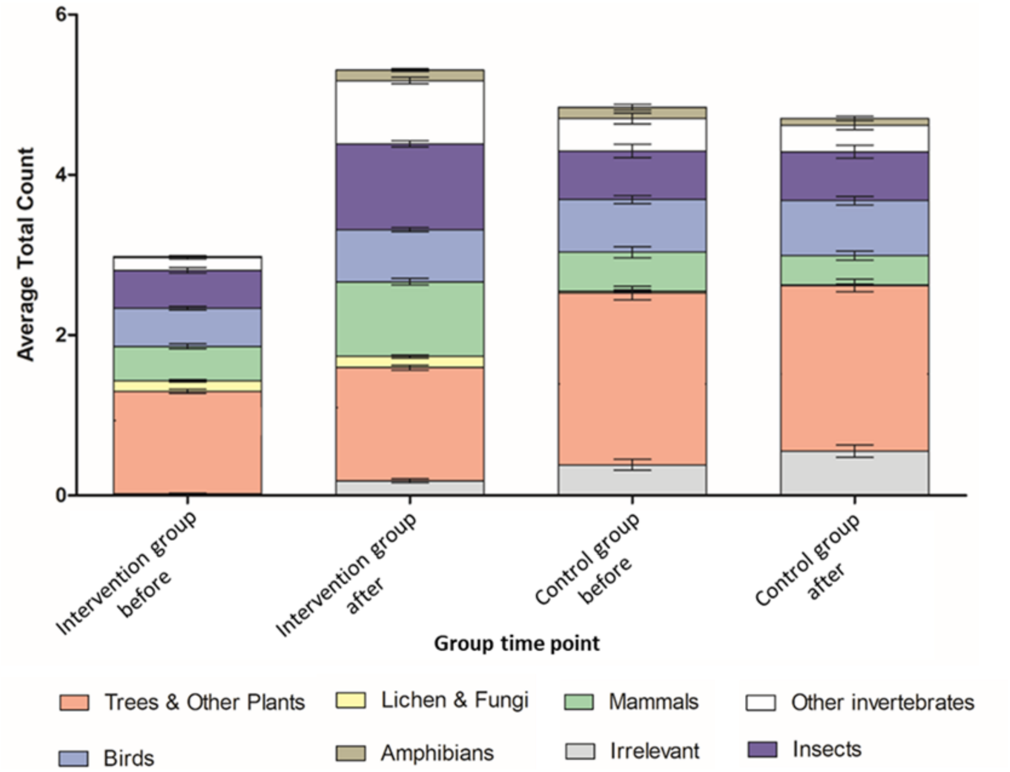


Figure 4.1: Mean number of drawn taxa before/after the activities by intervention and control groups. Error bars represent SEM.

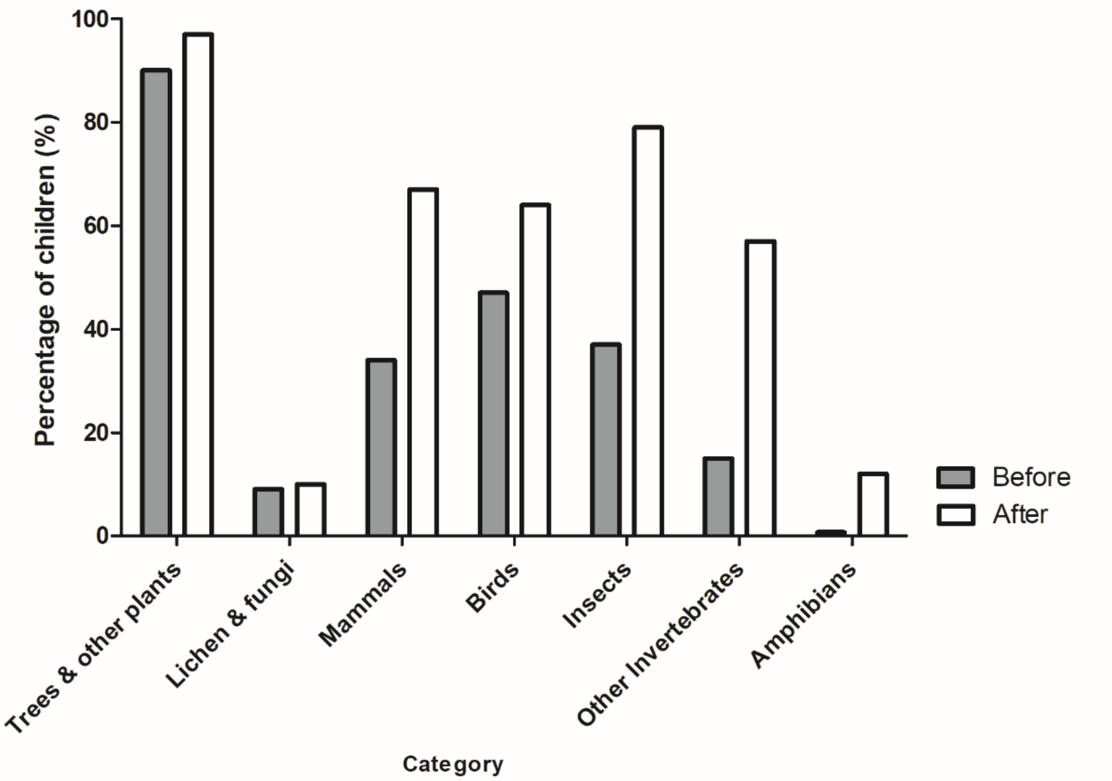
Overall, there was a significant increase in the number of taxa drawn in all explored categories within the intervention group, as seen in Table 4.5, while no change was identified within the control group.

Table 4.5 The change in the number of drawn items within each category for the intervention (n=294)

Category	Intervention (n = 294)		
	SE	**z-value**	**p-value**
Trees & other plants	0.04	-29.49	> 0.001
Lichen & fungi	0.10	-30.80	< 0.001
Mammals	0.05	-33.52	< 0.001
Birds	0.06	-34.16	< 0.001
Insects	0.05	-32.53	< 0.001
Other invertebrates	0.06	-34.34	< 0.001
Amphibians	0.15	-26.46	< 0.001

Similarly, only the intervention group showed significant changes in the percentage of children drawing the different categories at the end of the study (see Figure 4.2a); there were no significant changes for the control group (see Figure 4.2b). In the intervention group, only trees and other plants were drawn by over 50% of the children before the activities. After the activities, mammals, birds, insects, and other invertebrates were additionally drawn by over 50% of the children, with significant increases in the percentage of intervention group children drawing them. Importantly, when exploring the percentage of children who perceived the different categories following the intervention activities, it was found that a greater percentage of children drew mammals (χ^2= 24.44, df = 24, p < 0.01), birds (χ^2= 23.73, df = 24, p < 0.001), insects (χ^2= 23.29, df = 24, p < 0.01), other invertebrates (χ^2= 21.2, df = 24, p < 0.05), and amphibians (χ^2= 57.89, df = 14, p < 0.001). There was no significant change for the trees and other plants category or lichen and fungi category.

(a)



(b)

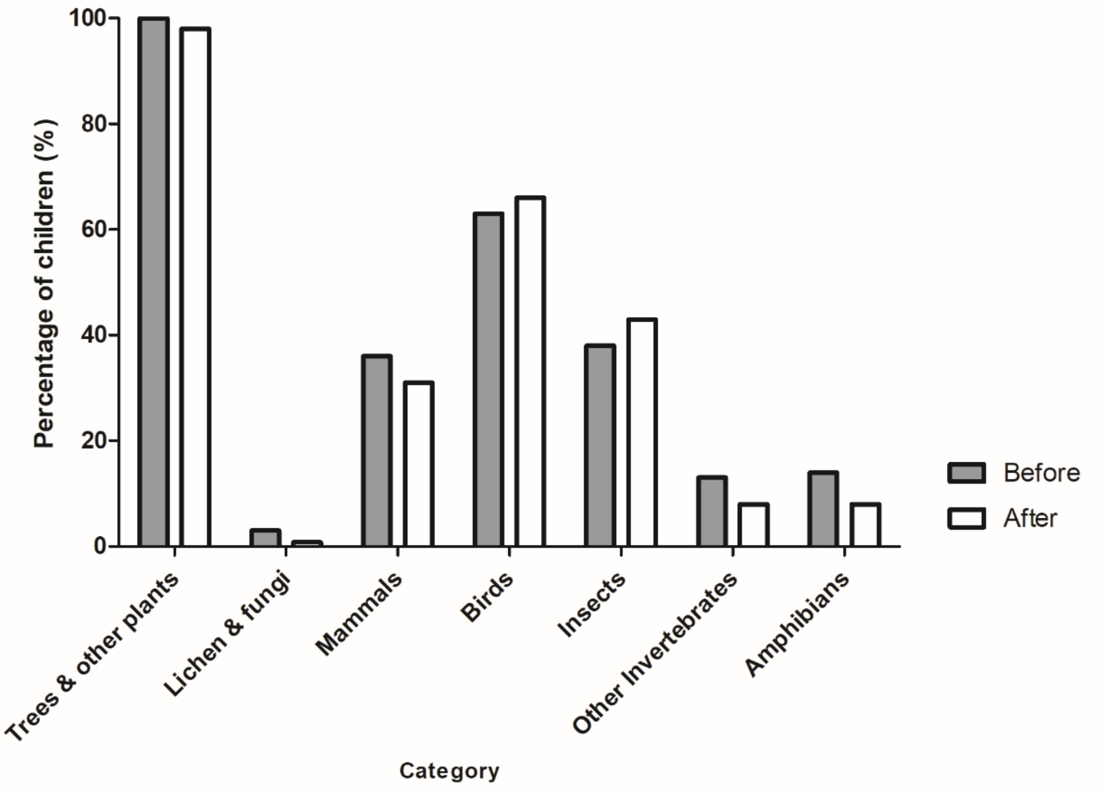


Figure 4.2: The overall percentage of children drawing each category of organisms in their school grounds before and after the activities, in (a) intervention group; (b) control group.

On average, there was a significant change in the perception of abundance of organisms within each biodiversity category within the intervention group, except for lichen & fungi and birds, as seen in Table 4.6. Meanwhile, the control group only perceived significant decreases in the abundance of amphibians.

Table 4.6:The change in perception of abundance in each category in adjusted p-values.

Category	**Intervention (n = 294)**		**Control (n = 96)**	
	V-value	**p-value**	**V-value**	**p-value**
Trees & other plants	36506.0	< 0.001	2240.0	> 0.05
Lichen & fungi	821.0	> 0.05	5.0	> 0.05
Mammals	7779.0	< 0.001	631.0	> 0.05
Birds	11592.0	> 0.05	1508.0	> 0.05
Insects	7863.5	< 0.001	561.0	> 0.05
Other invertebrates	2070.0	< 0.001	497.0	> 0.05
Amphibians	16.0	< 0.001	160.0	< 0.05

The average perception of abundance in each category before and after the set of activities in the intervention group and control group are shown in Figure 4.3. Whilst there was no change found for the control group, with the exception of amphibians, there were significant changes for the intervention group. Specifically, following the intervention activities, children's drawings indicated a reduction in percentage cover of trees and other plants ($V = 36506$, $p < 0.001$), and increases in percentage cover for mammals ($V = 7779$, $p < 0.001$), insects ($V = 7836.5$ $p < 0.001$), other invertebrates ($V = 2070$, $p < 0.001$), and amphibians ($V = 16$, $p < 0.001$).

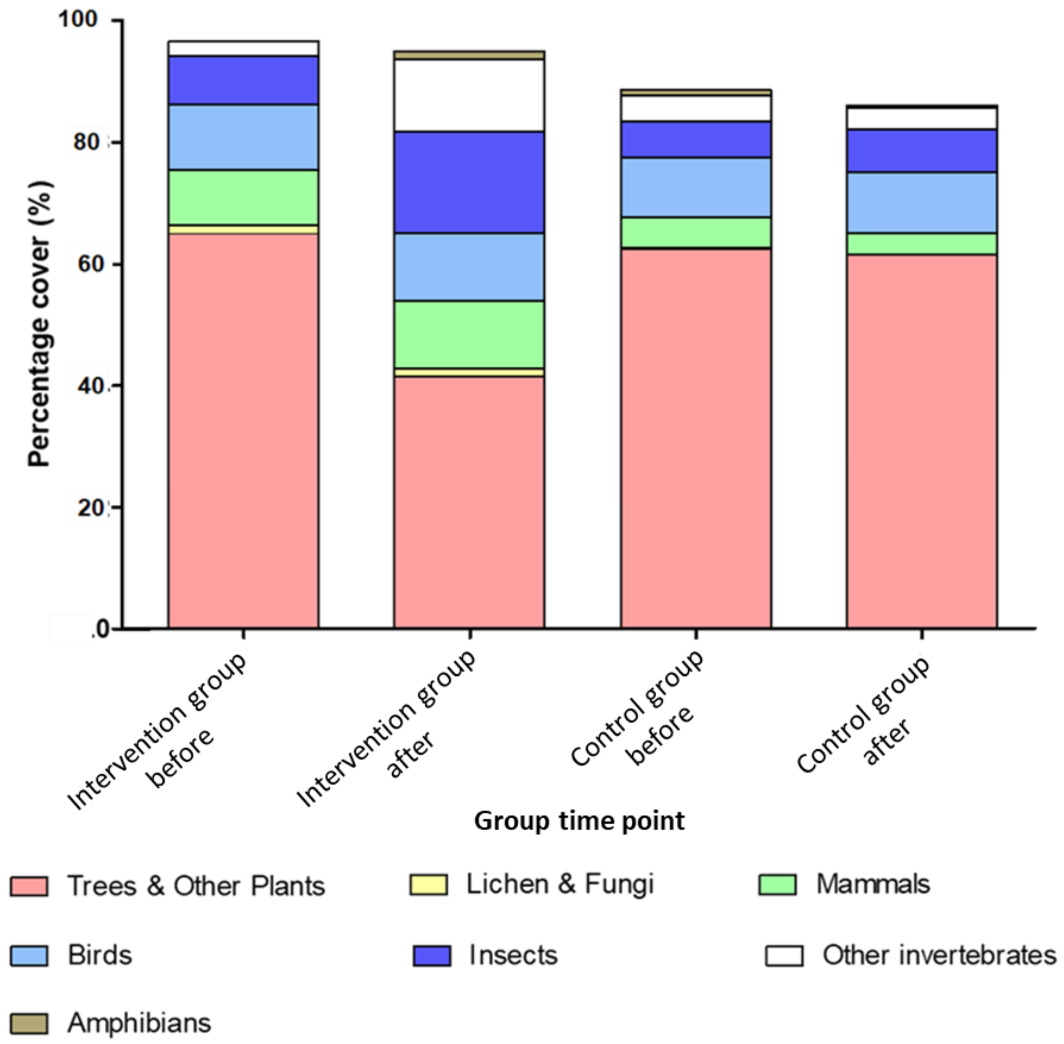


Figure 4.3: Average abundance of drawn taxa before/after the activities by intervention group and control group children. The percentage displayed does not equate to 100% due to the inclusion of irrelevant categories related to organisms' habitats, food source or man-made objects.

To evaluate the likeness of children's perceptions to school biodiversity, we compared their abundance perceptions with the biodiversity survey findings. Table 4.7 displays, for the intervention group only, whether children's perception changed following the intervention activities. Except for the lichen and fungi category, the likeness of children's perceptions of abundance significantly improved following the intervention (see Figure 4.4a). There were no significant improvements in the likeness of abundance for the control group.

Table 4.7: The change in biodiversity perception likeness to actual biodiversity within the intervention group with adjusted p-values.

Category	**V-value**	**p-value**
Trees & other plants	11167	< 0.001
Lichen & fungi	1018	> 0.05
Mammals	4268	< 0.001
Birds	8135	< 0.001
Insects	6377	< 0.001
Other invertebrates	2279	< 0.001
Amphibians	33	< 0.001

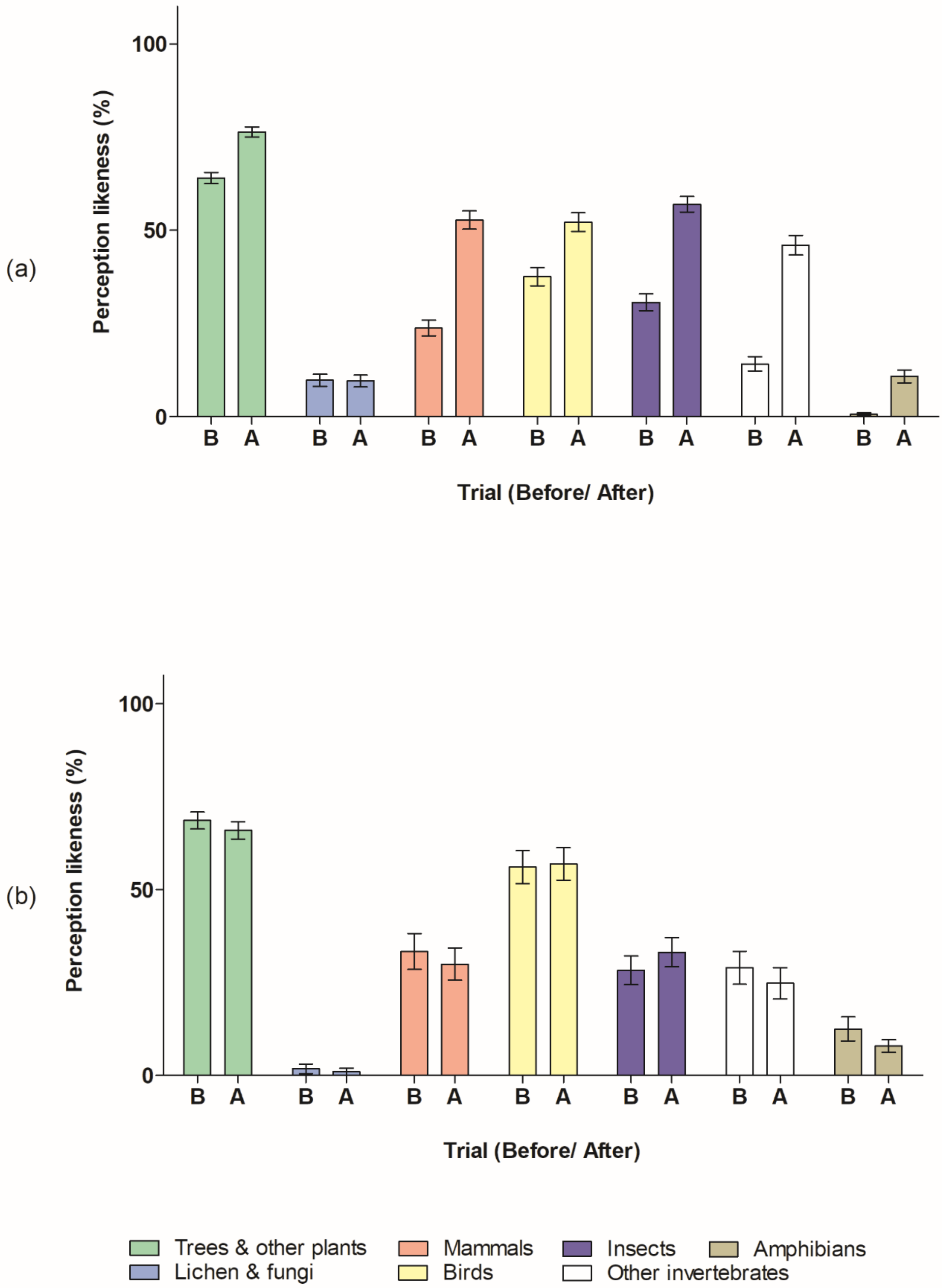


Figure 4.4:The percentage likeness of children's perception of biodiversity to biodiversity present in school grounds in the (a) intervention group and (b) control group children's drawings before (B) and after (A). Error bars represent SEM.

4.3.2 Wellbeing, Resilience & Nature Relatedness

There was no significant change in scores for wellbeing (χ^2= 1.96, df = 1, p > 0.05) or resilience (χ^2= 0.58, df = 1, p > 0.05) after the activities within the intervention and control groups. For both the intervention and control groups combined, the children's average wellbeing score of 113.6 (95% CIs 112.0, 115.2) was in the normal range, however, the average resilience score of 31.5 (95% CIs 31.2, 31.8) was in the upper range (KIDSCREEN Group Europe, 2006; Soliman, 2017; Ungar & Liebenberg, 2011). To explore whether children in the intervention group who had initially low scores benefitted, we carried out further exploratory analysis on the children who initially started with a low wellbeing score (KIDSCREEN Group Europe, 2006) (below 100, n = 25) and those who had a low resilience score (Soliman, 2017) (below 26, n = 21). After the intervention activities, those with initially low wellbeing had significant improvements in wellbeing (before $\bar{x}$ 92.1, after $\bar{x}$ 103.4, χ^2= 12.14, df = 1, p < 0.001) and those within initially low resilience had significant improvements in resilience (before $\bar{x}$ 23, after $\bar{x}$ 27, χ^2= 6.98, df = 1,, p < 0.01), displayed in Figure 4.5. No such significant change was identified for the control group who initially were low.

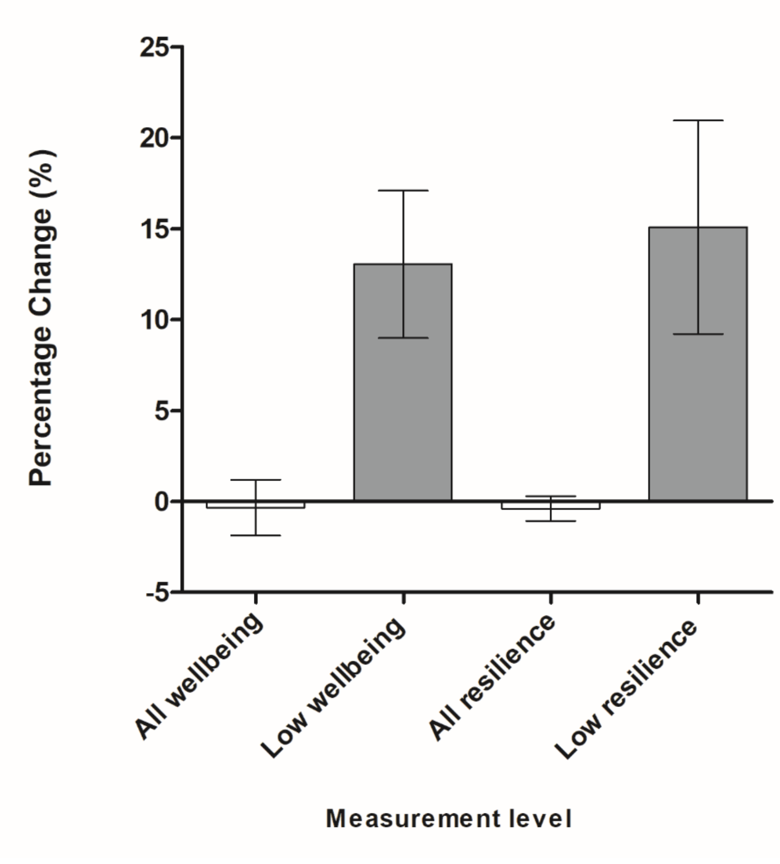


Figure 4.5: Mean percentage change of wellbeing and resilience scores in all participating children and in children that had initially low baseline scores. Error bars represent SEM.

A Spearman rank correlation identified that the intervention group children with higher wellbeing perceived a greater coverage of trees after the activities (rho = 0.22, $p < 0.05$); while those who perceived fewer insects (rho = - 0.20, $p < 0.05$) and had a less reflective perception of insect distribution (rho = 0.015, $p < 0.05$) after completing the set of activities, had better wellbeing.

Comparably, the intervention group children's resilience score before the activities were found to be positively associated with the diversity of tree species perceived (rho = 0.17, $p < 0.01$). However, following a reduction in the flora they perceived (before $\bar{x}$ = 57%, after $\bar{x}$ = 34%), after the activities the children's resilience was weakly positively associated with the coverage of trees (rho = 0.12, p = 0.05) and negatively associated with the number of plants species perceived (rho = 0.15, $p < 0.05$) and perception likeness of plant coverage (rho = - 0.15, $p < 0.05$).

Overall, the children's average nature connection score was 24.61 (95% CIs 24.09, 25.13) which is within the expected range for children of this age group (Bragg, Wood, Barton, & Pretty, 2013). There was no significant change in the children's nature connection after the intervention in either the intervention group or the control group (χ^2= 2.96, df = 1, $p > 0.05$). However, those that had a less reflective perception of bird abundance (perceived more birds than present) after the activities had a higher nature connection score (before $\bar{x}$ accuracy = 39%, SD = 0.43; after $\bar{x}$ accuracy = 52%, SD = 0.42).

4.4 Discussion

Our results show that children initially have a poor perception of the presence and abundance of local flora and fauna. Initially, children mostly perceived flora and birds, while underestimating invertebrates and amphibians. However, once children had participated in biodiversity activities within their school grounds (intervention group), they had a greater awareness of the various taxa, and had a more reflective perception of the biodiversity found in the local natural environment, while the control group did not. The significant improvements in children's perception of biodiversity, wellbeing, and resilience in children with initially low scores were achieved over a short time frame with limited intervention time of only twenty-one hourly sessions across the academic year. Children who perceived high levels of trees and other plants had higher wellbeing and resilience, while those that perceived a greater number of birds than present, had a higher level of nature connection.

This study strengthens the case that children have a poor awareness and understanding of local flora and fauna (Shwartz, Turbé, Simon, & Julliard 2014; White, Eberstein, & Scott, 2018). As the perception of local biodiversity was poor before the activities, this weak ability to acknowledge taxa that are present locally reflects how unaware children are of the natural environment (Hughes et al., 2018) and how spending more time engaging with nature in school benefits their understanding and awareness of biodiversity (Lindemann-Matthies, 2006; White, Eberstein, & Scott, 2018). However, this is an important finding, as providing environmental education opportunities can reduce the lack of awareness children have for the local environment and reduce the extinction of experience (Pyle, 1993). Although a greater awareness of the natural environment may not encourage pro-environmental behaviours, poor awareness and perception of biodiversity can make conservation efforts challenging (Balmford, Clegg, Coulson, & Taylor, 2002). An understanding and awareness of local flora and fauna are crucial to foster the next generation of environmentalists (Richardson et al., 2019).

Although children had a more reflective perception of biodiversity after the one-year intervention, the charismatic larger taxa of mammals and birds remained over-represented compared to local abundance, and insects and other invertebrates remained underrepresented. This finding supports previous investigations that identified children to favour larger animals, such as vertebrates, compared to invertebrates (Borgi & Cirulli, 2015; Snaddon, Turner, & Foster, 2008). Many factors may play a role in this. For example, children's books are often one of the first instances young people develop a connection with nature. Yet, within the title of children's books, 60% of animals have been found to be mammals and 18% birds (More, 1979). Clayton and Myers (2011) have argued that perceptions are formed throughout a lifetime and are strongly reliant on memory as well as the present and future experiences people have. Therefore, these past childhood experiences can enhance the distorted perception children have of the local environment (Clayton & Myers, 2011) and may reflect why children who perceived higher numbers of birds have a higher nature connection.

Furthermore, biological, social, and behavioural traits shared with certain taxa may result in people favouring animals that are like humans. Examples of these are pair-bonding and bi-parental investment in mammals and birds (Batt, 2009; Kellert, 1996). Likewise, it has been identified that children have a preference for the smallest phyla, such as mammals, and have a dislike and fear for invertebrates (Borgi & Cirulli, 2015; Cho & Lee, 2018) which may reflect why they overrepresented the larger organisms and underrepresented insects and other invertebrates within their drawings. However, through education, children can adapt their perceptions of biodiversity which can lead to a greater awareness of nature around them, allowing for a greater connection to nature to develop.

Before the activities, the intervention children only perceived over 50% likeness of the biodiversity present within the category trees and other plants, however, afterwards perception of mammals, birds and insects were also found to increase to over 50% likeness. Although the children only had 50% likeness of the biodiversity present, this is still a significant improvement after a short time of intervention activities.

While the set of activities lead to insects and other invertebrates being more widely acknowledged by the children and developed their awareness of the vastness of invertebrate presence, insects and other invertebrates were still greatly underestimated. This perception is reflective of research output, with flagship species, such as mammals, more widely researched and discussed in the media (Genovart, Tavecchia, Enseñat, & Laiolo, 2013; Titley, Snaddon, & Turner, 2017) compared to the smaller invertebrate species, and so the perception of the prominence and importance of insects is distorted in the public domain. However, to promote a greater awareness of the importance and scale at which invertebrates are present in our local environments, initiatives centred around insects are being more readily available to school children. An example of this is the Big Butterfly Count, which is now more widely reported in the media due to backing by prominent celebrities such as David Attenborough and Joanna Lumley (Butterfly Conservation, 2014). This is of particular importance at a time when 41% of insect species are threatened with extinction in the UK, eight times higher than vertebrate species (Sánchez-Bayo & Wyckhuys, 2019).

Previous studies have identified that a higher perception of species richness can influence wellbeing (Fuller et al., 2007). Our study identified that perceiving higher levels of vegetation than was present was associated with higher wellbeing and resilience. This is supportive of previous studies identifying that the presence of trees and plants can aid in stress and anxiety relief (Chang, 2005; Guan, Wei, He, Ren, & An, 2017) and that green space can aid in behavioural resilience (Flouri, Midouhas, & Joshi, 2014).

Additionally, although the children's perception of insects and other invertebrates increased after the activities, those who had a less accurate perception of insects and perceived fewer, had higher wellbeing. This may be reflective of the biophobia hypothesis (the fear of nature; Ulrich, 1993) of children having negative associations with invertebrates (Borgi & Cirulli, 2015; Cho & Lee, 2018). It has previously been identified that it can take a long time to unlearn a fear-response from natural objects, therefore, although the intervention group might have become more comfortable with invertebrates over the year, it may not have been long enough to combat these negative associations with insects (Clayton & Myers, 2009). However, continued exposure to nature could reduce these phobias and positively impact wellbeing in the long-term (Gascon et al., 2015; Ollendick & King, 1991), as previously identified in studies on engagement activities with 'non-charismatic' species of amphibians and insects (Barthel, Belton, Raymond, & Giusti, 2018; Cho & Lee, 2018).

Although there was no significant improvement in wellbeing and resilience for the intervention group after the intervention activities, these did improve for the intervention group children who had initially low wellbeing and resilience scores, but not the control group children. Previous studies have identified a similar trend that various activities within nature can positively influence children's wellbeing and resilience through an effect on their self-confidence, self-esteem, stress and restoration (Flouri, Midouhas, & Joshi, 2014; Roberts, Hinds, & Camic, 2019). However, as many of these studies have involved activities centred around adventure games, forming positive group relationships without control groups and focussing on the presence of neighbourhood nature, as opposed to interactions with it (Berger, 2008; Doucette, 2004; McArdle et al., 2013), our research has focussed primarily on the engagement with nature and can more reliably infer this has been the benefit of nature engagement.

It was surprising that as children's perception of nature improved, their nature connection did not increase. However, this may have been due to a ceiling effect with children on average scoring in the upper limits of the nature relatedness scale. Similar findings have been reported by Harvey et al. (2020) who discovered that only children who were initially poorly connected to nature before a one-year intervention had a significant improvement in this trait.

The findings from the investigation explore the influence biodiversity perception has on children's wellbeing, resilience, and nature connection, as well as the impact an outdoor education programme centred around the school's biodiversity, can have on children's perception of local flora and fauna. This paper contributes to the gap in knowledge of whether a reflective perception of biodiversity influences wellbeing, resilience and nature connection and which taxa influence them.

4.5 Conclusion

A poor perception and awareness of nature is found in children. This study contributes towards the understanding of the influence outdoor education, centred around nature engagement, can have on children. It highlights the importance of fieldwork during their education to enhance their awareness of local flora and fauna, as well as support their wellbeing and resilience. This research also emphasises that outdoor education can be achieved throughout school grounds. We have shown that engaging with nature over a short time can positively influence those with low wellbeing and resilience, reduce extinction of experience and improve awareness of local biodiversity which can lead to children being inspired to explore nature and foster pro-environmental behaviour for a sustainable future.

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Conflict of interest

The authors would like to disclose that there was no conflict of interest.

Author Contributions

LNM, DJH, DW designed the study; LNM, DJH recruited schools and coordinated data collection; LNM and DJH collected the data; LNM carried out the statistical analysis; LNM wrote the manuscript; LNM, DJH, DW and ACG edited the manuscript.

Data Availability Statement

We intend to archive the data in Dryad.

Ethical Approval

All data collected and used in this study were collected with approval from Royal Holloway University of London Research Ethics Committee procedures. Informed consent was obtained from all participants and guardians in this study.

Chapter 5 : The influence of outdoor education within school grounds on children's perspectives and knowledge of local wildlife

Abstract

Children are growing up more disconnected from the natural environment than previous generations. This generational extinction of experience is leading to poor knowledge and awareness of wildlife within local areas which is a cause of concern for the future of biodiversity conservation. School outdoor education activities centred around hands-on biodiversity engagement can promote a re-connection with the natural environment and instil knowledge and enthusiasm to learn. However, limited studies have been conducted to assess the impact of these engagements on local nature understanding and perspectives. This study explored the knowledge and perspectives of 410 primary school children (aged 8-12) on British wildlife before and after hands-on outdoor education activities over an academic year using quizzes, personal meaning maps and evaluation questionnaires. It was identified that children had initially poor knowledge of local wildlife; however, after the set of activities, knowledge significantly improved as well as a reduction in incorrect and negative perspectives. Children expressed enthusiasm to continue outdoor education and a growing enjoyment of nature. Teachers remarked on the benefit the outdoor education sessions had in supporting their teaching and children's wellbeing and learning experience. The findings from this study demonstrate the multiple benefits that can be obtained from exploring wildlife within school grounds over a short period throughout the academic year. Building outdoor education into the curriculum is an effective way to reconnect with nature while instilling knowledge and awareness of local wildlife to ensure future ecological values.

5.1 Introduction

Currently, throughout the world, more than half of the population live in urban areas, compared to only 30% in the 1950s (Grimm et al., 2008). This rapid increase in population movement into towns and cities over recent generations has led to more children being surrounded by human-made environments and a decline in the opportunities to engage with local wildlife (Cox et al., 2017). Furthermore, as a result of urbanisation, children are spending less time outdoors due to concerns about road traffic, social fears and the increase in technology (Gill, 2007; Pretty et al., 2009). This 'extinction of experience' (Pyle, 1993) has led to children in the UK growing up disconnected from the local nature and having a poor awareness, understanding and knowledge of local flora and fauna (Soga & Gaston, 2016). Additionally, the lack of nature experience has been shown to have negative consequences for people's wellbeing, cognitive abilities, and affinity to nature (Gascon et al., 2015; Richardson et al., 2019).

A detachment from local wildlife is resulting in the diminishment of natural history knowledge and identification skills (White et al., 2018). Yet, awareness and understanding of the natural environment are vital for conserving local biodiversity (Liefländer et al., 2013; Sousa et al., 2016). Shifting baseline syndrome is the process in which there is a shift in the standards of the natural environmental condition due to a lack of memory, experience or knowledge of how the environment was before (Papworth et al., 2009; Soga & Gaston, 2018). Therefore, reduced knowledge can lead to a shift in what is regarded as unspoiled local biodiversity, leading to further degradation of the natural environment and enhancing nature disconnection (Ballouard et al., 2011; Soga & Gaston, 2018).

Species identification is a substantial part of the knowledge of the natural environment and plays a large role in the conservation of local wildlife (Pilgrim et al., 2008). As countries become more developed, and individuals experience less daily contact with the natural environment, species identification skills of local flora and fauna decrease (Pilgrim et al., 2008; Sampaio et al., 2018). An affinity and understanding of nature are often developed at a young age when children are more inclined to build an emotional attachment to what they recognise and appreciate (Bilton, 2014b; Weilbacher, 1993). Previous research has identified young people to have poor identification skills of common wildflowers (Bebbington, 2005) and bird species (White et al., 2018). Poor bird identification skills are particularly surprising as they have previously been regarded as a charismatic group of organisms (defined as vertebrate species that arouse public interest (Simberloff, 1998;Borgi & Cirulli, 2015; White et al., 2018). Yet, children can identify a more significant proportion of cartoon Pokémon 'species' compared to common native wildlife (Balmford et al., 2002), highlighting the lack of time children spend interacting with the natural environment.

Furthermore, people have been found to have negative associations towards nature, referred to as biophobia (Ulrich, 1993). Previous research has shown that children's feelings of biophobia have been directed towards amphibians and insects (Borgi & Cirulli, 2015; Cho & Lee, 2018), and focus more attention towards exotic species due to exposure from the internet (Ballouard et al., 2011). A study has shown that decorative plants and non-native garden plants are regarded as the most attractive organisms by children, as well as pets and charismatic mammalian species (Lindemann-Matthies, 2005). However, it has been suggested that tackling these negative perspectives of nature and poor knowledge can be achieved through outdoor education in schools (Liefländer et al., 2013).

Knowledge and perspectives of charismatic and non-charismatic species are a crucial aspect of ensuring species decline globally are reversed. Since the 1930s, 97% of wildflower meadows have been lost in the UK, and currently, 36% of reptile and amphibian species and 41% of insect species are threatened with extinction; compared to 8% of birds and 11% of mammals within the UK and British overseas territories (Hayhow et al., 2019; Sánchez-Bayo & Wyckhuys, 2019). A drive for more outdoor education and fieldwork in schools is of particular importance to reduce biodiversity loss and promote conservation in the next generation, at a time when 41% of species have declined in abundance and 15% of species are threatened with extinction in the UK (Hayhow et al., 2019).

School grounds are a prime location for children to experience nature first hand (Harvey et al., 2019) and reintroduce them to local wildlife identification and knowledge through fieldwork (Bebbington, 2005). Direct and indirect links of outdoor education to academic performance have additionally been found in the subjects of mathematics, English, and science through making topics more engaging and aiding in attention restoration (Glenn, 2000; McCormick, 2017; Quibell et al., 2017). Currently, an interest in science within 9-12-year olds has been identified to be in decline since 2015. It was found that less than 40% of children enjoyed science at school (Childwise, 2019); therefore it is of particular importance to foster an interest in science and the natural environment through fieldwork undertaken in primary school years. Hands-on experience during child development is necessary to ensure positive perspectives of local wildlife, reduce misconceptions and develop a connection to nature that can be adopted for later years.

The aim of this study was to investigate whether children's perspectives and knowledge of British flora and fauna change after an outdoor education intervention (hands-on biodiversity activities) to engage children with the local wildlife in their school grounds over one academic year. Children's knowledge and perspectives were assessed with the use of quizzes and personal meaning maps (PMMs). An evaluation questionnaire after the outdoor education intervention was also completed at the end of the academic year by teachers and children to gain an understanding of whether they felt more connected to nature and whether the outdoor education intervention had given them more confidence in science education and outdoor learning.

It was hypothesised that children would have poor species identification skills and knowledge of taxa before the outdoor education intervention, but to a greater degree for less charismatic groups (insects and plants) compared to charismatic groups (mammals and birds). It was additionally hypothesised that children would have more negative perspectives towards the less charismatic taxa studied (insects and plants) and have more positive perspectives towards mammals and birds. Additionally, after the intervention, it was expected that the children's perspectives of the nature themes (insects, plants, mammals, and birds) would become less negative through tackling biophobia and knowledge of all investigated taxa and species identification skills would increase.

5.2 Methodology

5.2.1 Participants

A total of 410 children (8-12 years old), from 11 schools (four private and seven state) across the South East of England (Surrey, Berkshire and Middlesex) were recruited for the study through teachers and heads of school. Additionally, the class teacher from each participating class (n=15) was recruited to participate in the data collection process (detailed in section 5.2.4). Informed consent for every child was obtained from the participant as well as parents or guardians, as approved by the Royal Holloway, University of London, ethical review process. Each child was given a unique six-character code which consisted of the initials of their first and last name, the day they were born and their class (e.g. LM025C). The unique code was to ensure anonymity throughout the study and to match the children’s before and after survey responses. Table 5.1 displays the demographics of the participating children.

Table 5.1:Demographics of participating children.

Year group	**Age cohort**	**Participants**
4	8-9	157
5	10-11	215
6	11-12	38
School type	Private	83
	State	327

5.2.2 Outdoor education intervention

The hands-on outdoor education activities, referred to as the intervention, were aimed at engaging children with British species and habitats in their school grounds through monitoring local wildlife and building new habitats and food sources (Harvey et al., 2020). The outdoor education intervention aimed to teach children about biodiversity within their school grounds, through hands-on activities focussed around various taxa over an academic year, specifically on the major taxonomic groups of plants, lichens, fungi, mammals, birds, amphibians and invertebrates (see section 2.2.4 and Appendix 1 for more information). The activities were developed to be appropriate for all participating schools, irrespective of the environmental quality or size of the school grounds, and to accommodate the school curriculum.

The nature engagement activities were carried out over one academic year (September 2018 – June 2019) for one hour per week, for seven weeks per term; equating to 21 sessions in the academic year. Each session began with a short PowerPoint presentation in the classroom to introduce the children to what they would be doing over the next hour and to ensure the outdoor education intervention was standardised across activity leaders. The intervention was delivered to the schools by the researchers with undergraduate student volunteers as support. All volunteers were Biological Science students who were trained before the sessions.

5.2.3 Knowledge attainment and perspective measurement

Each child completed four quizzes and four PMMs to assess local wildlife identification and taxa knowledge on mammals, birds, insects, and plants. These were completed before and after the outdoor education intervention to assess children's knowledge and perspectives. The quizzes and PMMs assessed whether the children's knowledge of how to identify the various taxa and species had developed following the outdoor education intervention. Quiz answers on species identification questions were marked as correct (1 point for full common name, e.g. blue tit); partially correct (0.5 points e.g. tit) or incorrect (0 points) for mark comparison; while other questions were marked as correct (1 point) or incorrect (0 points). Each fact (incorrect or correct) or perspective (positive, negative, or neutral) on the PMMs were given a score of 1 for quantitative analysis. All PMMs and quizzes were given a total score for each theme. Spelling was not penalised.

5.2.3.1 'Is it a mammal?' quiz

The mammal quiz involved fifteen questions to explore whether children understand key mammal characteristics. The children answered 'yes' or 'no' for whether the animal was a mammal in questions 1-7 and the name of the species: red squirrel (*Sciurus vulgaris*), ladybird (*Coccinella septempunctata*), robin (*Erithacus rubecula*), hedgehog (*Erinaceus europaeus*), sand lizard (*Lacerta agilis*), frog (*Rana temporaria*), field mouse (*Apodemus sylvaticus*). Questions 8-11 asked whether the mammal was a carnivore, herbivore, omnivore and/or rodent and name the animal: field mouse (*Apodemus sylvaticus*), fox (*Vulpes vulpes*), badger (*Meles meles*), roe deer (*Capreolus capreolus*). Questions 12-14 asked for the name of a mammal that would consume grass, chickens, and earth worms. The final question asked for a definition of the term 'warm blooded'.

5.2.3.2 Bird quiz

The bird quiz focussed on bird identification and asked children to identify 16 species of British birds, namely: Blackbird (*Turdus merula*), Starling (*Sturnus vulgaris*), Robin (*Erithacus rubecula*), Song thrush (*Turdus philomelos*), Magpie (*Pica pica*), Chaffinch (*Fringilla coelebs*), Wood pigeon (*Columba palumbus*), Feral pigeon (*Columba livia domestica*), Black-headed gull (*Chroicocephalus ridibundus*), Jay (*Garrulus glandarius*), Blue tit (*Cyanistes caeruleus*), Carrion crow (*Corvus corone*), Pied wagtail (*Motacilla alba*), House sparrow (*Passer domesticus*), Jackdaw (*Corvus monedula*), and Dunnock (*Prunella modularis*).

5.2.3.3 'Is it an insect?' quiz

The insect quiz focussed on insect characteristics with children answering 'yes' or 'no' on whether the 22 invertebrates were an insect or not and identify each invertebrate species common name: Shield bug (*Palomena prasina*), Tick (*Ixodes ricinus*), Earwig (*Forficula auricularia*), Spider (*Araneus diadematus*), Woodlouse (*Oniscus asellus*), Centipede (*Lithobius forficatus*), Devil's coach horse (*Staphylinus olens*), Mayfly larvae (*Ephemera danica*), Ladybird (*Harmonia axyridis*), Snail (*Cepaea nemoralis*), Slug (*Limax flavus*), Stag beetle larvae (*Lucanus cervus*), Silverfish (*Lepisma saccharina*), Froghopper (*Philaenus spumarius*), Ant (*Lasius flavus*), Moth (*Mimas tiliae*), Crane fly (*Tipula paludosa*), Water boatman (*Corixa punctate*), Blue bottle fly (*Calliphora vomitoria*), Bumblebee (*Bombus terrestris*), Harvestman (*Phalangium opilio*), and Cricket (*Leptophyes punctatissima*).

5.2.3.4 'Is it a plant?' quiz

The plant quiz focussed on plant characteristics with children answering 'yes' or 'no' on whether the six pictures were a plant and identify the name: Moss (*Eurhynchium striatum*), Lichen (*Xanthoria polycarpa*), Fern (*Dryopteris filix-mas*), Mushroom (*Amanita muscaria*), Oak tree (*Quercus robur*), and Poppy (*Papaver rhoeas*).

5.2.3.5 Personal Meaning Maps

PMMs have been proven to be a useful tool to asses children's learning as it allows the topic to be assessed in addition to the quizzes, without any leading questions through a manner that enables the child to share their views and knowledge of each given theme (Falk & Reinhard, 2007; Mupezeni & Kriek, 2018). PMMs have the topic word (e.g. insects) written in the middle of the page and then each child has two minutes to write down what facts and ideas they can think of to do with that given theme. Separate PMMs were completed by each participant at the start and end of the academic year in which the activities took place.

The PMM responses were grouped into themes: positive perspectives, negative perspectives, neutral perspectives, correct facts and descriptions (species names and taxa specific), and incorrect facts and descriptions (irrelevant and inaccurate facts and descriptions).

5.2.4 Post-intervention evaluation questionnaires

Immediately after the outdoor education intervention, the teachers and children completed an evaluation questionnaire of whether they felt the intervention impacted them through 'yes' or 'no' answers (see Appendix 12 and 13). The teachers were asked whether they were more confident teaching outside the classroom; felt more connected to nature; had a greater knowledge of the natural environment; would integrate some of the resources into their teaching; whether they felt the children's connection to nature and wellbeing had benefited; and what they enjoyed the most and least. The children's questionnaire was centred around whether they felt more connected to nature, learnt more outside, whether they liked the individual taxa of mammals, birds, insects and plants more than before the outdoor education intervention, whether they want to continue outdoor education, and whether they noticed nature more. Finally, the children were asked to name their favourite activity throughout the year.

5.2.5 Data analysis

Data from all quizzes and PMMs were checked, and unpaired before or after quizzes and PMMs were removed due to child absences. All statistical analysis was carried out using R 3.5.3 (R Core Team, 2019). Before and after correct scores of quizzes were analysed with paired Wilcoxon signed-rank tests with Bonferroni correction (to control for multiple testing) for all children within themes and between themes. Generalised linear mixed models (GLMM) with Poisson error structure were used to assess the impact of demographic factors of year and school type on the fully correct quiz scores and PMMs. Fully correct scores were analysed using GLMM with Poisson error structure to account for the random effect of individuals. Interaction and statistical significance were gathered by sequentially removing terms and testing significance to build a final full model. Tukey post hoc tests were additionally used to test the significance of each pairwise comparison to investigate the scores between different years and school types (private and state).

The answers to the teacher and children's post-intervention evaluation questionnaires were explored using descriptive statistics of percentages. There was a potential source of bias, as respondents may have answered the questionnaires in an approach believed to be more appropriate compared to how they accurately felt. However, to reduce the source of bias, questionnaires were completed anonymously and the children were reminded that the questionnaires were not a test (Ballouard et al., 2015; White et al., 2018).

5.3 Results

5.3.1 Quizzes

The total mean score of the quiz themes within all schools significantly improved after the outdoor education intervention, as displayed in Figure 5.1. The bird ($V = 13.5$, $p < 0.001$) and mammal ($V = 2073$, $p < 0.001$) total mean scores were lowest out of all four investigated quiz themes before and after the outdoor education intervention compared to insect ($V = 2277$, $p < 0.001$) and plant ($V = 4817$, $p < 0.001$) scores. There was a significant difference between the baseline scores of all the themes investigated, with birds having the lowest before score, followed by mammals, then insects and finally plants having the highest initial score out of all investigated themes. After the set of activities, there were fewer pairwise differences as birds and mammals significantly improved and did not significantly differ in after scores.

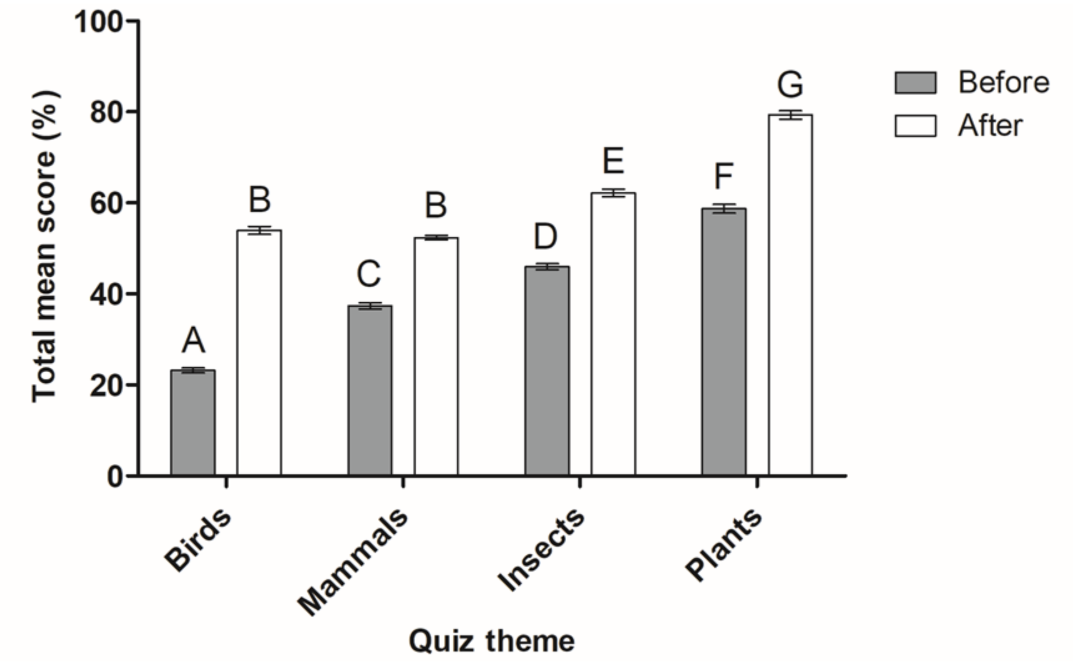


Figure 5.1:Total mean percentage quiz score before and after the intervention. Birds n = 382; Mammals n = 331; Insects n = 375; Plants n = 348. Groups not sharing a letter denote statistical significance (p < 0.05). Bars represent SEM.

Children had a good initial ability identifying which taxa group the species belonged to, achieving a mean score of over 60% on all taxa groups before the outdoor education intervention. The mean taxa identification score significantly increased after the outdoor education intervention with children identifying species correctly as mammals the most and identifying invertebrate species to be insects the least successfully, before and after the intervention. Figure 5.2 displays the mean taxa identification score (identifying given organisms to be either mammals, insects, or plants) within the quizzes: mammals ($V = 3204$, $p < 0.001$), insect ($V = 5149$, $p < 0.001$) and plants ($V = 509$, $p < 0.001$).

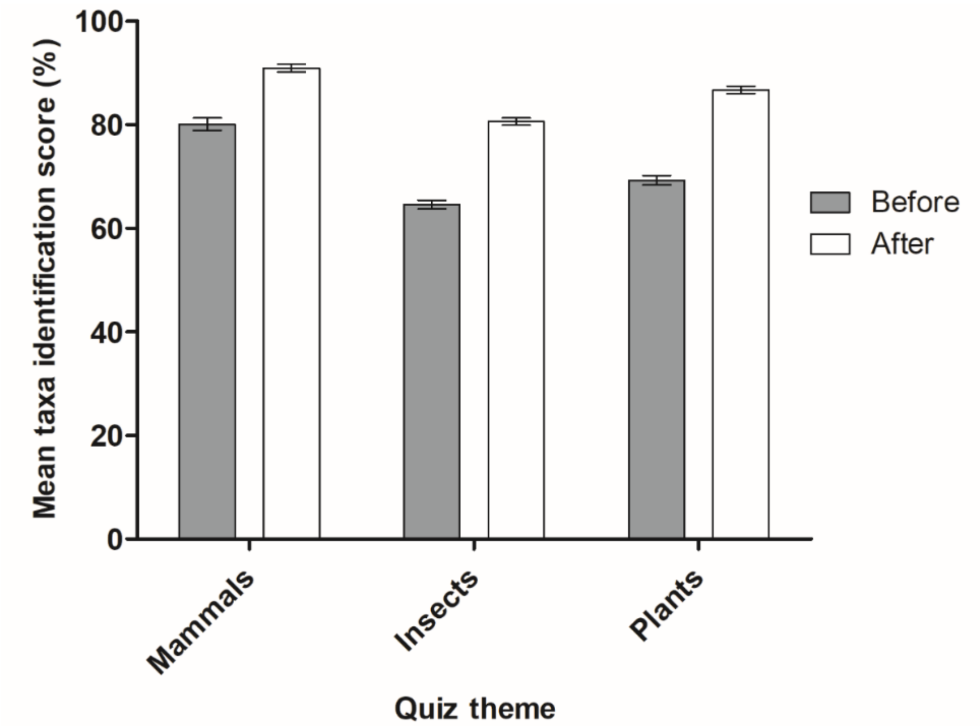


Figure 5.2: Mean percentage quiz score of taxa identification before and after the intervention. Mammals n = 331; Insects n = 375; Plants n = 348. Bars represent SEM.

Children had a poor initial ability identifying the common name of each species before the intervention. 'Mammals' was the only theme that children could identify over 50% of species names within the quiz before the outdoor education intervention. Mean species identification score significantly increased in all themes after the outdoor education intervention: birds ($V = 13.5$, $p < 0.001$), mammals ($V = 8560$, $p < 0.001$), insects ($V = 9122$, $p < 0.001$) and plants ($V = 5034.5$, $p < 0.001$); however, insects remained below 50% correct species identification after the intervention.

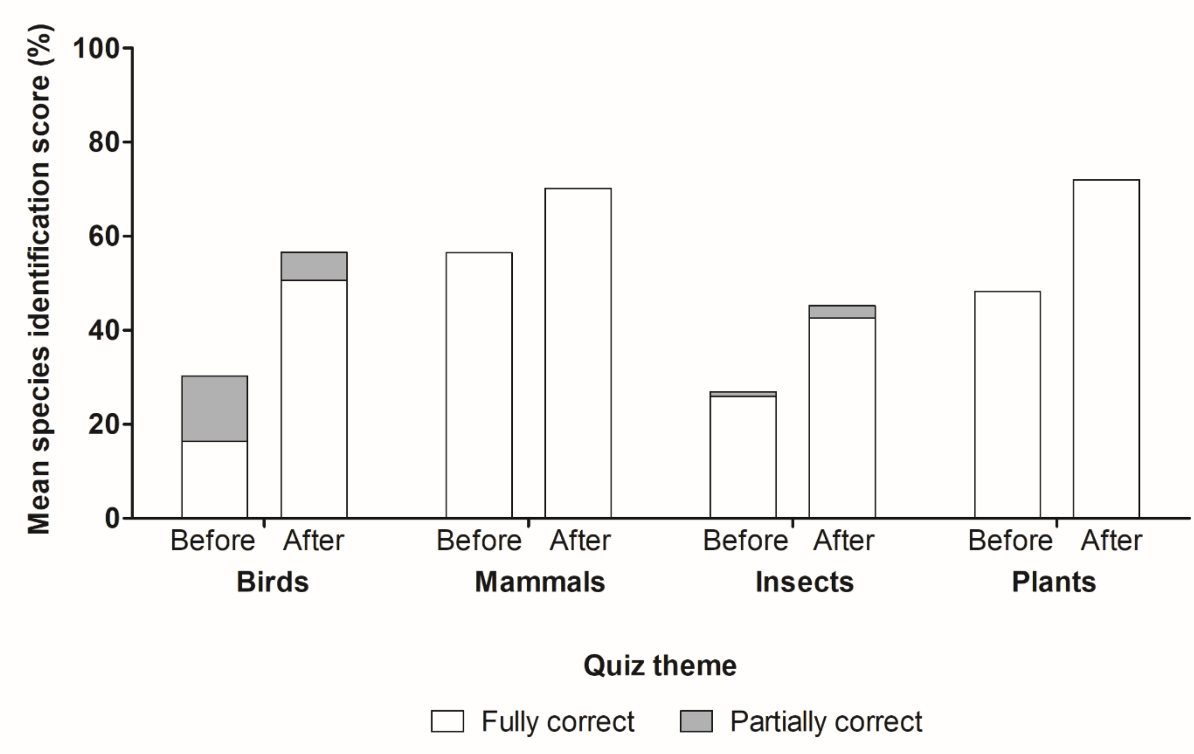


Figure 5.3: Mean species identification scores of partly correct and fully correct before and after the intervention for each quiz theme.

The bird and insect quizzes primarily focused around species identification; therefore, these two themes were more closely analysed. Figure 5.4 displays the number of correct (partially and fully) bird species identification, out of 16 questions, before and after the intervention. Bird identification significantly improved after the intervention ($V = 13.5$, $p < 0.001$). Before the intervention, only 21% of children fully correctly identified four or more (over 25% of questions) species, whereas after the intervention, 90% of children fully correctly identified four or more species.

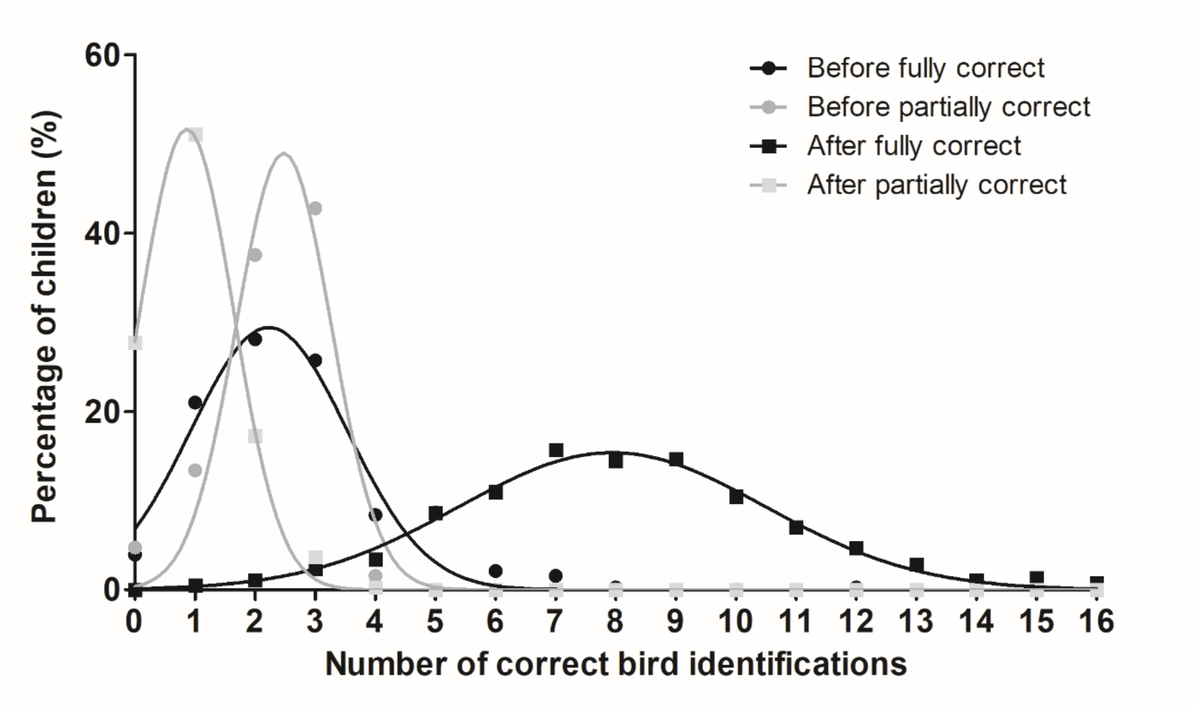


Figure 5.4: Percentage of fully or partially correct bird identifications (out of 16) before and after the intervention.

Figure 5.5 displays the percentage of children who correctly (partially or fully) identified each bird species before and after the intervention. Robin was the only species that was fully correctly identified by over 50% of children before the intervention. However, after the intervention, seven species were fully correctly identified by over 50% of children. Additionally, wood pigeon, feral pigeon and black-headed gull were partially identified by 50% of children before the intervention; however, only feral pigeon remained partially identified by over 50% of children after. The three most correctly (fully and partially) identified species before and after the intervention were robin, woodpigeon, and black-headed gull.

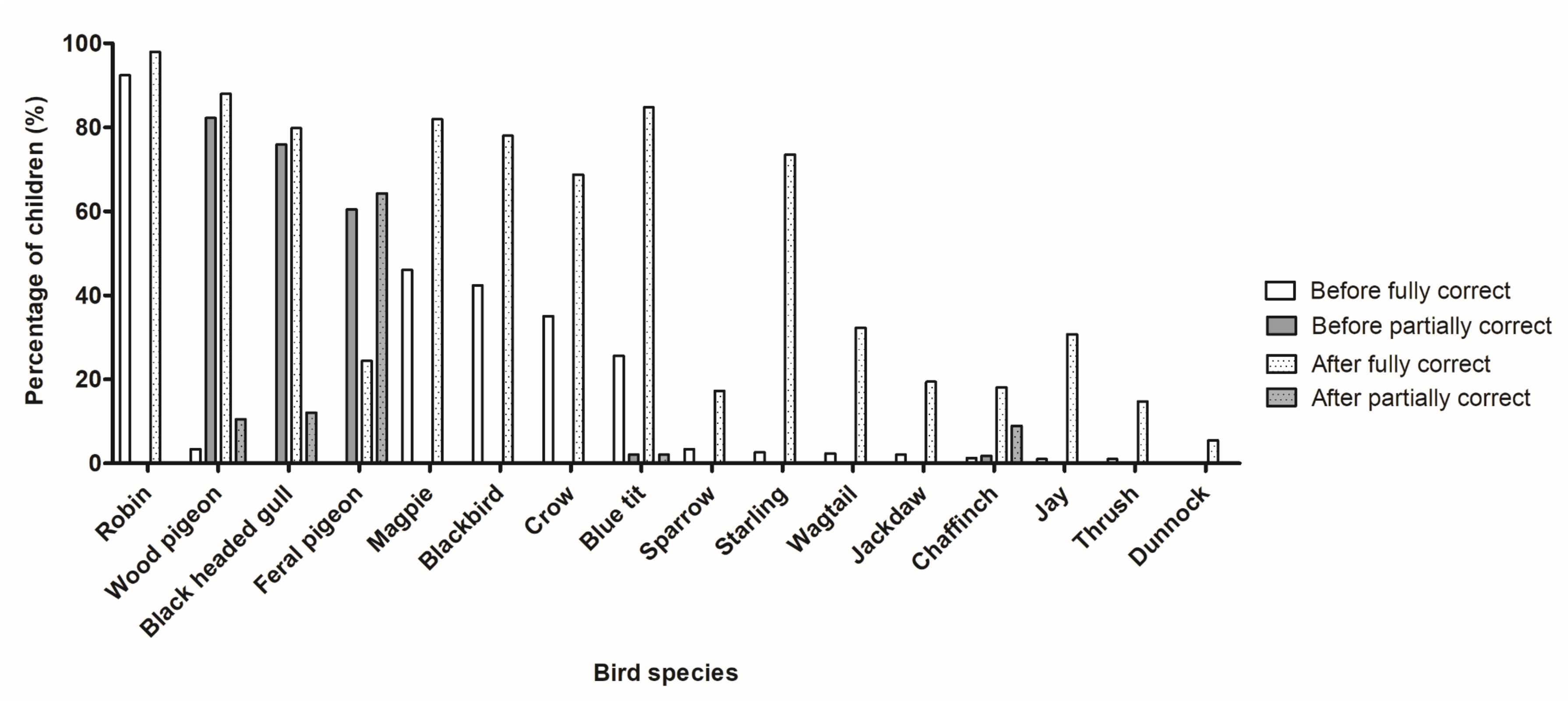


Figure 5.5: Percentage of children that fully or partially correctly identified each bird species (a) before and (b) after the outdoor education intervention.

Table 5.2 displays the GLMM results summary on fully correct bird quiz scores. Baseline ($\chi^2 = 13.92$, df = 1, $p < 0.001$) (Table 5.2a) and post-intervention ($\chi^2 = 8.63$, df = 1, $p < 0.01$) (Table 5.2b) scores were significantly higher in private school children. However, there was no significance between school type or year group when investigating the change scores between before and after the intervention (Table 5.2c).

Table 5.2: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's fully correct bird quiz scores before, after and change scores with individuals (n = 382) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before bird quiz score**		
	df	LogLik	p-value
School Type * Year	2	-675.1	> 0.05
Year	2	-675.5	> 0.05
School Type	**1**	**-677.0**	**< 0.001**
Minimal model	Before bird score ~ School Type + (1|individual ID)		

Model Parameter	**(b) After bird quiz score**		
	df	LogLik	p-value
School Type * Year	2	-905.5	> 0.05
Year	2	-905.5	> 0.05
School Type	**1**	**-907.1**	**< 0.01**
Minimal model	After bird score ~ School Type + (1|individual ID)		

Model Parameter	**(c) Change bird quiz score**		
	df	LogLik	p-value
School Type * Year	2	-879.0	> 0.05
Year	2	-880.2	> 0.05
School Type	1	-880.6	> 0.05

Figure 5.6 displays the number of correct invertebrate identifications, out of 22 questions, before and after the intervention. Species identification significantly improved after the intervention ($V = 9122.5$, $p < 0.001$). Children scoring zero decreased to below 20% after the intervention as displayed on the y-axis, and the average score improved after the intervention, from eight before to twelve after. 56% of children scored six or more (over 25% of questions) before the intervention, while it increased to 77% of children after.

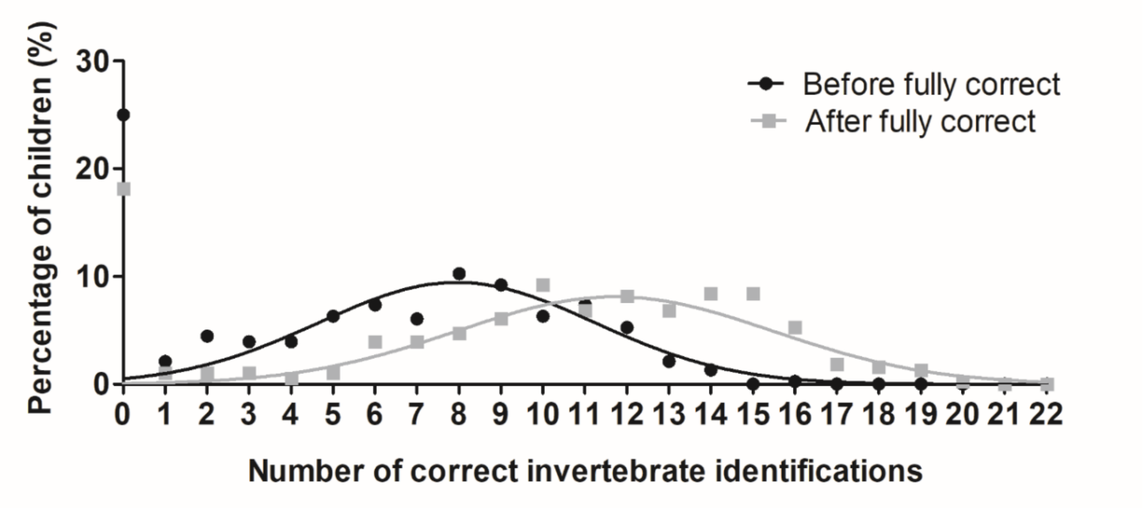


Figure 5.6: Percentage of fully correct invertebrate identifications before and after the intervention.

Figure 5.7 displays the percentage of children that correctly identified each invertebrate species before and after the intervention. Each species presents an improvement in the percentage of children that correctly identified the species after the intervention, with 50% of children identifying six species before, and 50% of children identifying nine species after the intervention. The top three most correctly identified species before the intervention were snail (*Cepaea nemoralis*), ladybird (*Harmonia axyridis*) and bumblebee (*Bombus terrestris)*; however afterwards, snail (*Cepaea nemoralis*), ladybird (*Harmonia axyridis*), and slug (*Limax flavus*) were the most identified invertebrate species.

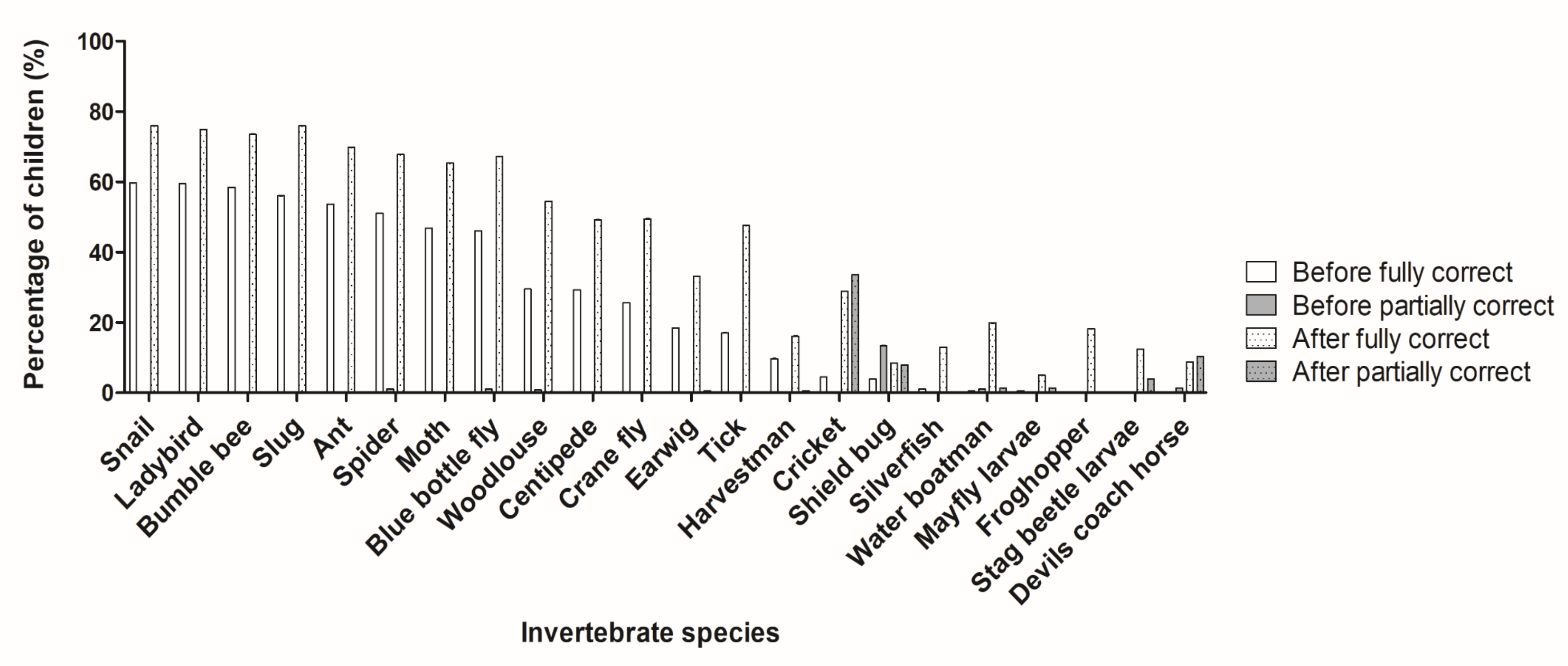


Figure 5.7: Percentage of children that fully and partially correctly identified each invertebrate species before and after the intervention.

Table 5.3 displays the summary of GLMM results on fully correct insect quiz scores. Baseline (χ^2 = 24.0, df = 1, p < 0.001) and post-intervention (χ^2 = 49.3, df = 1, p < 0.001) scores were significantly higher in private school children, as well as between all year groups before (χ^2 = 20.7, df = 2, p < 0.001). After, private school had significantly higher scores than state school (χ^2 = 49.3, df = 1, p < 0.001), and year (χ^2 = 7.9, df = 2, p < 0.05) was found to be significantly different. Year six was significantly higher than year four (SE = 0.04, z = 4.96, p < 0.001) and year five groups (SE = 0.04, z = 3.71, p < 0.001). Private schools had a significantly higher knowledge change after the intervention (χ^2 = 20.6, df = 1, SE = 0.31, z = -2.16, p < 0.01).

Table 5.3: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's fully correct insect quiz scores before, after and change scores with individuals (n = 375) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before insect quiz score**		
	df	LogLik	p-value
School Type * Year	2	-1159.5	> 0.05
Year	**2**	**-1161.6**	**< 0.001**
School Type	**1**	**-1161.6**	**< 0.001**
Minimal model	Before insect score ~ School Type + Year + (1|individual ID)		
Model Parameter	**(b) After insect quiz score**		
	df	LogLik	p-value
School Type * Year	2	-1238.6	> 0.05
Year	**2**	**-1239.8**	**<0.05**
School Type	**1**	**-1239.8**	**< 0.001**
Minimal model	After insect score ~ School Type + Year + (1|individual ID)		
Model Parameter	**(c) Change insect quiz score**		
	df	LogLik	p-value
School Type * Year	2	-1133.1	> 0.05
Year	2	-1133.5	> 0.05
School Type	**1**	**-1133.5**	**< 0.001**
Minimal model	Change insect score ~ School Type + (1|individual ID)		

Baseline mammal scores (χ^2 = 16.1, df = 1, p < 0.001; Table 5.4a) were significantly higher in private school children. Before, there was also a significant difference between year groups (χ^2 = 32.0, df = 2, p < 0.001) with year five significantly higher than year four (SE = 0.04, z = -5.49, p < 0.001) and year six also significantly higher than year four (SE = 0.11, z = 2.54, p < 0.05). After, only private schools were found to be significant (χ^2 = 3.8, df = 1, p = 0.05; Table 5.4b). Private school children had a significantly greater change in knowledge after the intervention (χ^2 = 6.8, df = 1, p < 0.01; Table 5.4c), compared to state school children. There was also a significant difference between change scores in years (SE = 0.07, z = 5.24, p < 0.01), with year four having the greatest change in scores compared to year five and six.

Table 5.4: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's fully correct mammal quiz scores before, after and change scores with individuals (n = 331) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before mammal quiz score**		
	df	LogLik	p-value
School Type * Year	2	-759.0	> 0.05
Year	**2**	**-759.1**	**< 0.001**
School Type	**1**	**-759.1**	**< 0.001**
Minimal model	Before mammal score ~ School Type + Year + (1|individual ID)		
Model Parameter	**(b) After mammal quiz score**		
	df	LogLik	p-value
School Type * Year	2	-761.5	> 0.05
Year	2	-761.5	> 0.05
School Type	**1**	**-761.5**	**= 0.05**
Minimal model	After mammal score ~ School Type + (1|individual ID)		
Model Parameter	**(c) Change mammal quiz score**		
	df	LogLik	p-value
School Type * Year	2	-711.5	> 0.05
Year	**2**	**-711.5**	**< 0.001**
School Type	**1**	**-711.5**	**< 0.001**
Minimal model	Change mammal score ~ School Type + Year + (1|individual ID)		

Table 5.5 displays the summary of results from the GLMM on plant quiz scores. A significant difference was identified between year groups within the baseline plant scores (χ^2 = 16.9, df = 2, p < 0.001). Year six was significantly higher than year four (SE = 0.10, z = 2.19, p < 0.05), and year five was significantly higher than year four (SE = 0.04, z = -4.0, p < 0.001); however there was no significant difference between year five and year six. After the activities, private schools were found to have a significantly higher score (χ^2 = 10.7, df = 1, p < 0.01) compared to state schools. Additionally, a significant difference was found between year four and year five after the activities (SE = 0.04, z = -2.60, p < 0.05). Finally, private schools had a significantly higher change in knowledge (χ^2 = 4.2, df = 1, p < 0.05) compared to state schools.

Table 5.5: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's fully correct plant quiz scores before, after and change scores with individuals (n = 348) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before plant quiz score**		
	df	LogLik	p-value
School Type * Year	2	-774.0	> 0.05
Year	**2**	**-774.6**	**< 0.001**
School Type	1	-774.6	> 0.05
Minimal model	Before plant score ~ Year + (1|individual ID)		
Model Parameter	**(b) After plant quiz score**		
	df	LogLik	p-value
School Type * Year	2	-781.1	> 0.05
Year	**2**	**-782.1**	**<0.05**
School Type	**1**	**-782.1**	**< 0.01**
Minimal model	After plant score ~ School Type + Year + (1|individual ID)		
Model Parameter	**(c) Change plant quiz score**		
	df	LogLik	p-value
School Type * Year	2	-707.6	> 0.05
Year	2	-707.6	> 0.05
School Type	1	**-707.6**	**< 0.05**
Minimal model	Change plant score ~ School Type + (1|individual ID)		

5.3.2 PMMs

The mean number of total facts or perspectives on the PMMs significantly improved after the intervention. There was a greater increase in the number of facts or perspectives the children wrote for the bird ($V = 10366$, $p < 0.001$), mammal ($V = 7810$, $p < 0.001$) and plant ($V = 10571$, $p < 0.001$) PMM, compared to the insect PMMs ($V = 18320$, $p < 0.001$). Despite being considered a charismatic group of organisms, mammals had the lowest mean number of facts or perspectives written before the intervention. Figures 5.8 to 5.11 display word clouds with all written facts or perspectives by the children before and after the activities of each theme. The word clouds display the words larger the more frequent it is written with the mean number of facts or perspectives by each child before and after the set of activities displayed below the word cloud. There are more diverse correct species and facts included in the children's after PMMs.

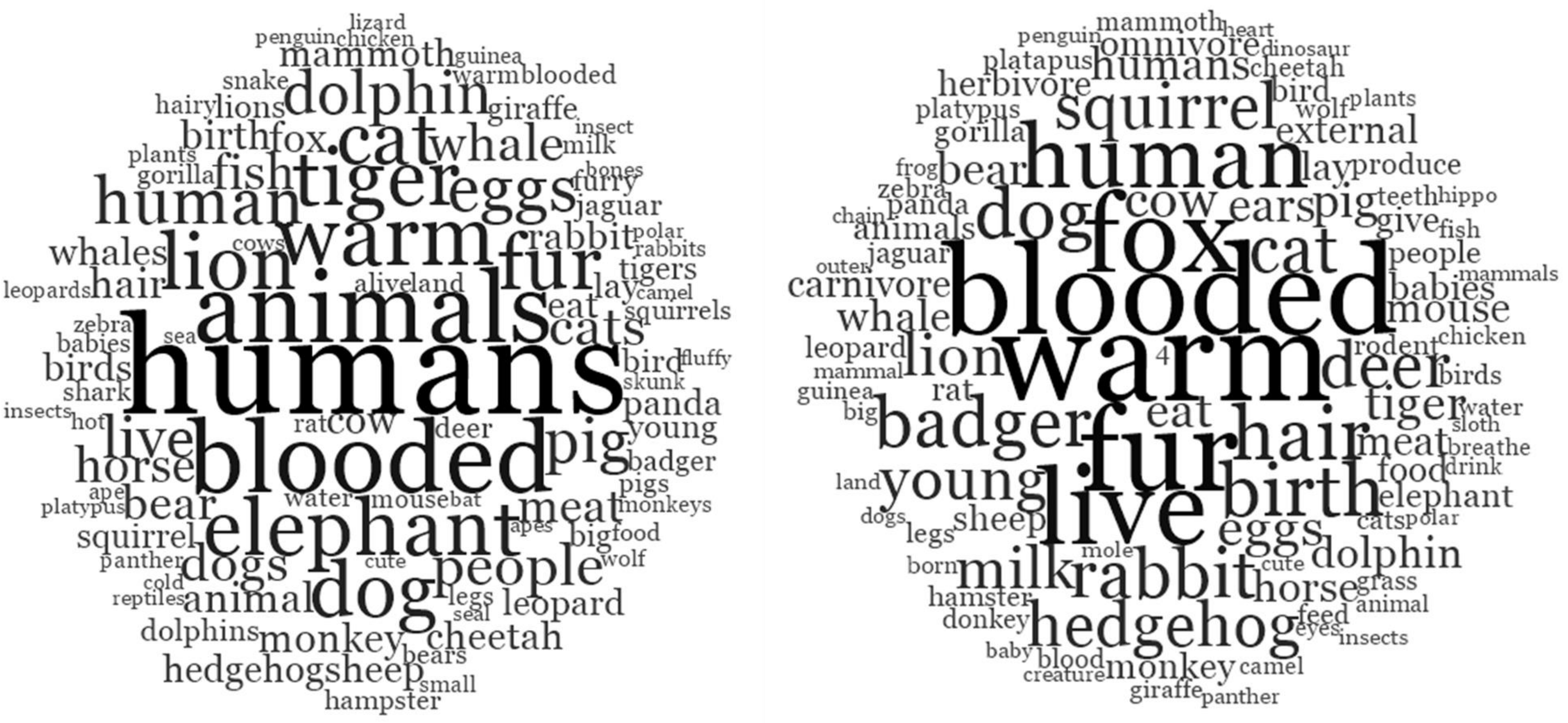
Birds

Before $\bar{x}$ = 8.16, SEM 0.20

After $\bar{x}$ = 11.17, SEM 0.22

Figure 5.8: Word clouds of each themes responses from children with mean number of total responses children wrote on their bird PMM before and after the intervention.

Mammals



Before $\bar{x}$ = 5.14, SEM 0.20

After $\bar{x}$ = 9.16, SEM 0.24

Figure 5.9: Word clouds of each themes responses from children with mean number of total responses children wrote on their mammals PMM before and after the intervention.

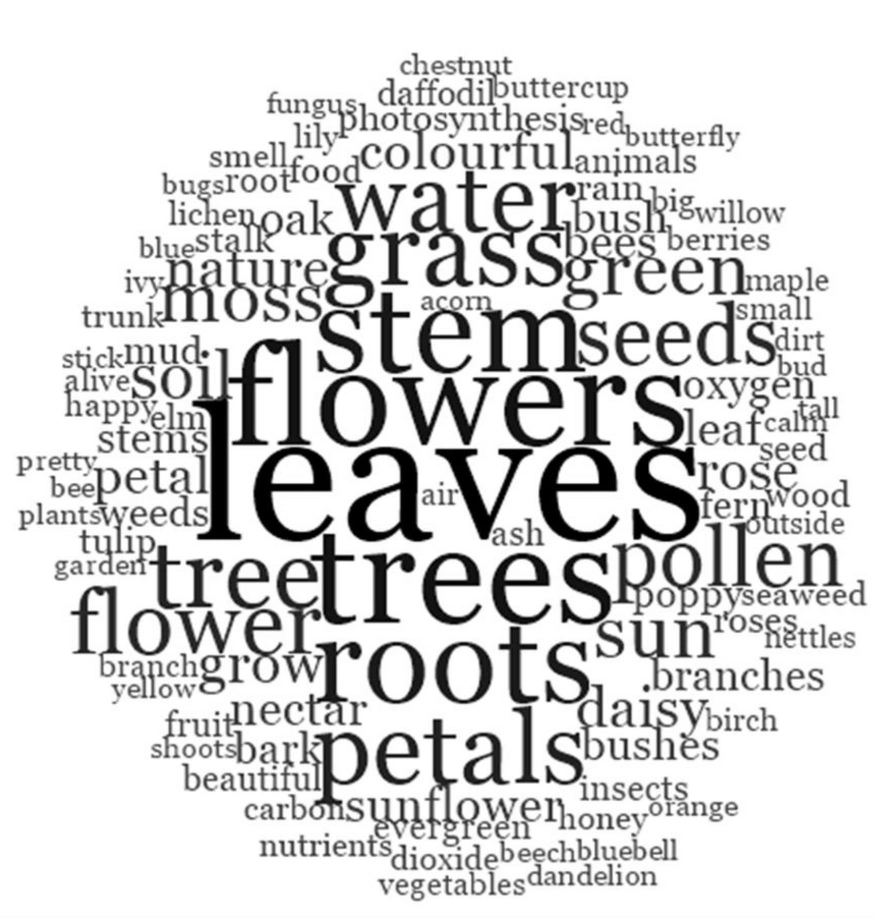
Insects

Before $\bar{x}$ = 7.73, SEM 0.20

After $\bar{x}$ = 8.99, SEM 0.23

Figure 5.10: Word clouds of each themes responses from children with mean number of total responses children wrote on their insects PMM before and after the intervention.

Plants



Before $\bar{x}$ = 8.12, SEM 0.21

After $\bar{x}$ = 11.45, SEM 0.25

Figure 5.11: Word clouds of each themes responses from children with mean number of total responses children wrote on their plants PMM before and after the intervention.

Table 5.6 displays the summary of results from the GLMM on bird PMM total scores. The total number of written responses for bird PMM were found to be significantly higher in year six private school children compared to year six state school children ($\chi^2 = 16.03$, df = 2, $p < 0.001$) (Table 5.6a). After, there was no significant difference between school type ($\chi^2 = 2.08$, df = 1, $p > 0.05$) but there was a significant difference between year ($\chi^2 = 9.26$, df =2, $p < 0.01$), with year six found to write significantly more perspectives and facts compared to year five (SE = 0.07, z = 2.76, $p < 0.01$) and year four (SE = 0.07, z = 3.57, $p < 0.01$) (Table 5.6b). When investigating the difference between before and after scores, a significant difference was identified in year six state school children compared to year six private school children ($\chi^2 = 5.49$, df = 2, $p < 0.05$) with state school children showing a greater increase (Table 5.6c).

Table 5.6: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for bird PMMs before, after and difference scores with individuals (n = 410) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before bird PMM total**		
	df	LogLik	p-value
School Type * Year	**2**	**-1113.2**	**< 0.05**
Minimal model	Before bird total ~ School Type * Year + (1|individual ID)		
Model Parameter	**(b) After bird PMM total**		
	df	LogLik	p-value
School Type * Year	2	-1172.4	> 0.05
Year	**2**	**-1172.4**	**< 0.01**
School Type	1	-1172.4	> 0.05
Minimal model	After bird total ~ Year + (1|individual ID)		
Model Parameter	**(c) Change bird PMM score**		
	df	LogLik	p-value
School Type * Year	**2**	**-1003.8**	**< 0.05**
Minimal model	Change bird total ~ School Type * Year + (1|individual ID)		

Table 5.7 displays the summary of results from the GLMM on mammal PMM total scores. Before the activities, scores were significantly different between school type ($\chi^2 = 4.40$, df = 1, $p < 0.05$) and year ($\chi^2 = 8.47$, df = 2, $p < 0.05$). Year five (SE = 0.07, z = -2.31, $p < 0.05$) and year six (SE = 0.14, z = 2.47, $p < 0.05$) wrote significantly more than year four children. Additionally, private school children wrote significantly more than state school children (SE = 0.09, z = -2.11, $p < 0.05$). After, a significant difference was identified between year groups ($\chi^2 = 7.44$, df = 2, $p < 0.05$) and school type ($\chi^2 = 9.59$, df = 1, $p < 0.01$) with private schools writing more. Years six wrote significantly more responses after the activities compared to year five (SE = 0.10, z = 2.38, $p < 0.05$) and year four (SE = 0.10, z = 2.76, $p < 0.05$). Finally, no significance was identified between the difference in the before and after totals.

Table 5.7: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for mammal PMMs before, after and difference scores with individuals (n = 375) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before mammal PMM total**		
	df	LogLik	p-value
School Type * Year	2	-962.2	> 0.05
Year	**2**	**-965.1**	**< 0.05**
School Type	**1**	**-965.1**	**< 0.05**
Minimal model	Before mammal total ~ Year + School Type + (1|individual ID)		
Model Parameter	**(b) After mammal PMM total**		
	df	LogLik	p-value
School Type * Year	2	-1064.6	> 0.05
Year	**2**	**-1066.9**	**< 0.05**
School Type	**1**	**-1066.9**	**< 0.05**
Minimal model	After mammal total ~ Year + School Type + (1|individual ID)		
Model Parameter	**(c) Change mammal PMM score**		
	df	LogLik	p-value
School Type * Year	2	-954.23	> 0.05
Year	2	-955.5	> 0.05
School Type	1	-955.42	> 0.05

Before the activities, total insect PMM scores were found to be significantly different between year groups ($\chi^2 = 16.45$, df = 2, $p < 0.001$). Year six wrote significantly more than year five (SE = 0.09, z = 3.95, $p < 0.001$) and year four (SE = 0.09, z = 3.95, $p < 0.001$). After, a significant difference was identified between year groups ($\chi^2 = 6.44$, df = 2, $p < 0.05$) and school type ($\chi^2 = 14.22$, df = 1, $p < 0.001$). Year four wrote significantly less after the activities compared to year five (SE = 0.05, z = -2.87, $p < 0.01$) and year six (SE = 0.09, z = 2.93, $p < 0.01$). Additionally, private school children wrote significantly more compared to state school children (SE = 0.06, z = -4.47, $p < 0.001$). Finally, the change scores was significantly higher in private school children compared to state school children ($\chi^2 = 4.97$, df = 1, $p < 0.05$), with year five private school children having significantly higher change scores than year five state school children ($\chi^2 = 5.00$, df = 1, $p < 0.05$).

Table 5.8: Summary of the results from the GLMM with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for insect PMMs before, after and difference scores with individuals (n = 357) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before insect PMM total**		
	df	LogLik	p-value
School Type * Year	2	-958.1	> 0.05
Year	**2**	**-958.4**	**< 0.001**
School Type	1	-690.3	> 0.05
Minimal model	Before insect total ~ Year + (1|individual ID)		
Model Parameter	**(b) After insect PMM total**		
	df	LogLik	p-value
School Type * Year	2	-993.4	> 0.05
Year	**2**	**-993.9**	**< 0.05**
School Type	**1**	**-993.9**	**< 0.001**
Minimal model	After insect total ~ Year + School Type + (1|individual ID)		
Model Parameter	**(c) Change insect PMM score**		
	df	LogLik	p-value
School Type * Year	**2**	**-798.5**	**< 0.05**
Minimal model	Change insect total ~ School Type * Year + (1|individual ID)		

Table 5.9 displays the summary of results from the GLMM on plant PMM total scores. Before the activities, the total number of written perspectives and facts for plant PMMs were found to be significantly different between year groups (χ^2 = 48.61, df = 2, p < 0.001), with year six writing significantly more than year five (SE = 0.11, z = 3.22, p < 0.01) and year four (SE = 0.11, z = 5.72, p < 0.001), and year five writing significantly more than year four (SE = 0.05, z = -6.03, p < 0.001). Additionally, private school children wrote significantly more than state school children (SE = 0.061, z = -3.16, p < 0.01) (Table 5.9a). After the activities, a significant difference was identified between state and private school children within all year groups (χ^2 = 8.58, df = 2, p < 0.05): year four (χ^2 = 4.49, df = 2, p < 0.05); year five (χ^2 = 3.94, df = 2, p < 0.05); year six (χ^2 = 12.37, df = 2, p < 0.001) (Table 5.9b). Finally, no significance was identified in the change scores (Table 5.9c).

Table 5.9: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for plant PMMs before, after and difference scores with individuals (n = 390) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Before plant PMM total**		
	df	LogLik	p-value
School Type * Year	2	-1046.9	> 0.05
Year	**2**	**-1048.6**	**< 0.001**
School Type	**1**	**-1048.6**	**< 0.01**
Minimal model	Before plant total ~ Year + School Type + (1|individual ID)		
Model Parameter	**(b) After plant PMM total**		
	df	LogLik	p-value
School Type * Year	**2**	**-1140.5**	**< 0.05**
Minimal model	After plant total ~ Year * School Type + (1|individual ID)		
Model Parameter	**(c) Change plant PMM score**		
	df	LogLik	p-value
School Type * Year	2	-1000.1	> 0.05
Year	2	-1000.6	> 0.05
School Type	1	-1002.5	> 0.05

Figure 5.12 displays the mean number of perspectives the children wrote on their PMM themes of mammals, birds, insects, and plants.

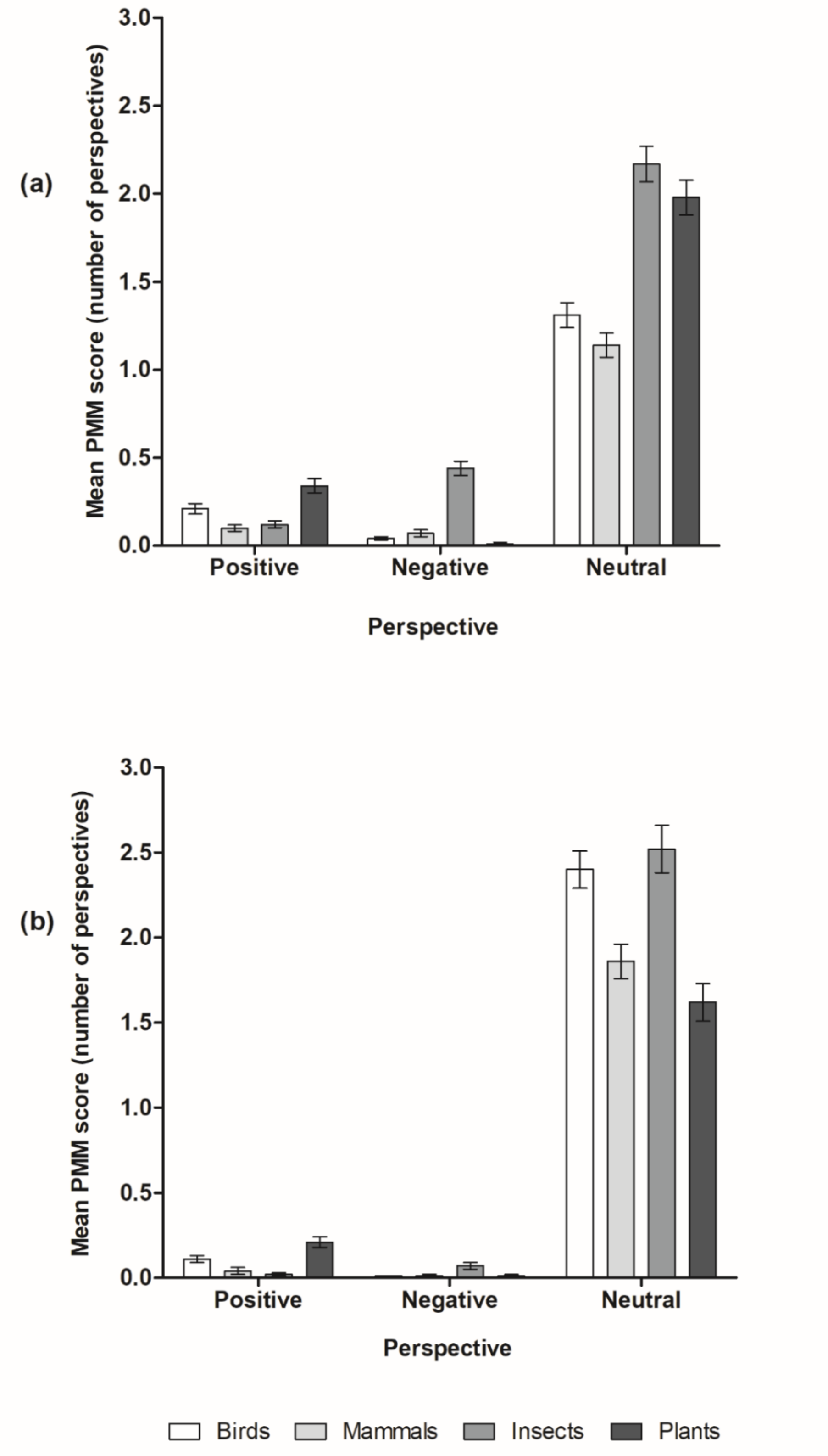


Figure 5.12: Mean number of positive, negative and neutral perspectives children wrote on their bird, mammal, insect, and plant PMM (a) before and (b) after the intervention. Error bars represent SEM.

It can be seen there is a significant decrease in the number of positive and negative perspectives of all categories. Insects had the highest number of negative and neutral responses both before and after the activities, while plants had the highest positive perspectives before and after the activities. An increase in neutral perspectives for birds and mammals was identified, while there was no significant difference in the number of neutral perspectives of insects, and a decrease in neutral mean responses for plants. Table 5.10 displays the significant difference in the number of perspectives the children have written before and after responses.

Table 5.10: The difference in the number of positive, negative, and neutral perspectives on birds, mammals, insects, and plants the children wrote before and after the set of activities.

Taxa	**Perspective**	**V-value**	**p-value**
Birds	Positive	2322.0	< 0.001
	Negative	115.0	< 0.05
	Neutral	11711.0	< 0.001
Mammals	Positive	314.0	< 0.5
	Negative	186.0	< 0.01
	Neutral	13244.0	< 0.001
Insects	Positive	625.5	< 0.001
	Negative	5130.0	< 0.001
	Neutral	18781.0	> 0.05
Plants	Positive	3766.5	< 0.01
	Negative	382.0	< 0.001
	Neutral	26282.0	< 0.001

Figure 5.13 displays the mean number of correct and incorrect facts the children wrote during the PMMs.

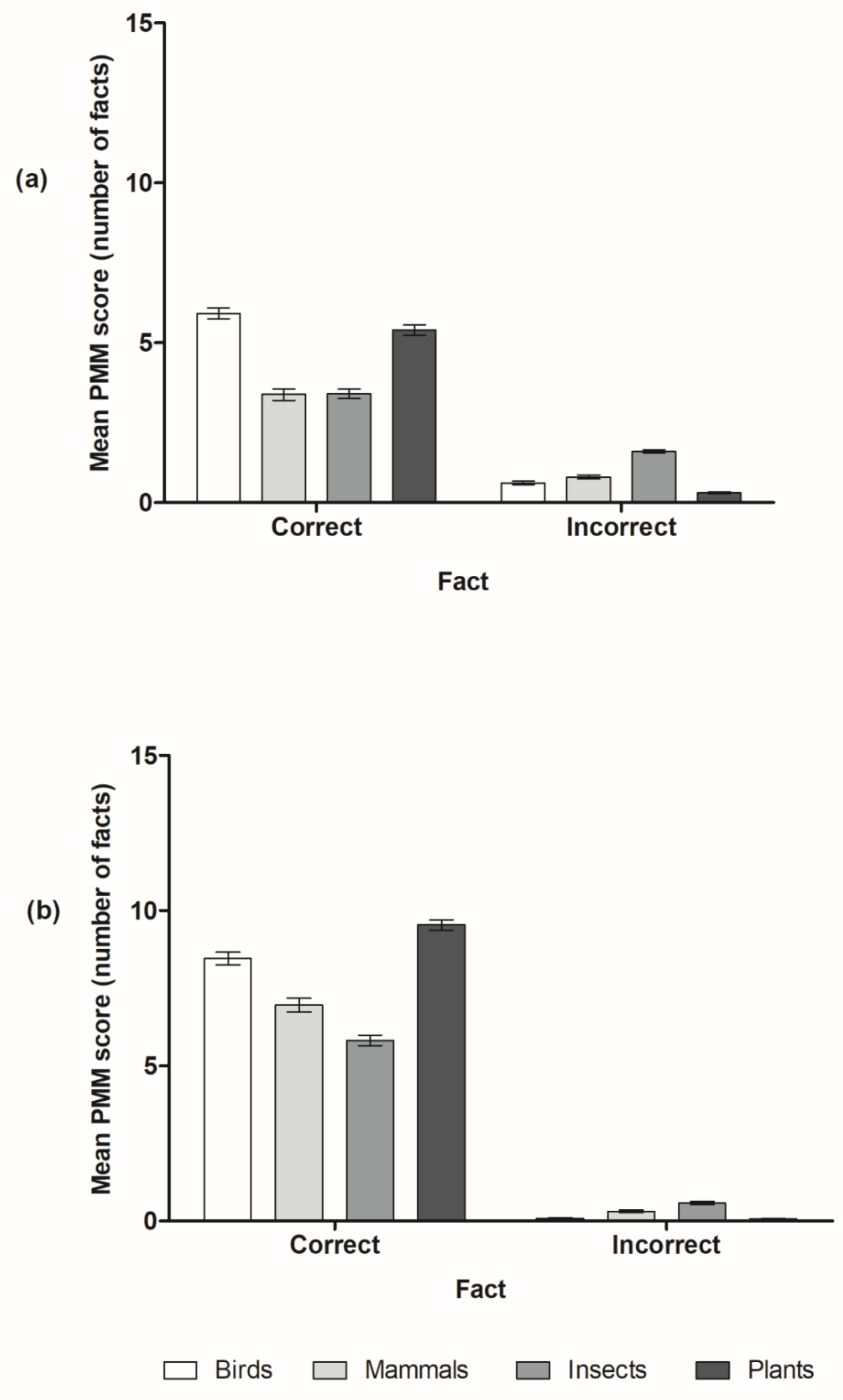


Figure 5.13: Mean number of correct and incorrect facts children wrote on their bird, mammal, insect, and plant PMM (a) before and (b) after the intervention. Error bars represent SEM.

It can be seen there is a significant increase in correct facts and a decrease in the number of incorrect facts in all categories. Insects had the greatest number of incorrect facts both before and after the activities. Insect facts on average written on the children's PMMs were lowest out of the four taxa categories both before and after the activities. Table 5.11 displays the significant difference in the number of facts the children wrote before and after responses.

Table 5.11: The difference in the number of correct and incorrect facts on birds, mammals, insects, and plants the children wrote before and after the set of activities.

Taxa	Facts	V-value	p-value
Birds	Correct	12264.0	< 0.001
	Incorrect	10279.0	< 0.001
Mammals	Correct	6633.0	< 0.001
	Incorrect	13000.0	< 0.001
Insects	Correct	7364.0	< 0.001
	Incorrect	28050.0	< 0.001
Plants	Correct	6058.0	< 0.001
	Incorrect	3768.0	< 0.001

Table 5.12 displays the summary of results from the GLMM on positive, negative, and neutral bird PMM perspectives. Private school children within year six presented a higher difference in the number of negative perspectives written compared to year six state school children (χ^2 = 6.92, df = 2, p < 0.01); while no significance was found within the positive and neutral perspectives written.

Table 5.12: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's positive and negative written responses for bird perspective difference scores with individuals (n = 410) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Positive bird perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-256.5	> 0.05
Year	2	-257.3	> 0.05
School Type	1	-257.5	> 0.05
Model Parameter	**(b) Negative bird perspective PMM change**		
	df	LogLik	p-value
School Type * Year	**2**	**-609.7**	**< 0.05**
Minimal model	Negative bird total ~ School Type * Year + (1|individual ID)		
Model Parameter	**(c) Neutral bird perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-732.6	> 0.05
Year	2	-733.3	> 0.05
School Type	1	-733.5	> 0.05

Table 5.13 displays the summary of results from the GLMM on correct and incorrect bird PMM facts. There was no significance between the year and school type for the difference in the number of correct facts written after the intervention compared to before. However, year four state school children had a significantly higher difference in the number of incorrect facts written after the intervention compared to year four private school children ($\chi^2 = 12.35$, df = 2, $p < 0.001$).

Table 5.13: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for bird perspective difference scores with individuals (n = 410) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Correct bird fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-945.3	> 0.05
Year	2	-947.7	> 0.05
School Type	1	-948.8	> 0.05
Model Parameter	**(b) Incorrect bird fact PMM change**		
	df	LogLik	p-value
School Type * Year	**2**	**-447.0**	**< 0.05**
Minimal model	Incorrect bird total ~ School Type * Year + (1|individual ID)		

Table 5.14 displays the summary of results from the GLMM on positive, negative and neutral mammal PMM perspectives. No significance between the year and school type for the difference in the number of any of the investigated perspectives after the intervention compared to before was identified.

Table 5.14: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's positive and negative written responses for mammal perspective difference scores with individuals (n = 375) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Positive mammal perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-112.8	> 0.05
Year	2	-113.1	> 0.05
School Type	1	-113.1	> 0.05
Model Parameter	**(b) Negative mammal perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-75.8	> 0.05
Year	2	-75.3	> 0.05
School Type	1	-75.3	> 0.05
Model Parameter	**(c) Neutral mammal perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-626.9	> 0.05
Year	2	-629.7	> 0.05
School Type	1	-628.8	> 0.05

Table 5.15 displays the summary of results from the GLMM on correct and incorrect mammal PMM facts. School type was significant with state schools having a higher difference in correct before and after facts compared to private school children ($\chi^2 = 4.80$, df = 1, $p < 0.05$). At the same time, there was no significant difference between incorrect facts.

Table 5.15: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for mammal perspective difference scores with individuals (n = 375) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Correct mammal fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-948.8	> 0.05
Year	2	-949.5	> 0.05
School Type	**1**	**-949.5**	**< 0.05**
Model Parameter	**(b) Incorrect mammal fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-474.6	> 0.05
Year	2	-474.8	> 0.05
School Type	1	-474.9	> 0.05

Table 5.16 displays the summary of results from the GLMM on positive, negative and neutral insect PMM perspectives. No significance was identified within the difference between positive or neutral perspectives written before and after the intervention, but there was a significant difference between state and private school children with state school showing a higher difference in negative perspective ($\chi^2 = 4.0$, df = 1, $p < 0.05$).

Table 5.16: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's positive and negative written responses for insect perspective difference scores with individuals (n = 357) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Positive insect perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-131.0	> 0.05
Year	2	-134.2	> 0.05
School Type	1	-134.3	> 0.05
Model Parameter	**(b) Negative insect perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-311.6	> 0.05
Year	2	-311.7	> 0.05
School Type	**1**	**-311.69**	**< 0.05**
Minimal model	Negative difference ~ School Type + (1|individual ID)		
Model Parameter	**(c) Neutral insect perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-664.0	> 0.05
Year	2	-665.9	> 0.05
School Type	1	-664.6	> 0.05

Table 5.17 displays the summary of results from the GLMM on correct and incorrect insect PMM facts. Year six state school children displayed a significantly larger difference in the correct facts written in their before and after PMMs compared to year six private school children ($\chi^2 = 6.65$, df = 2, $p < 0.01$); yet no significance was identified within the difference in the number of incorrect facts written.

Table 5.17: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for insect perspective difference scores with individuals (n = 357) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Correct insect fact PMM change**		
	df	LogLik	p-value
School Type * Year	**2**	**-802.4**	**< 0.05**
Model Parameter	**(b) Incorrect insect fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-579.9	> 0.05
Year	2	-582.8	> 0.05
School Type	1	-585.4	> 0.05

Table 5.18 displays the summary of results from the GLMM on positive, negative, and neutral plant PMM perspectives. The year was significant ($\chi^2 = 12.31$, df = 2, $p < 0.01$) for positive perception between the difference in before and after scores with year six being significantly higher than year four (SE = 0.43, z = 3.30, $p < 0.01$); and five (SE = 0.41, z = 2.13, $p < 0.05$); and year five being significantly higher than year four (SE = 0.23, z = -2.34, $p < 0.05$). There was no significance identified in change scores of negative and neutral perspectives.

Table 5.18: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's positive and negative written responses for plant perspective difference scores with individuals (n = 390) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(a) Positive plant perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-316.8	> 0.05
Year	**2**	**-3.17.1**	**< 0.01**
School Type	1	-316.8	> 0.05
Model Parameter	**(b) Negative plant perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-103.9	> 0.05
Year	2	-103.9	> 0.05
School Type	1	-103.9	> 0.05
Model Parameter	**(c) Neutral plant perspective PMM change**		
	df	LogLik	p-value
School Type * Year	2	-699.7	> 0.05
Year	2	-700.7	> 0.05
School Type	1	-700.4	> 0.05

Table 5.19 displays the summary of results from the GLMM on correct and incorrect plant PMM facts. Finally, no significance was found between the difference in facts written before and after the activities.

Table 5.19: Summary of the results from the generalised linear mixed model with Poisson error structure selection testing the significance of the effects of the valid parameters and interactions measured on the children's total written responses for plant perspective difference scores with individuals (n = 390) used as a random effect. Bold values indicate significant terms.

Model Parameter	**(d) Correct plant fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-1008.9	> 0.05
Year	2	-1010.7	> 0.05
School Type	1	-1010.6	> 0.05
Model Parameter	**(e) Incorrect plant fact PMM change**		
	df	LogLik	p-value
School Type * Year	2	-278.1	> 0.05
Year	2	-278.6	> 0.05
School Type	1	-279.1	> 0.05

5.3.3 Results Summary of Quizzes & PMMs

Taxa	**Quiz**	**PMM**
All	Significant improvement in: - total score - taxa identification - species identification	Significant: - increase in total written phrases - increase in correct facts - decrease in incorrect facts - decrease in positive and negative perceptions - increase in neutral perceptions
Bird	- Private school children did significantly better before and after the activities compared to state school children.	- Year 6 private school had higher difference in the number of negative perspectives written compared to year six state school children. - Year four state school children had a significantly higher difference in the number of incorrect facts written after the intervention compared to year four private school children.

Mammal	-Private school children did significantly better before and after the activities, as well as in their change score compared to state school children. -Younger children (year 4) had a significant change in score compared to older children.	- State school children have a higher difference in correct before and after facts compared to private school children.
Insect	- Private school children did significantly better before and after the activities, as well as in their change score compared to state school children. - Older year groups did better than younger year groups.	- State school children have a higher difference in negative perspective after the activities compared to private school children. - Year six state school children have a significantly higher difference in the correct facts compared to year six private school children.
Plant	- Older year groups did better than younger years before. - Older year groups compared to younger year groups and private school, compared to state school did better after. - Private school children achieved a better change in score compared to state school children.	- No significant difference identified within changes in facts and perceptions between year groups and school systems.

5.3.4 Project Evaluation

Figure 5.14 displays the children's responses (n = 350) to how they felt the set of activities impacted them. After the set of activities had been completed, over 90% of children felt more connected to nature, notice nature more and learnt outside more, as well as would like to continue outdoor education as part of their curriculum. Over 80% of children responded that they like birds, mammals, and plants more after the set of activities, while only 69% of children responded that they like insects more.

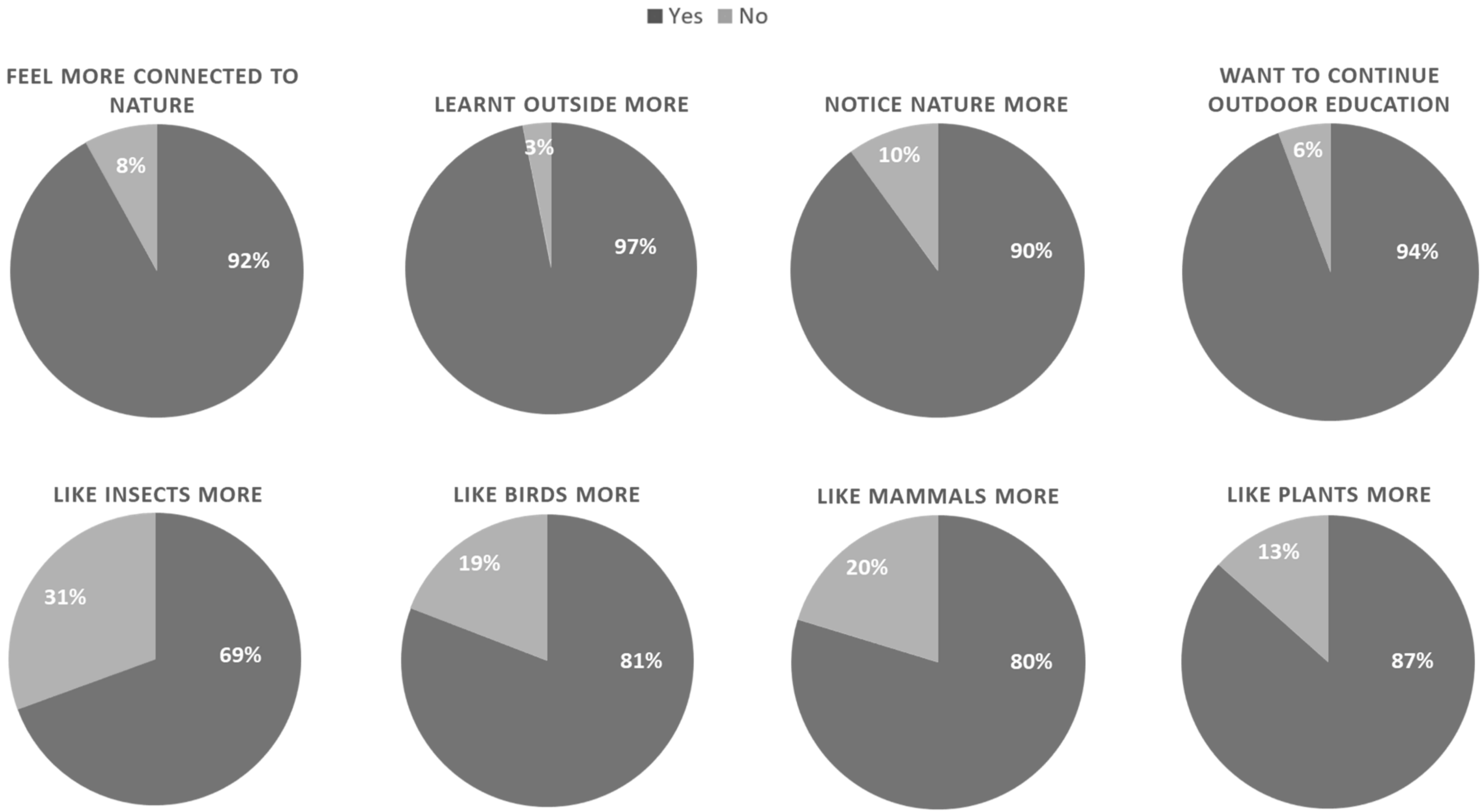


Figure 5.14: Responses by participating children (n = 350) on how they felt the set of activities impacted them.

Figure 5.15 displays the participating children's responses when asked "what did you enjoy the most from the school's biodiversity project?". 29% enjoyed the activities focussed around invertebrates the most; 19% of children enjoyed bird activities the most; 12% enjoyed being outside with nature the most; 10% enjoyed activities focussed on amphibians the most; and 9% enjoyed activities focussed around mammals the most.

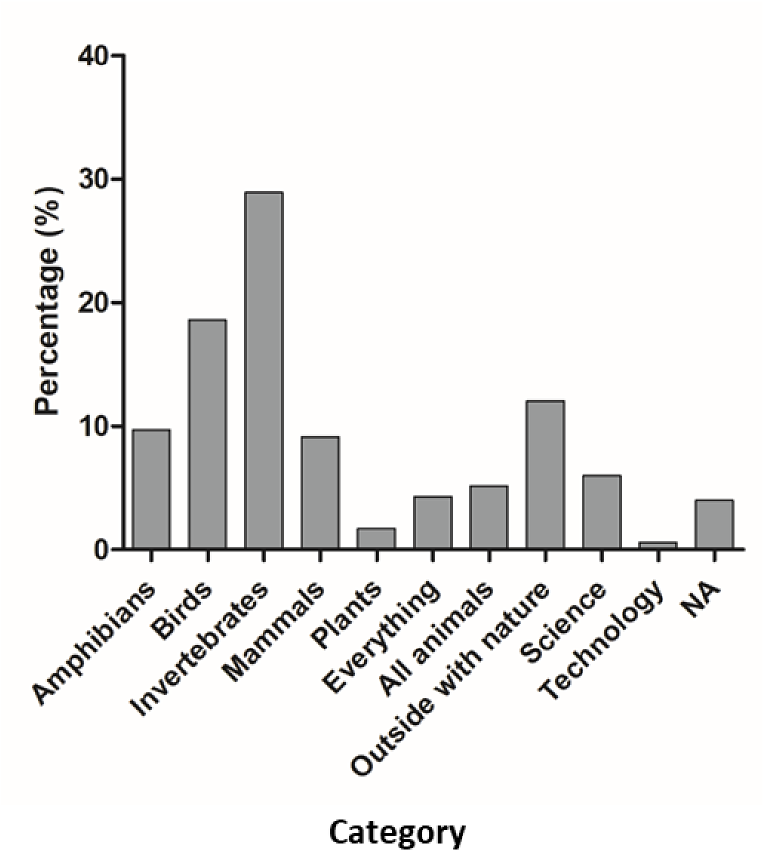


Figure 5.15: Responses by participating children (n = 350) on which category of the activities they most enjoyed.

All schoolteachers (n = 15) completed the project feedback form after the outdoor education intervention. 100% of teachers felt the set of activities benefited their confidence in teaching outside of the classroom, as well as their knowledge on the natural environment and would integrate some of the themes and methods of teaching into different subject lessons in the future, such as science and design technology. 93% of teachers felt they developed a better connection to nature after being involved with the project, however, the teacher that did not feel more connected to nature felt they were already very connected. 100% of teachers felt the set of activities had benefitted the children's knowledge, while 93% of teachers felt there had been a benefit to the children's wellbeing.

Following the project, 100% of teachers would recommend participating; however, one teacher would discontinue the project due to curriculum pressures. 18% of teachers commented that they felt there was a particular benefit to children's health and wellbeing as well as aiding in information retention, and 12% of teachers felt the children benefitted due to having new experiences. 93% of teachers commented that the outdoor learning assisted their teaching, and 30% said that the set of activities aided their ability to engage children with science and the hands-on experience benefitted their teaching. Figure 5.16 displays the teacher's responses.

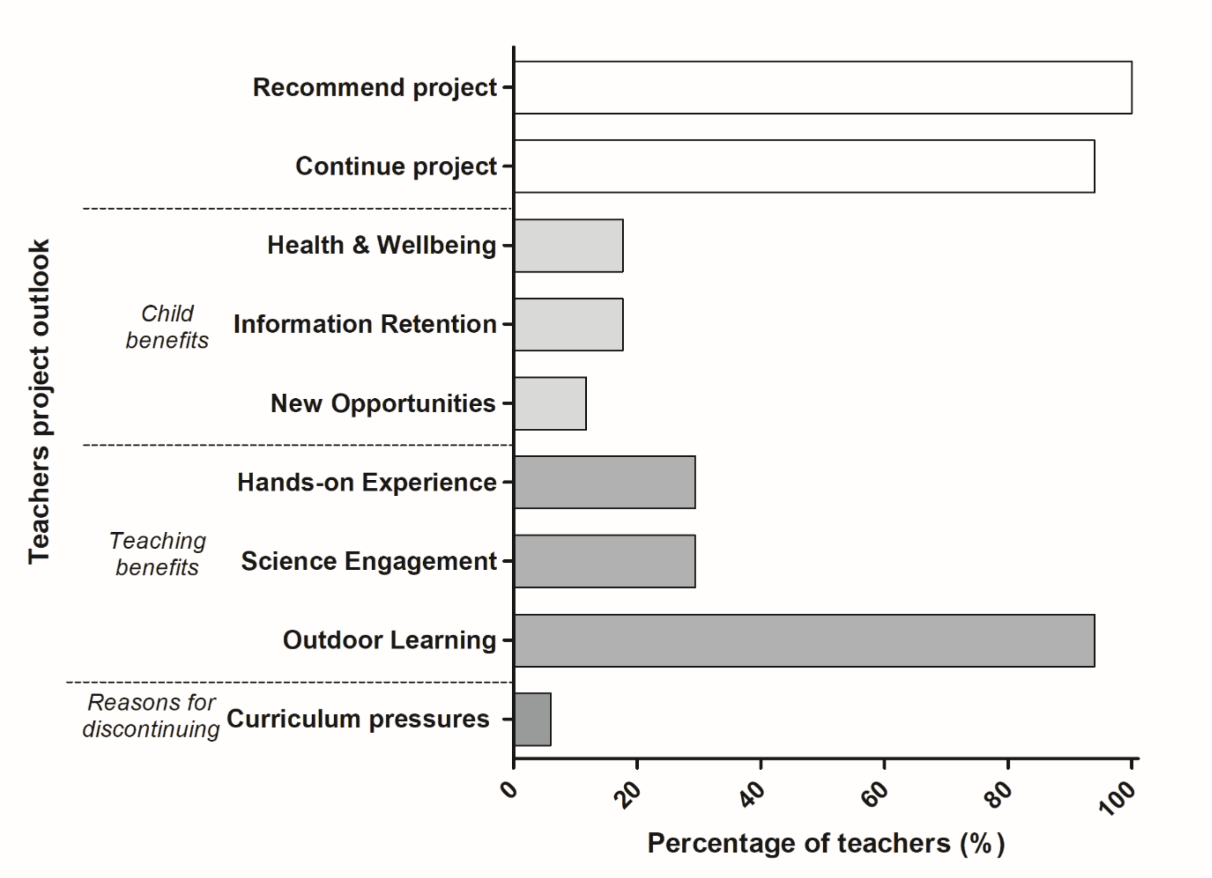


Figure 5.16: Teacher responses (n = 15) on their outlook of the outdoor education intervention.

5.4 Discussion

The results from the current research show that children initially have poor identification skills and knowledge of British wildlife, but good understanding of taxa classification as shown in baseline assessments of taxa and species identification quizzes, and incorrect facts in PMMs. Additionally, children primarily had neutral, unspecific perspectives of taxa and few negative and positive opinions at the beginning of the study. However, once the children had participated in biodiversity activities within school grounds, their identification skills of taxa and species became significantly more accurate, and the percentage of children able to identify local species significantly increased. Children also had a reduction in the negative perspectives of local flora and fauna after the intervention and an increase in neutral perspectives, as well as showing improved general knowledge of taxa with significantly more correct facts, and a significant reduction of incorrect facts. From the evaluation surveys, the majority of children reported they felt more connected to nature and like birds, mammals, plants and insects more than they did before the intervention. Teachers also reflected that the activities benefitted their teaching and connectivity to nature and had improved their confidence in outdoor education.

Reduced nature contact is of particular concern, because if children are uninformed of organisms that inhabit their local environment, they will be unaware if the organisms become threatened (Weilbacher, 1993). However, it is encouraging that after a short time of only 21 hours throughout the academic year, taxa and species knowledge and identification improved significantly. However, their ability to identify species within the taxa of bird and insects varied. As with White et al.'s findings (2018), robin (*Erithacus rubecula*) was the most commonly identified bird. After participating in bird activities and exploring through the activities what other species look like, species that had no distinguishing features or bold colours became more commonly identified, such as female blackbirds (*Turdus merula*) and starlings (*Sturnus vulgaris*). Similarly, ladybird (*Harmonia axyridis*) and bumblebee (*Bombus terrestris)* were species most commonly identified before the intervention, likely due to the colours and passively observing them when flying or resting on flowers (Burkitt, Barrett, & Davis, 2003; Ptáčková et al., 2017; White et al., 2018). Additionally, it is interesting to note that slug (*Limax flavus*) became more commonly recognised over bumblebee (*Bombus terrestris)* after the intervention, possibly related to the frequency that children actively hunted and held invertebrates after being introduced to them in the activities. These results suggest that if children are given the opportunities to experience nature first-hand, it can promote their awareness and knowledge of local wildlife, and enable them to develop a connection with it to ensure future conservation (Kuo, Barnes, & Jordan, 2019).

Children's knowledge of organisms can vary greatly, and it could be expected that children have a greater knowledge of organisms that they have more positive attitudes towards. However, before the intervention, less than 1% of children were able to identify over half the bird species in the quiz, while 16% of children were able to identify half of invertebrate species. Still, identification of over half the species increased to 57% in bird species and 49% in invertebrate species. Interestingly, although children typically have fearful and disgusted responses to insects (Breuer et al., 2015), a higher proportion of children were able to identify over half of the invertebrate species before the intervention, compared to bird species which are deemed charismatic (Simberloff, 1998; White et al., 2018). Previous research with 10 to 15 year old children found that they had a better knowledge of 'unpopular' animals (potato beetle, wolf and mouse) compared to 'popular' animals (ladybird, rabbit and squirrel), despite more negative attitudes towards 'unpopular' animals (Prokop & Tunnicliffe, 2010).The results in these studies suggest that it is important to develop knowledge of all taxa and not concentrate on popular or unpopular organisms to ensure a knowledge of different organisms can be developed to safeguard local biodiversity.

Although children's identification skills significantly improved, it is important to note that less than 60% of children were able to identify over half of the birds and less than 50% were able to identify half of invertebrate species after the set of activities. These poor identification skills highlight the disconnection between children and nature (Hughes et al., 2018) and reflect how little time children spend on direct nature observation or learning about local biodiversity (Lindemann-Matthies, 2006). Outdoor education opportunities during school can mitigate the extinction of experience with nature during childhood. Children's initially high plant scores compared to the other investigated taxa may be indicative of the fact that plants are all around, which enables children to touch wild plants easily compared to other wild taxa (Tunnicliffe & Reiss, 2000). Children learn through their senses, and thus, direct experiences with nature can lead to theoretical knowledge being easier to retain as it can be put into practice (Abdullah, Zakaria, & Razman, 2018; James & Williams, 2017).

It is unsurprising that when looking at the number of facts written down in the children's PMMs, the older year groups did better. This is expected due to their ability to write more down at a faster pace. Additionally, private school children wrote significantly more in the PMMs and achieved better scores in the quizzes. These findings are likely due to private schools having designated science teachers who may be more enthusiastic about the natural environment and therefore promote extra learning on the themes through independent work (Lindemann-Matthies, 2006). However, a variety of factors may be involved with regards to the differences identified between state and private schools. A comparison of academic achievement in English private and state schools has previously identified private schools having higher scores in comparison to the same year groups within the state sector (Ndaji, Little, & Coe, 2016). Private schools have the ability to employ teachers in a more competitive manner with higher pay scales to ensure effective teaching which can influence children's attainment (Davies & Davies, 2014). Additionally, private schools have more resources available per pupil and as a result have smaller class sizes, leading to more attention received per pupil. English state and private schools have also been identified to have an uneven distribution of children from different socio-economic and cultural backgrounds (Jenkins, Micklewright, & Schnepf, 2008). This segregation between schools can lead to inequality in academic achievement that can result from fee paying schools having admission criteria based on academic ability. Similarly, evidence has been shown that science education which incorporates the discussion of socio-cultural perspectives about scientific concepts promotes positive attitudes towards science (Jegede & Okebukola, 1991) which may be more difficult to achieve in schools with more diverse backgrounds, typically found in the state schools (Davies & Davies, 2014; Jegede & Okebukola, 1991).

Interestingly, the younger children achieved a greater change in quiz scores for the charismatic taxa themes of birds and mammals, compared to older age groups. Previously young children have been found to have a preference for mammals and birds compared to invertebrates and plants due to children's early nature connection through storybooks that commonly have birds and mammals (Borgi & Cirulli, 2015; Lindemann-Matthies, 2005). Therefore, these childhood schemas may have influenced the younger children's interest in these taxa.

Equally, childhood experiences may have led to children responding with more false facts on insects compared to the other taxa. These misconceptions may be due to misinformation about insects that children retain from popular children's films. For example, previous research associated with the *Bee Movie* found misrepresentation of insect anatomy, lifecycle and behaviour (Worsham & Diepenbrok, 2013). Moreover, research has found that children have a greater knowledge about the harmful aspects of insects to humans which additionally reflects the negative associations perceived, which can lead to biophobia (Barrow, 2002; Cho & Lee, 2018). Furthermore, a study by Wagler & Wagler (2008) identified that teachers had a negative attitude towards insects which led to a reduction in the likelihood to engage with these in science education settings. Although the children regarded the invertebrate activities as the most enjoyable, the attitudes of teachers that participated in the activities might have impacted the children's perceptions of insects. This may have led to why there were a greater proportion of negative perspectives for insects shared by children after the activities compared to the other themes.

The reduction in negative perspectives the children wrote down for mammals, birds, insects, and plants suggests there was a reduction in biophobia. Similar findings have been identified by researchers who found children had a reduction in fear and negative perception of salamanders (Barthel et al., 2018) and honey bees (Cho & Lee, 2018) after activities focussing on these organisms. Additionally, it was surprising that there was an increase in neutral perspectives and a decrease in positive perspectives. This is likely due to an increase in more time spent writing factual knowledge, possibly due to bias of children wanting to portray how much they know as opposed to their perspectives. To reduce the possibility of bias during the study, the children were reminded it was not a test and that they could write down anything they could think of associated with the given theme, whether it be feelings or facts. Moreover, a reduction in written positive and negative perspectives, yet an increase in neutral perspectives, may have also been due to a process of habituation leading to a reduction in biphobia and biophilia (Tighe & Leaton, 2016; White & Heerwagen, 1998).

Despite the decrease in positive perspectives, over 90% of children reflected that they felt more connected to nature and noticed nature more, and over 80% of children stated they like mammals, birds, and plants more. Although only 69% of children shared that they like insects more than they did before the start of the project, the invertebrate activities were considered to be the most popular. This is possibly owing to the ability of handling and interacting with live organisms up close, unlike mammals and birds. Similar findings were found by Kerr (2017) on the ParkLife Education Programme in Belfast. Although this Programme involved topics on animals and plants, the most common responses from children included comments centred around invertebrates, for example, 'digging for worms' and 'looking at bugs' (Kerr, 2017).

This research strengthens the argument that children are becoming more disconnected from nature due to the extinction of experience (Pyle, 1993; White et al., 2018) but also highlights the claims that outdoor education can reduce biophobia and aid in children's appreciation of nature as well as enthusiasm to learn. Previous studies conducted in Toronto, Canada, elementary, middle and secondary schools identified that 90% of students had higher levels of engagement and interest for learning in the school grounds compared to the classroom (Dyment, 2005). These findings are reflected in the current research, with over 90% of children indicating that they want to continue outdoor education and learn more outside. Teachers additionally stated that the children's engagement for science and knowledge in the classroom had benefitted from the outdoor sessions.

Teacher's comments on aiding the general wellbeing of the children maintain suggestions that wellbeing can be supported by nature contact at school (Harvey et al., 2020). Previous research conducted in school grounds by Largo-Wight et al. (2018) indicated that teachers reported a modest advantage in children's wellbeing when participating in learning outside, despite no significance identified within the children's happiness surveys compared to children who participated in classroom-based learning.

Finally, the teacher project evaluation demonstrates a positive endorsement for outdoor education centred around biodiversity; however, there were concerns of time limitations to meet curricular deadlines. Curricular pressures have been identified to be a recurring theme in teachers responses to outdoor education (Marchant et al., 2019). If outdoor education is more readily included in the national curriculum with learning objectives involving hands-on outdoor engagement as opposed to theoretical ideas taught in the classroom, these could mitigate teacher concerns (Palavan et al., 2016). Teachers shared in their evaluation forms that some of the activities could be implemented to integrate a variety of learning objectives in different subjects, and not purely science. Additionally, the benefit of teaching within school grounds avoids teacher concerns reported by other researchers on outdoor education consisting of a full day trip taking time away from lessons, travel costs, health and safety risks and extra administration tasks for parental consent forms (Palavan et al., 2016; Rickinson et al., 2004).

There are several limitations to consider from the current study. Firstly, the study was unable to obtain a control group of children to complete the PMMs and quizzes. This was primarily due to the participating schools wanting to have equal opportunities for all their children. The research could be strengthened by recruiting a matched number of control group children.

Secondly, the use of evaluation questionnaires has a variety of limitations. Social bias may have been involved when the children and teachers were completing these at the end of the programme leading to limited validity of the surveys. However, the reduction of social bias was achieved due to ensuring anonymity when answering the questionnaires. Additionally, the use of an evaluation survey compared to a pre-post programme assessment method could lead to poor memory recall, and therefore the impact of the programme may not be fully identified. Furthermore, as an evaluation survey is not completed more than once the reliability of the evaluation may be limited. Despite these limitations, the use of the evaluation survey can ensure information can be gathered quickly on the impact of the programme and identify areas that require improvement.

5.5 Conclusion

The poor knowledge and awareness of local wildlife that children have acknowledges the increasing disconnection between people and nature. This study demonstrates that hands-on outdoor education within school grounds can improve children's knowledge and increase their awareness and improve perspectives of local biodiversity. This research emphasises that engaging with nature within school grounds is an enjoyable method for children to learn about the natural environment while supporting their engagement and enthusiasm to learn. The current research has shown that participating in biodiversity activities for only an hour per week over the academic year can enhance children and teachers' connection to nature while instilling an awareness of the natural environment to foster ecological values in the future.

Chapter 6 : A case study to investigate the impact of invertebrate focused activities on children's mood, wellbeing, perspective, and knowledge in a Froebelian ethos school compared to mainstream private and state schools

Abstract

A Froebelian ethos school focusses on unity with the natural environment to aid children's wellbeing and educational experience throughout the everyday curriculum. This study explored whether outdoor invertebrate-focussed activities impacted children from Froebelian, and mainstream educated private and state schools over two months. The children's mood, wellbeing, connection to nature, and perspective and knowledge were investigated before and after the set of activities. There was a significant improvement in all children's mood with no significant difference identified between schools. Only mainstream schools were found to have children who had a low connection to nature but their connection to nature significantly improved after the activities, while all Froebelian children had a connection to nature within the recommended range before and after the activities. Negative and neutral perceptions and knowledge of insects improved after the activities, particularly in mainstream educated children. In comparison, Froebelian children had the highest unspecific neutral responses both before and after the activities and state school children responded with more positive perspectives before and after the activities, in comparison to Froebelian children. Outdoor education provided a means to relieve the stress associated with learning and enhanced children's concentration. Froebelian children responded more on how nature impacted them, and their relationships compared to mainstream school children. Integrating nature engagement into school curriculum could improve wellbeing and educational engagement while allowing children to develop a connection to nature.

6.1 Introduction

Over recent years, the influence of Forest Schools and outdoor learning (O'Brien & Murray, 2007) on children's wellbeing has increased (DEFRA, 2018). As part of the British Government's 25 Year Environment Plan (DEFRA, 2018), it is proposed to develop further the initial plans for 'more children to experience nature by outdoor learning, through practical support to schools and reducing red-tape for outdoor learning' (DEFRA, 2011).

Despite this growing movement, increasing awareness among policymakers, and the government identifying a need for more practical teaching approaches including fieldwork, mainstream methods of teaching are typically restricted to the classroom (Passy et al., 2019). Outdoor engagement alongside the school curriculum is declining, particularly in the discipline of biology (Barker & Slingsby, 2002; Lock, 2010). The lack of outdoor education is due to concerns such as curricular pressure, cost and access to resources, safety worries and confidence in teaching outside (Edwards-Jones et al., 2018; Marchant et al., 2019). These challenges have resulted in primarily classroom-based learning, and a loss of nature engagement as children progress through their education (Dillon et al., 2006; Leather & Quicke, 2010; Lindemann-Matthies et al., 2011; Soga & Gaston, 2016).

Fieldwork is a beneficial tool for teaching, as it helps children consolidate information learnt in the classroom. Also, it instils motivation and inspiration in children who may struggle with formal classroom-based education while encouraging enjoyment in content-based schooling (Marchant et al., 2019). Further to this, fieldwork can enable children to develop educational objectives such as teamwork, problem-solving and allowing pupils to link theory and observation (Tilling, 2018). Fieldwork provides children with the opportunity to gain a greater understanding of more complex and abstract learning outcomes in a visual and hands-on environment, as well as adding value to their school experience and developing skills for a sustainable future (Barker et al., 2002; Lock, 2014).

Outdoor education has previously been found to benefit mental and physical health (Twohig-Bennett & Jones, 2018), which in turn is essential for wellbeing and educational attainment (Patel et al., 2007; The Children's Society, 2017). Scheduling time away from the classroom and embracing the natural environment in school grounds and local areas can allow mental recuperation from work (Cox et al., 2017; Han, 2017) and tackle academic stress. It also allows children to learn in a fun and interactive style more actively and physically compared to indoor activities (O'Brien, 2009). Bentsen et al. (2009) reported Danish schools running outdoor education as a weekly or bi-weekly event, referred to as *udeskole*, supports learning through an informal setting which has been implemented nation-wide across private and state schools. Their findings suggest *udeskole* adds value to classroom teaching through means of benefitting health, social and wellbeing perspectives over the long term.

Moreover, building a connection to nature through the school environment and fieldwork can help tackle children's disconnected lifestyle from wildlife and prevent a fear of nature, termed 'biophobia' (Ulrich, 1993). Although invertebrate species make up 95% of global species (Titley et al., 2017), children favour charismatic mammalian species (Ballouard et al., 2011; Drissner et al., 2014; Genovart et al., 2013; Lindemann-Matthies et al., 2005), and have suggested they associate insects with negative feelings of biophobia (Cho & Lee, 2018). Therefore, within the current investigation, insects were chosen as a tool to explore whether these negative associations could be changed to positive perceptions through environmental education and hands-on experience. Tackling this negative perception of insects is vital at this current time, as insects are facing extinction at a rate eight times higher than vertebrates, with 41% of insect species currently threatened with extinction (Sánchez-Bayo & Wyckhuys, 2019). This decline in insects has also impacted vertebrate species such as insectivorous birds (Woodward, 2018), therefore engendering a knowledge of insects in the younger generations may help to foster adults that are interested in insect conservation and preserve biodiversity.

Currently, on average, children within the UK have a low connection to nature (Hughes et al., 2018). A rapport between children and the natural world is essential to develop future environmentalists (Bird, 2007; Dearborn & Kark, 2010; Kahn & Friedman, 1995) to confront the current and emerging issues. These environmental issues are creating more significant threats to human wellbeing and a sustainable future than ever before, such as climate change and habitat degradation (Dallimer et al., 2012; Marine Conservation Society, 2018; Seto et al., 2012). Empathy and interest for the natural world are essential for both the benefit of children's mental and physical wellbeing (Bragg et al., 2013; Chawla, 2007; Kuo et al., 2018). Additionally, a positive perception of the environment is vital to ensure there is no further degradation of ecosystems (Barthel et al., 2018).

Current conventional methods of education are primarily classroom-based, with children predominantly listening, writing and observing in the classroom, mostly interacting with the natural environment in an artificial context using technology (Wen et al., 2009). However, the Froebelian method of teaching created by Friedrich Froebel in 1849, focusses on 'wholeness and unity of experience' (Bruce, 2012; Provenzo, 2009) ensuring one experience is interconnected with many others to allow a more in-depth understanding (Smedley & Hoskins, 2015). A greater knowledge through interconnected experiences is often achieved with local professional expertise from the community passed on to the children. Additionally, learning through nature is an essential part of the Froebelian philosophy with outdoor learning a fundamental aspect of the children's school life throughout the curriculum, allowing a holistic education for active development through collaborative purposeful learning and to ensure they develop an affinity to the natural world (Provenzo, 2009; Smedley & Hoskins, 2015).

Furthermore, the Froebelian method of teaching has a large focus on the interpersonal experiences outside the school environment. As children have preconceived ideas and understandings, developed from their personal experiences, the Froebelian school actively build upon their prior knowledge and experience through utilising a child-led educational approach to develop their knowledge and interests, compared to the structured curriculum of the mainstream method of teaching. Froebel's ensures children can build upon their experiences and previous knowledge to develop ideas and ways of learning to ensure children progress at a pace suitable to their development while the mainstream methods of teaching follow strict curriculum and goals in each year group (Falk, 2009; Jafari Amineh & Davatgari Asl, 2015).

Froebel's principles have a focus around children's happiness with an emphasis that the Froebelian method of teaching best serves children's wellbeing while maintaining that the natural world plays a vital role within children's education (Smedley & Hoskins, 2018). However, many mainstream schools throughout England have been suggested to neglect pupils' wellbeing, and possibly harm it, with schools primarily focussing on academic achievement; and Ofsted reports no longer concentrating on wellbeing but academic subjects (Bonell et al., 2014). The movement towards a focus on academic output has been primarily due to the policy within the education system in England putting more emphasis on schools advancing pupils educational attainment while ignoring their wellbeing and health (Department for Education, 2010).

This study aimed to explore how expert-led nature engagement activities to discover the local insect biodiversity within school grounds impacts the children's mood, wellbeing and connection to nature in a Froebelian ethos school, compared with mainstream state and private schools. Furthermore, the children's perspectives and knowledge of insects were explored, to investigate how this varied between the schools and whether it changed after the activities. The viewpoint of the pupils and teachers were also examined through focus groups to gain a better understanding of the complex issues of wellbeing and feelings towards nature.

It was hypothesised that mainstream children would have a higher improvement in their mood, wellbeing, and connection to nature after the activities compared to Froebelian children. However, it was further hypothesised that as the Froebelian children's schooling incorporated nature engagement daily throughout their education, they would show little change in their mood, wellbeing and connection to nature after the activities; and would have a higher initial mood, wellbeing and connection to nature. It was additionally hypothesised that the Froebelian children would have better initial knowledge and more positive appreciation of insects compared to the mainstream educated children. It was further hypothesised that children within all schools would have a reduction in negative and unspecific neutral perspectives and mainstream children would have an increase in positive perspectives towards insects following the activities. Finally, it was hypothesised that all children and teachers would report a positive experience to their education, wellbeing, and connection to nature.

6.2 Methodology

6.2.1 Participants

Participants recruited included 18 children from a Froebelian ethos primary independent school, 25 children from a primary state school and 15 children from a primary private school in the south-east of England, via schoolteachers and head teachers. Additionally, the class teacher from each school participated in the data collection process (detailed in section 6.2.2.4). The state and private schools were selected to compare to the Froebelian school as they were representative of mainstream methods of schooling within the state and private sectors. All three classes were mixed with boys and girls between the ages of 8 and 10. Informed consent was acquired from the children's parents/ guardians, as approved by the institutional ethical review process at Royal Holloway University of London. Each child's dataset was anonymised by assigning a unique ID code composed of their first and last initial, the day of their birth, and their class (e.g. LM025C).

6.2.2 Procedure

6.2.2.1 Outdoor education program

A total of seven one-hour sessions involving different invertebrate-focussed activities were developed to engage the children with insects in the school grounds to teach the children about them via a hands-on approach. The sessions were carried out in each school across seven weeks over the summer term (May to July 2018). Insects were chosen due to species abundance and individuals' ability to locate and identify them (Cox & Gaston, 2018). Activities were focussed on discovering and monitoring species and informing children there are a variety of methods used to investigate invertebrate species. Figure 6.1 displays some examples of the activities.

(a) (b) (c)

Figure 6.1: Examples of activities carried out during the outdoor education sessions. (a): caterpillar predation investigation; (b): male stag beetle from insect morphology investigation when searching for invertebrates on ground level; (c): female Emperor moth from moth trap.

The full list of activities that were carried out are described below:

Caterpillar predation

The predation rate of caterpillars on common oak trees (*Quercus robur*) was explored by each child making their own 3 cm long dummy caterpillars (Figure 6.1a), with a 1 cm^3 piece of plasticine on a 12 cm long thin piece of wire. If a child struggled or did not want to make one themselves, they worked in pairs. Low lying, north, south, east, and west facing thin branches (< 1 cm) were chosen on a single oak tree and five caterpillars were placed on each branch 10 cm apart. The dummy caterpillars were left out for a total of 6 weeks. The markings were initially checked two weeks after installation. The caterpillars were investigated, re-made, and checked again four weeks later. During the two week and six week check, bird and insect predation marks were counted, and predators markings were identified each time with the use of identification keys (Castagneyrol et al., 2019) and the difference between the number of markings and the length of time the caterpillars were left out were discussed with the children.

Pitfall traps

Non-harmful pitfall traps (without liquid to kill invertebrates) were set up across the school grounds to catch invertebrates over a week. The class divided into pairs, with two children making one pitfall trap between them. This was achieved by digging a small hole to sink the plastic cups into the ground, ensuring the cup rim was level with the ground. Small stones were placed around the edge of the cup to have a tile raised off the ground to provide a shelter from rain and allow invertebrates to crawl underneath into the pit. Leaves, grass and small stones were placed at the bottom of the cup to a quarter of the way up to ensure nothing would crawl out while ensuring it would be an appropriate habitat for invertebrates (Southwood & Henderson, 2000). Invertebrates were then inspected to explore the different morphologies between molluscs, insects, arachnids, crustaceans and myriapods with the use of invertebrate identification guides (OPAL, 2010).

Tree beating

White A1 pieces of card and beating sticks were used to collect invertebrates from trees and hedgerows with children working in pairs (Southwood & Henderson, 2000). The branches were tapped with the sticks so the invertebrates would fall onto the white card. The invertebrates were then looked at closely with hand lenses and phonescopes. Species found on the vegetation were identified with the use of invertebrate identification guides (OPAL, 2010) and compared to taxa and species obtained from pitfall traps to explore how species vary to those active at ground level.

Sweep nets

Sweep nets (45 cm x 25 cm) were used in pairs within the meadow area of the school grounds to catch insects (Southwood & Henderson, 2000). The children looked at how these species of insects were mainly pollinators and differed from those found at soil level and on trees. (Southwood & Henderson, 2000). During this activity the morphology was studied with the use of guides to identify the different species (OPAL, 2010, 2015).

Moth trap

A non-harmful light-box moth trap was left overnight to monitor moth species (Southwood & Henderson, 2000). The night-flying moths (Figure 6.1c) were compared to day-flying moths and butterfly species caught with the sweep nets. Species were identified, and the difference between moths and butterflies were examined with identification guides (OPAL, 2015).

6.2.2.2 Mood, wellbeing, and nature connectivity monitoring

The mood of each pupil was measured at the beginning and end of each individual session. A mood questionnaire containing 14 adjectives (Harvey et al., 2020) from the reduced Positive and Negative Affect Schedule for Children (PANAS-C) (Watson, Clark, & Tellegen, 1988) was used. The questionnaire is validated for use with 8-18-year-olds, and the altered scale showed good internal reliability ($\alpha = 0.88$). The questionnaire presents a list of seven positive and seven negative emotions that the children were asked to rate according to their current mood. A five-point Likert scale ranging from 'not at all' (1) to 'extremely' (5) was used. Emoticons were added below each emotion to make the response format more child friendly. The order of positive and negative mood items was randomised to minimise response bias. The negative emotions scores, such as ‘annoyed’, were reversed, so a high score represents better mood. A total score for each individual was generated for before and after each session, from low mood (14) to high mood (70).

The change in children’s wellbeing and connection to nature were measured by the individuals answering questionnaires the week before all activities commenced, and again the week after the activities had been completed. The wellbeing measures comprised of the Kidscreen-27 (Ravens-Sieberer et al., 2014) and the Good Childhood Index (GCI) (The Childrens Society, 2017) which are both validated to assess children’s wellbeing from the ages of 8-18. The questionnaires were completed together to gather an understanding of how the children feel their physical wellbeing, psychological wellbeing, autonomy, relationship with parents and peers, the children’s social support and school environment, and finally the children’s overall life satisfaction. The Kidscreen-27 is a series of 27 questions on a 5-point scale from strongly disagree (1) to strongly agree (5), broken into five subsections: physical activities and health; general mood and feelings about yourself; family and free time; friends; and school and learning. The GCI had a series of five questions on a five-point scale of overall life satisfaction and eleven questions on a ten-point scale from very unhappy (1) to very happy (10) on school life and relationships with family and friends.

Connection to nature was measured using the Connection to Nature Index (Chen-Hsuan Cheng & Monroe, 2012), validated for ages between 8-12. The questionnaire explored four subsections of nature connection: enjoyment of nature; empathy for creatures; a sense of oneness with nature; and sense of responsibility for the environment. The questions within each of the above sections were ranked on a five-point scale from strongly disagree (1) to strongly agree (5). The responses were graded to calculate each individual overall score (range of 16 to 80), as well as a score for the four subsections (Bragg et al., 2013). A higher value represents a better connection to nature.

6.2.2.3 Knowledge attainment measurement

Personal meaning maps (PMMs) (Jesus-Leibovitz et al., 2017) were used to assess the pupils' knowledge relating to insects before and after the five invertebrate activities (Figure 6.2). PMMs were chosen to evaluate the topic of insects covered in the sessions specifically and to avoid any leading questions to ensure the individual can express any thoughts, phrases, or facts they felt related to insects. PMMs allow the impact of the outdoor educational experience to be measured on the pupils' knowledge gain (Mupezeni & Kriek, 2018) as well as personal experience of the topic (J. H. Falk & Reinhard, 2007).

The children completed an insect PMM over two minutes with the word 'insects' in the centre of the page before any invertebrate activities were carried out, and then again after the activities had been completed. A new PMM was completed to ensure the individuals were not led by their previous responses, giving a more accurate representation of how their perspectives and knowledge had changed following the activities.

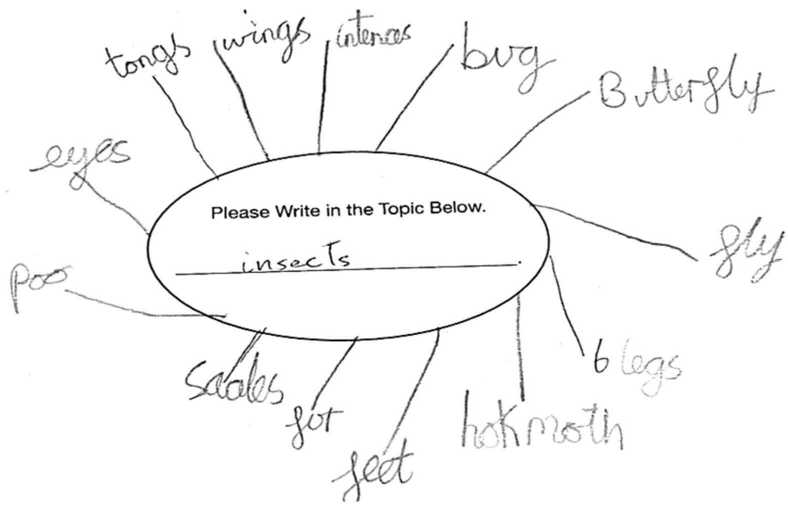


Figure 6.2: Example of children's insect PMM.

6.2.2.4 Focus groups, interviews, and questionnaires

Semi-structured focus groups were conducted with the children to explore further how the children felt their connection to nature had changed after partaking in the activities and how they felt about outdoor education (see Appendix 15 for children focus group questions). Semi-structured focus groups are considered to be an appropriate method of assessing interventions and allows children to articulate themselves in a way that is not focussed on decisive questionnaires (Marchant et al., 2019). The focus group allowed the children to share their thoughts in an approach that allowed children to discuss their opinions with each other. It allowed a more qualitative impression of how the activities impacted their views of the natural environment.

The class teachers within each school were interviewed with open-ended questions about how they felt the children responded to the outdoor education intervention (see Appendix 16). The Froebelian teacher was also interviewed about the Froebelian method of teaching and how invertebrate activities complemented it. The teacher and pupil interviews were audio-recorded and subsequently transcribed and checked for accuracy by a second person.

6.2.2.5 Data analysis

Data from all surveys were input electronically and checked by two people after the sessions. Questionnaire measures for scores as detailed in section 6.2.2.2 were used. All three schools were compared for the children's score before and after participation for mood, wellbeing, and connection to nature.

PMMs were categorised into themes and checked by two people. The PMMs were analysed by grouping the themes into 'positive' (encompassing all positive descriptions, thoughts, feelings, correct facts and insect species); 'negative' (all negative descriptions, thoughts, feelings, incorrect facts, and non-insect species; and 'neutral' (all non-insect specific descriptions and neutral thoughts and feelings).

All statistical analysis was carried out using R 3.5.3 (R Core Team, 2019), and graphs were made on GraphPad Prism (GraphPad Software, 2010). The effects of school, gender and collection time point (before and after) on the children's mood, wellbeing, connection to nature (including the subscales of enjoyment of nature, empathy for creatures, sense of oneness, and sense of responsibility), and PMM scores were analysed using generalised linear mixed models (GLMM) with Poisson error structure to account for influential random effects of individuals. Interaction and statistical significance were gathered by removing terms sequentially and testing the significance between the models until a minimal model was achieved. Tukey post hoc tests were additionally used to test the significance of each pairwise comparison to investigate the difference in mood, wellbeing, connection to nature and PMM scores within the different schools. Change score was calculated from the before score minus the after score, where a positive score indicated an improvement in mood, wellbeing, connection to nature, or PMM score.

Teacher interviews and children focus-groups were explored through thematic analysis (Braun & Clarke, 2006) by identifying themes through coding within the transcribed interviews and then the frequency of responses corresponding to each theme were recorded (White et al., 2018). Each transcript had an open-coding process to allow participants views to be summarised with words or short phrases before identifying themes. During the analysis, initial codes were written within the margins of the transcripts. The codes were then screened to categorise them under overarching themes and subthemes through inductive reasoning (Braun & Clarke, 2006; Pattinson et al., 2017).

6.3 Results

6.3.1 Mood

As displayed in Table 6.1, the impact that invertebrate activities had on children's total average mood was not significantly different between schools (χ^2 = 2.957, df = 2, p > 0.05) or gender of the children (χ^2 = 0.088, df = 1, p > 0.05). However, there was a significance between the before and after collection time points (χ^2 = 11.245, df = 1, p < 0.001), with the before collection time point having a significantly lower mood score compared to after the activities took place (SE = 0.011, z = -3.358, p < 0.001).

Table 6.1: Summary of the results from the generalised linear mixed model selection testing the significance of the effects of the valid parameters and interactions measured on the children's total mood with individuals used as a random effect. Bold values indicate significant terms.

Model Parameter	**Total Mood**		
	df	LogLik	p-value
School * Time point	2	-1688.4	> 0.05
Gender	1	-1690.2	> 0.05
Time point	**1**	**-1690.2**	**< 0.001**
School	2	-1690.2	> 0.05
Minimal model	Total mood score ~ Time point + (1|individual ID)		

As displayed in Figure 6.3, Froebelian children had the highest average mood score before the activities began compared to the mainstream school children, with the state school children having the lowest average mean mood score before and after the activities.

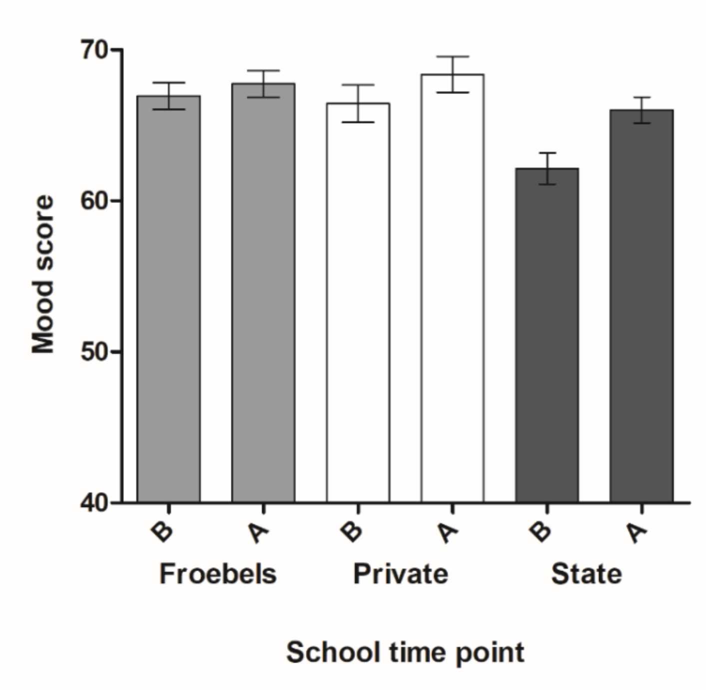


Figure 6.3: The average total mood score in schools before (B) and after (A) the invertebrate activities. Bars represent SEM.

Figure 6.4 displays the change score between the before and after collection time point. Although school and gender were found to be insignificant, the state school children on average improved the greatest and Froebelian school the least; with boys within each school showing less improvement in each school compared to girls, although not significantly.

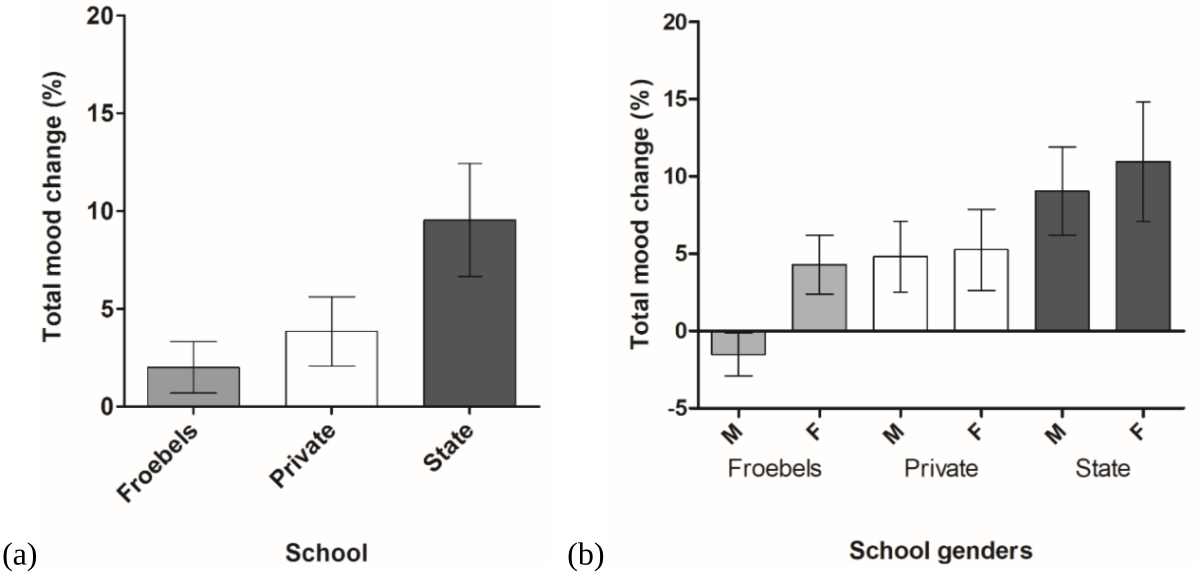


Figure 6.4: The average total mood percentage change in schools (a, b), and between gender (b) within each school after the invertebrate activities (M = male; F = female). Bars represent SEM.

Similarly, Table 6.2 shows there was a significant difference between time point for negative mood. The negative mood scores significantly improved, with lower scores found before the activities, compared to after (χ^2 = 8.1632, df = 1, SE = 0.015, z = -2.863, p < 0.001).

Table 6.2: Summary of the results from the generalised linear mixed model selection testing the significance of the effects of the valid parameters and interactions measured on the children's negative mood with individuals used as a random effect. Bold values indicate significant terms.

Model Parameter	**Negative Mood**		
	df	LogLik	p-value
School * Time point	2	-1473.3	> 0.05
Gender	1	-1474.3	> 0.05
Time point	**1**	**-1474.3**	**< 0.001**
School	2	-1474.3	> 0.05
Minimal model	Negative mood score ~ Collection time + (1| individual ID)		

Additionally, there was the suggestion that positive mood score difference between before and after the activities were significant between schools (χ^2 = 3.4736, df = 2, SE = 0.016, z = -1.87, p = 0.06). Figure 6.5 shows that state schools had the greatest increase in positive mood scores, while the Froebelian school children had the least, like that of the negative mood scores.

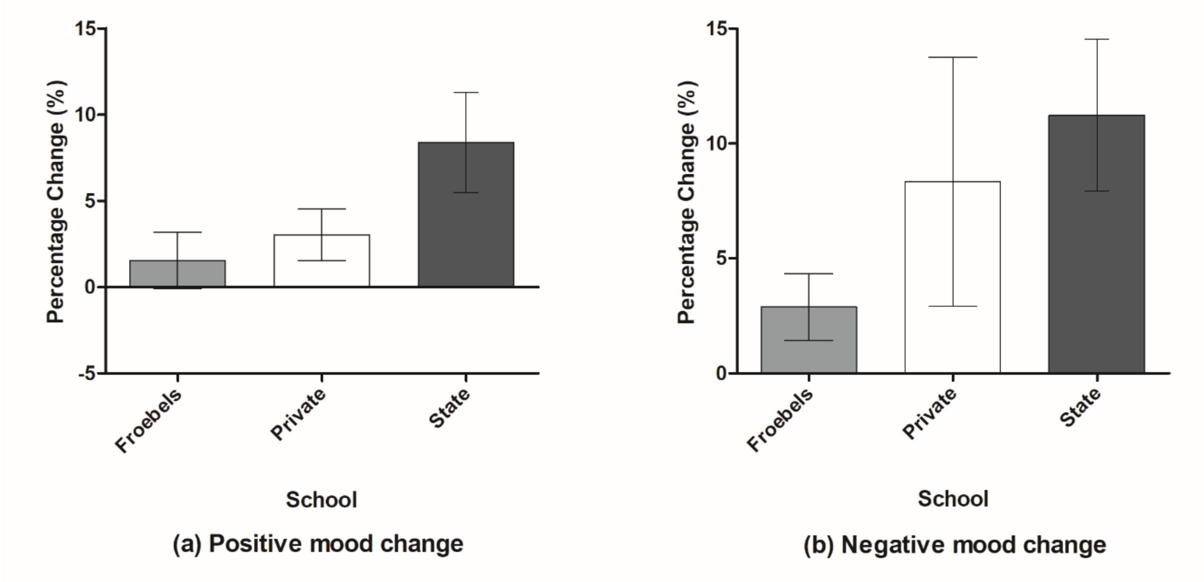


Figure 6.5: The average positive mood score changes (a), and negative mood score changes (b) within each school after the invertebrate activities. Bars represent SEM.

6.3.2 Wellbeing

As shown in Figure 6.6, although there was no statistical significance between the schools (KS: χ^2 = 0.856, df = 2, p > 0.05; GCI: χ^2 = 0.293, df = 2, p > 0.05) or collection time points (KS: χ^2 = 0.227, df = 1, p > 0.05; GCI: χ^2 = 0.212, df = 1, p > 0.05); the impact the invertebrate activities had on children's wellbeing did improve in schools, with the exception of state school children. However, the state school children had the highest initial wellbeing. Additionally, there was no significance between gender (KS: χ^2 = 1.94, df = 1, p > 0.05; GCI: χ^2 = 0.04, df = 1, p > 0.05).

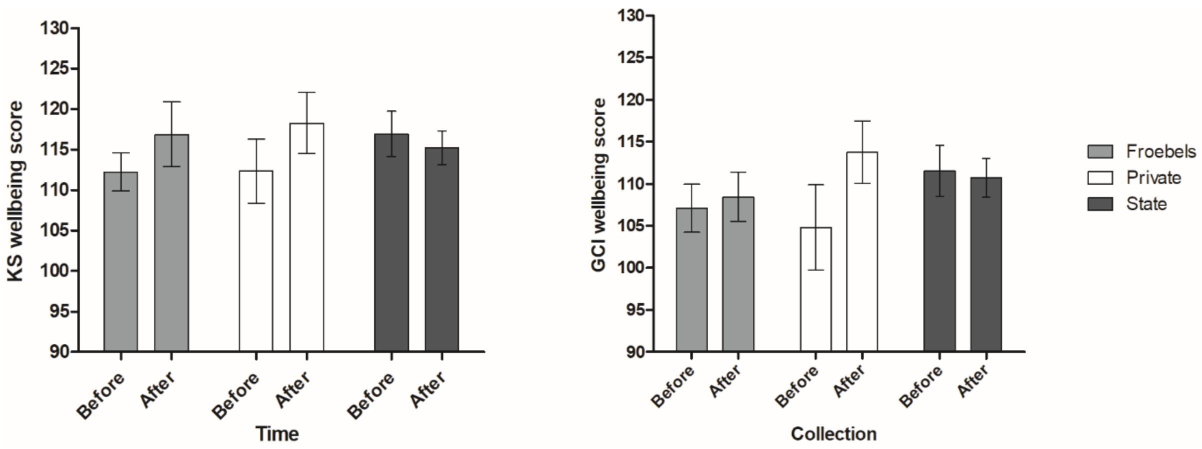


Figure 6.6: The average total KS and GCI wellbeing scores before and after the set of activities within the different schools. Bars represent SEM.

There was an improvement in Froebelian and private school children in the KS questionnaire after the set of activities, but no change on average in state school children. Similarly, as seen in Figure 6.7, the children in the private school had an improvement in their wellbeing after the set of activities, however, on average, there was no change in Froebelian and state school children.

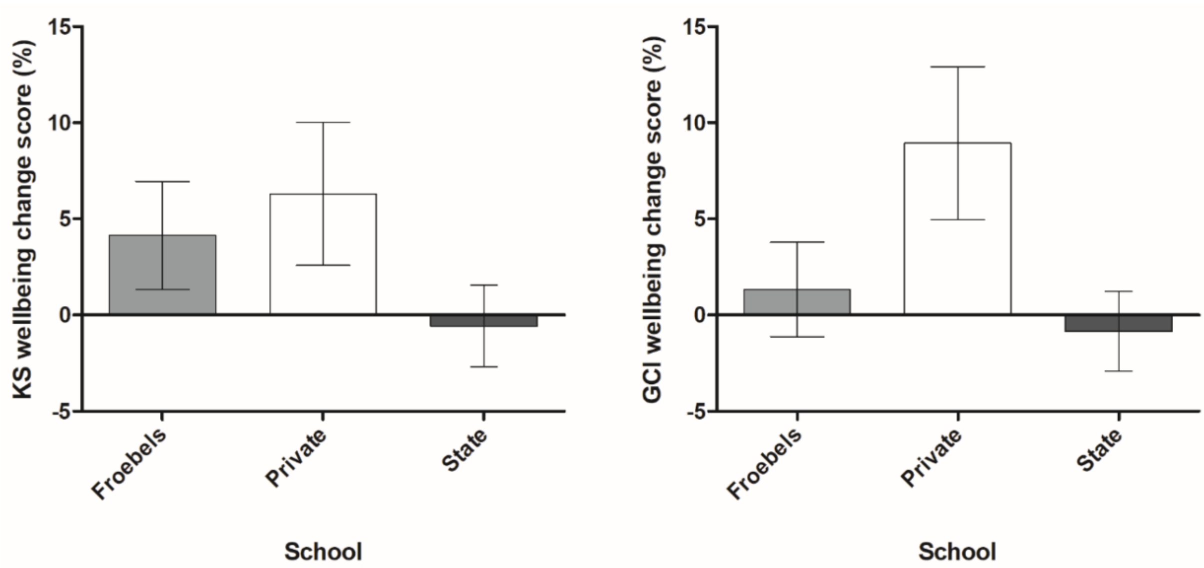


Figure 6.7: The average total KS and GCI wellbeing change of the different schools after the invertebrate activities. Bars represent SEM.

6.3.3 Nature Connection

As displayed in Table 6.3, there was no significant difference between school (χ^2 = 1.642, df = 2, p > 0.05) and collection timepoint (χ^2 = 0.087, df = 1, p > 0.05) of the children's connection to nature. However, there was a significance between the children’s gender ($\chi^2 = 4.238$, df = 1, $p < 0.05$). The post hoc test revealed girls had a higher connection to nature compared to boys (SE = 0.029, df = 1, z = -2.266, $p < 0.05$); specifically, this difference was identified to be only within the enjoyment subsection of the connection to nature survey ($\chi^2 = 4.704$, df = 1, $p < 0.05$) , while no significant difference was found in the subsections of empathy, responsibility and oneness.

Table 6.3: Summary of the results from the generalised linear mixed model selection testing the significance of the effects of the valid parameters and interactions measured on the children's connection to nature with individuals used as a random effect. Bold values indicate significant terms.

Model Parameter	**Connection to Nature**		
	df	LogLik	p-value
School* Time point * Gender	2	-393.22	> 0.05
School * Time point	2	-393.64	> 0.05
Time point * Gender	2	-394.83	> 0.05
School * Gender	2	-395.20	> 0.05
Gender	**1**	**-397.70**	**< 0.05**
Time point	1	-397.74	> 0.05
School	2	-397.74	> 0.05
Minimal model	Connection to Nature score ~ Gender + (1|individual ID)		

Although there was no significant change in schools’ connection to nature after the set of activities, on average it can be seen in Figure 6.8 that each school started with a high connection to nature. The Froebelian children had the highest connection to nature before and after the set of activities out of all three schools. Additionally, the private school children had an improvement in their connection to nature after the set of activities, to a similar level of the Froebelian children.

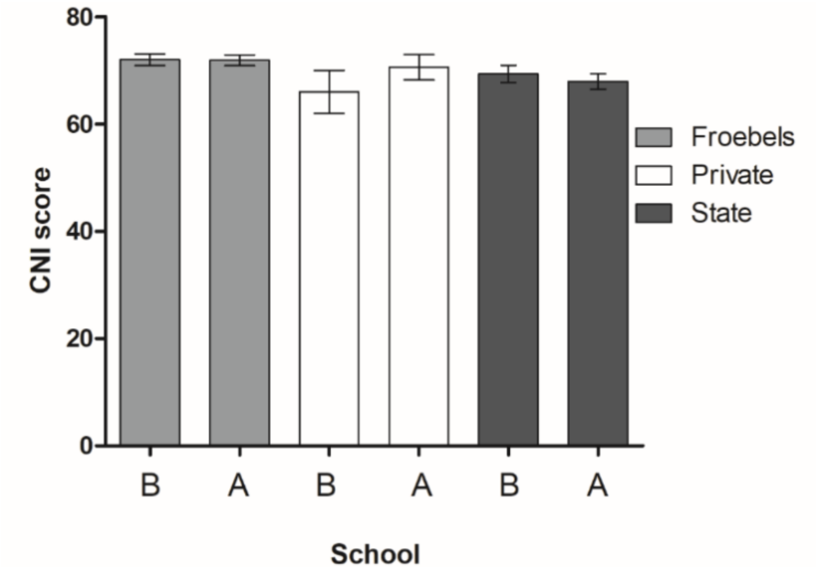


Figure 6.8: Average before (B) and after (A) CNI scores in Froebelian, private and state school children. Bars represent SEM.

As the greatest proportion of children across all schools (n = 46) on average had a connection to nature index within the recommended range (Hughes et al., 2018), an additional exploratory analysis was carried out to examine how the set of activities impacted those with a low connection to nature (below 4.06 on average or a total score of 64.96). The children who initially had a score below 64.96 on the connection to nature questionnaire were identified (n = 12) to be in the mainstream private and state schools. These children significantly improved after the set of activities (Figure 6.9), however they remained below the recommended level ($p = 0.003$, $V = 3$, before $\bar{x} = 3.46$, before SE = 0.191, after $\bar{x} = 3.97$, after SE = 0.124).

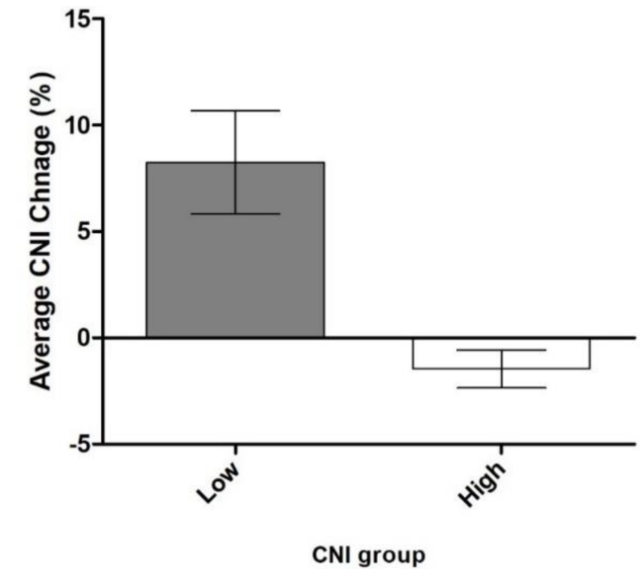


Figure 6.9: Average change in CNI in low connected children and high connected children. Bars represent SEM.

6.3.4 Knowledge and perspective

Figure 6.10 displays the children's total, positive, negative, and neutral perspectives, and facts (PMM score) of insects before and after the set of activities took place. Mainstream private school children demonstrated the greatest improvement in total, positive, negative, and neutral scores, while Froebel's children displayed the greatest decrease in negative scores. Mainstream schoolchildren had the highest positive and negative scores before and after the activities; compared to Froebel children who had the highest neutral perspectives before and after the activities.

There was a significant difference between collection time points (χ^2 = 6.72, df = 1, $p < 0.01$) and schools (χ^2 = 10.16, df = 2, $p < 0.01$) for the total number of written perspectives and facts on insects (Figure 6.10a). There was a significance between the state and private school (SE = 0.16, z = 3.23, $p < 0.01$), and private school and Froebelian school (SE = 0.18, z = 2.65, $p < 0.01$). Displayed in Figure 6.10b, state school children had the highest positive score compared to Froebelian children. In the children's positive scores, a significant interaction between school and collection timepoint was identified (χ^2 = 8.93, df = 2, $p < 0.01$), with a significant improvement in private school children (χ^2 = 10.32, df = 1, $p < 0.01$), but not within Froebelian or state school children. Inclusive of all children, negative scores decreased after the set of activities within all schools (χ^2 = 8.53, df = 2, $p < 0.01$; Figure 6.10c). Neutral scores also significantly decreased in all schools, (χ^2 = 19.71, df = 2, $p < 0.001$), with private mainstream school children showing a greater change than Froebelian children (SE = 0.31, z = 2.41, $p < 0.05$) and Froebelian neutral responses remaining the highest after the activities (Figure 6.10d).

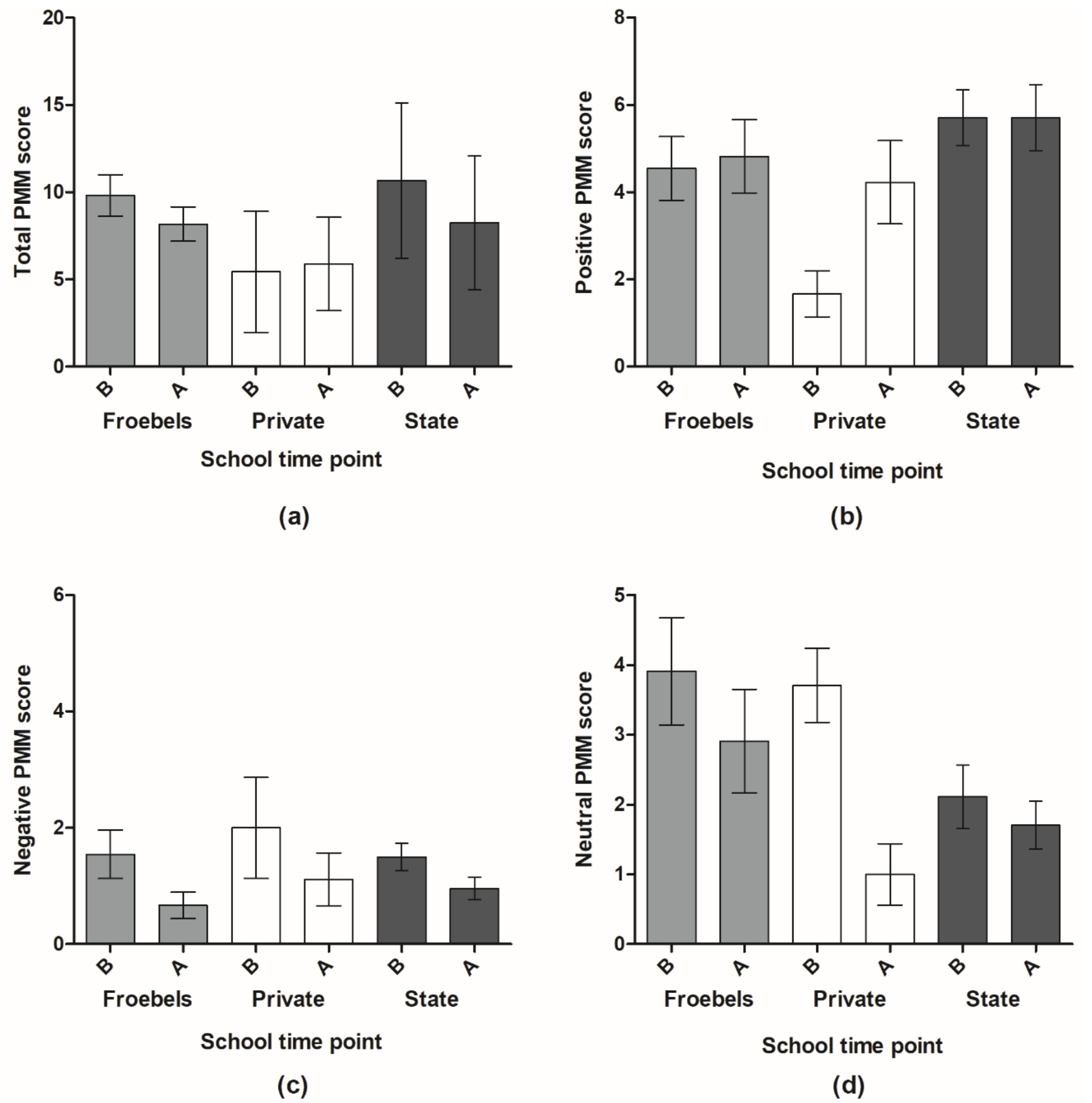


Figure 6.10: Before (B) and after (A) scores of perspectives and facts written on insect PMM for (a) Total written perspectives and facts; (b) positive perspectives and facts; (c) negative perspectives and facts; (d) neutral perspectives and facts. Bars represent SEM.

6.3.5 Thematic analysis

Four themes and 12 subthemes (presented in Table 6.4, see Appendix 16 for more information) were identified through qualitative analysis (Braun & Clarke, 2006) on the teacher interviews and children's focus-groups. The themes were decided upon by the content of the answers, and the frequency of the responses within each theme were recorded (White et al., 2018). The four main themes were 'personal support, 'relationships', 'lesson support', and 'nature awareness'. Table 6.4 displays the subthemes within each category and an example quotation from teachers and pupils within Froebelian school and mainstream schools.

Table 6.4: Themes and subthemes with example views from children and teacher interviews of outdoor learning experiences.

Personal benefit	Froebelian pupils	Froebelian teacher	Mainstream pupils	Mainstream teachers
Buffer stress and anxiety	I like working outside because I like listening to all the sounds and it makes me feel really peaceful.	Time in nature is an essential ingredient in maintaining mental health and happiness.	I feel better because I didn't use to look at nature this much. When you're raging you can just go outside and look at nature.	The children undoubtedly have their stresses and worries momentarily taken away.
Confidence boost	I'm proud to say I've held stag beetles, and I've held an elephant hawk moth cause lots of people haven't.	Developing independent learning and skills.	x	Show their strengths that they have previously not been able to.
First-hand experience	I usually play upstairs in my room. And being outside and learning about insects is a way for me to get outside, and so now when I go outside, I look and identify things in my garden.	The emphasis is on they're making those choices for themselves.	x	Gives them an opportunity to experience new things.

Relationships	Froebelian pupils	Froebelian teacher	Mainstream pupils	Mainstream teachers
Empathy	Now I realise they're actually really magical creatures.	That's just amazing and oh we must look after that.	I reckon we'd probably be better caring for the environment because this time last year I didn't really know.	Being more empathetic with their immediate peers.
Teamwork	x	To what extent teamwork is helped depends on the activity.	x	They have learnt to share and take turns.
Sense of community	Lots of people haven't even seen them and then you can like tell them facts about them.	Sense of with the experts in your community who do all these different sorts of things.	x	To help the environment that are in their back garden or local.

Lesson support	Froebelian pupils	Froebelian teacher	Mainstream pupils	Mainstream teachers
Concentration	If you're outside you're kind of multitasking in a way and you're doing it and listening at the same time.	Concentration spans of the children here are far greater.	Although it's still work, I found it better.	Outdoors helps children to concentrate more when they are in the classroom.
Learning by seeing and doing	We can learn it better while we're in it.	We have a lot of emphasis on the children playing and exploring.	It's more fun, rather than like someone telling you what to do and you write down.	Can make links to some of the things we have studied outside.
Enthusiasm for subject and learning	More interesting because you know more.	We are aiming for a deeper connection with the natural environment…um…and also...erm… the integration of the curriculum as well.	I honestly think it's…it's most of the time it's actually more interesting than normal science that's like not outside.	Allowed for greater enjoyment of science.

Nature awareness	Froebelian pupils	Froebelian teacher	Mainstream pupils	Mainstream teachers
Oneness with nature	I used to just think moths ate your clothes and stuff and now I realise they're actually really magical creatures and it's actually really cool to hold them and be so close to them.	How that inspires a connection with nature and how that inspires and grows in you something that is genuinely important.	We are part of nature.	Changed the way, I think, how they see nature.
Enhanced knowledge-enhanced interest	More interesting because you know more about them and they're names.	Can identify and name that bug, but then you've also got, that's just amazing, and oh we must look after that.	I never knew nature was so interesting.	Seeing things for real […] gives them a direct link rather than just seeing a picture.
Wider nature consciousness	Look after the environment so it's clean and because a lot	It's very disempowering with big issues because you can't have an impact on	The government don't have to keep on building buildings over the	Help the environment that are in their back garden or very local.

	of plants like trees can help us.	them. But my little eco committee […] they are really on it and they really understand why we need to do this, and we did a book swap last week, so we were recycling books.	grasslands and as K said we can stop using energy.

6.4 Discussion

This short-term case study measured the impact that hands-on invertebrate-focussed outdoor activities within school grounds can have on children's mood, wellbeing, connection to nature, and perspective and knowledge attainment; specifically, on a Froebelian ethos school in comparison to the mainstream schooling system. The results of mood and wellbeing show that the hypothesis of mainstream educated children receiving a greater impact from the intervention and that Froebelian children have initially higher mood and wellbeing was not upheld. It was found that taking part in these activities provided all children with significant immediate benefit to their mood across the course of each session, however there was no significant difference between schools. Additionally, over the short term, no significant improvements in wellbeing or difference between schools was identified. There was a tendency for wellbeing within mainstream private school children on average to increase, although this was insignificant in both wellbeing measures. Mainstream state school children displayed no change in wellbeing and Froebelian children showed a tendency to increase within the KS measure. Additionally, although no significant difference in connection to nature was found between mainstream and Froebelian schools overall, children who were deemed to have a low connection to nature were only within mainstream schools, while Froebelian school children were considered to have a connection to nature within the recommended level, as hypothesised. No significant improvement was identified within the mainstream or Froebelian school children overall, however, a significant improvement was achieved in children after the set of activities who had an initially low nature connectivity (identified to be from mainstream schools). Moreover, there was a significant increase in positive perspectives and knowledge associated with insects by the mainstream private school children but not within state or Froebelian children. Unexpectedly, mainstream state school children responded with the most positive perspectives and correct knowledge before and after the activities. There was a decrease in negative and incorrect facts, and neutral perspectives and facts on insects by both mainstream and Froebelian children after the set of activities, as hypothesised. However, Froebelian children responded with the most neutral perspectives of insects compared to mainstream children both before and after the activities. Finally, as hypothesised, children and teachers reported a positive experience these outdoor learning activities provided to children's stress and anxiety, learning experience and connection to nature; while Froebelian children responded more compared to mainstream school children on how nature has impacted them and their relationships.

6.4.1 Mood

Several studies have shown a considerable improvement in mood in those who partake in physical activities outside compared to artificial environments (Barton, et al., 2012; Dallimer et al., 2012; Karmanov & Hamel, 2008). Additionally, Roe & Aspinall (2011) have previously identified that learning through nature engagement can offer cognitive and emotional support to children compared to the confinement of learning in the classroom, as well as provide restoration for children to aid concentration and ease anxiety and frustration (McCurdy et al., 2010). The results in the current study supplement these earlier findings as mood significantly improved in all children after participating in the activities. State school children who started with the lowest mood displayed the most improvement, while the Froebelian children, improved the least. The contrast between the state school children and the Froebelian children is likely due to Froebelian education incorporating outdoor education into the curriculum on a daily basis. The influence that outdoor learning and nature engagement within the curriculum, similar to *udeskole* (Bentsen et al., 2009), has on wellbeing perspectives is evoked from the Froebelian children's high mood scores at the start of each session. The Froebelian children learn through 'seeing and doing', often engaging with nature throughout their schooling. Therefore, the hypothesis that the current outdoor education programme would have little effect on Froebelian children was upheld. Following the activities, the mainstream schoolchildren had improved their negative and positive emotions to raise their mood to a similar level of the initial mood of the Froebelian children. The state school children received the greatest impact on their mood, perhaps due to the limited outdoor experience they receive throughout their curriculum, as reflected by the comments made during the focus group.

The Woodland Trust carried out a retrospective study on the impact of tree planting on wellbeing within 11 to 16-year-old children in mainstream secondary schools through surveys and discussion groups. Emotional and social benefits to the children, as well as connection to nature and developing oneself were achieved through interacting with flora over the tree planting experience that had been carried out for up to one month (Puttick & Hughes, 2012). The current study reflects that these beneficial outcomes can be achieved through intimate contact with smaller organisms than trees, such as invertebrates, despite previous research identifying children to have negative attitudes towards them (Soga et al., 2016)

The present findings corroborate the concept that increased funding into outdoor education through the Nature Friendly Schools Programme can ensure that school grounds support children's knowledge of nature while fostering children's health and happiness (DEFRA, 2018). The significant change on negative and positive emotions within the children's mood following the interactive invertebrate activities shows that nature can reduce the impact of negative thoughts (Ulrich et al. 1991), as well as tackle an aversion towards organisms through direct contact (Simaika & Samways, 2010). Although this has been acknowledged to be achieved through children watching documentaries (Barbas et al., 2009), previous research has identified that experience of physically being with nature has a more beneficial impact on mood than through an artificial manner (Fuegen & Breitenbecher, 2018). Therefore, it would be more valuable for children to have additional opportunities to learn outdoors, and not view nature as something they can only engage with through technology within the classroom (Tay and Wang, 2016).

6.4.2 Wellbeing

Engaging with nature has been found to provide people with life satisfaction and wellbeing benefits (Frumkin et al., 2017) through reduced stress and anxiety (Song et al., 2015; Ward Thompson et al., 2016), improvement in social connectedness (Cohen-Cline et al., 2015) and cognitive performance (Fjørtoft 2001). Furthermore, allowing children to have access to green space has been found to influence memory, attention, behaviour, competence and test scores (McCormick, 2017). Using the wellbeing questionnaires, it was identified that although there was no significant change, Froebelian and mainstream private school children had overall improved wellbeing over the short term. This is of particular interest, as mental health and wellbeing within young people has deteriorated in recent years following a 6% increase in long-standing mental health conditions reported between 1995-2014 (Pitchforth et al., 2018). Further to this, there has been a 26% increase in referrals to child and adolescent mental health services (CAMHS) between 2013-2018 (Crenna-Jennings & Hutchinson, 2018). Despite this, many young people do not get the help they need which is expected to continue for years to come (House of Commons Committee of Public Accounts, 2019). Therefore, the government is aiming to improve children's ability to interact with nature both inside and outside of school over the next twenty-five years to aid wellbeing (DEFRA, 2018); as more than half of mental health illness start by age 14 (House of Commons Committee of Public Accounts, 2019). Ensuring children have outdoor education from the primary school which continues into secondary school may aid in relieving some of these pressures.

Previous research has identified that contact with nature can have a positive influence on children's self-esteem and academic performance (Keniger et al., 2013). However, the quantitative results within the current study found that there was no significant influence over the short term on the children's wellbeing; specifically, within subscales of feelings about 'self' and 'school and learning'. However, it was noted within the interviews that the children's confidence and concentration were positively impacted following the outdoor education invertebrate activities. Additionally, benefits to physical wellbeing when participating in outdoor learning has been suggested to be linked to the higher physical activity partaken in outdoor environments compared to classroom settings (Finn et al., 2018; Nielson et al., 2016). However, again, our findings of outdoor education impact on children's wellbeing in relation to their physical health were not found to be significant within this area over the short term but may have had an influence if carried out for a more extended period.

6.4.3 Connection to Nature, Perspective & Knowledge Attainment

The Froebelian education system offers an approach to teaching that allows the children to engage with the natural environment throughout different themes and subject matters, ensuring the children are closely connected to the natural world (Bruce, 2012). Due to this method of teaching and school ethos, all Froebelian children had a connection to nature within the recommended level and were above the UK average (Hughes et al., 2018). The children's connection to nature additionally emphasises the pro-conservation mentality within the Froebelian school, which has been found to be driven by those highly connected to nature (Hughes et al., 2018; Richardson et al., 2016).

Following the invertebrate activities, on average, connection to nature scores did not significantly change. However, private school children's connection to nature did improve; yet the Froebelian children's initial overall connection to nature was higher than these increased scores. The high connection to nature scores in the Froebel's children may be consequential of the children spending a lot of time engaging with nature throughout the curriculum. Fieldwork carried out weekly in children ages 9 to 13 has been identified to foster pro-environment behaviour and responsibility for the natural environment, as well as improving prosocial behaviour between peers in a school setting (LeBlanc & Chaput, 2017). The mainstream educated children (as remarked upon during their focus group responses) spend much of their time learning within the classroom but had more excitement for science with weekly outdoor education incorporated into their learning. These comments support research that identifies the role outdoor education within school grounds can play to aid science attainment through greater engagement in the subject, as well as enabling pupils to have more intrinsic motivation for learning while fostering environmentally mindful students (Bølling et al., 2018; Quibell et al., 2017; Rios & Brewer, 2014).

Although the mainstream school children continued to have a lower connection to nature than the Froebelian children after completing the set of activities, children who were found to have an initially low connection to nature significantly improved. This finding reflects that even organisms that children typically have a fear and dislike of (Borgi & Cirulli, 2015), can improve their connection to nature through hands-on activities altering their perspectives and improving their understanding of them. Richardson et al. (2016) have suggested that children with higher levels of connection to nature are more likely to participate in conservation efforts. An improved pro-conservation mentality following the activities, as indicated in the initially low scoring connection to nature children and the children's comments in the focus group, supports previous researchers suggesting a higher connectivity influences greater concern for nature's disappearance (Kareiva, 2008; Soga & Gaston, 2016; Swaisgood & Sheppard, 2011). As environmental degradation is of great concern currently, both publicly and politically (Smith, 2019), these outdoor learning opportunities enable children to foster the pro-environmental behaviours for adulthood, which is essential for future sustainability (Richardson et al., 2019). In turn, this can encourage a new generation of environmentalists that could contribute to reducing the decline of insects in the UK (Goulson, 2019).

Moreover, as revealed during the focus group and interview responses, the insect activities allowed children within both mainstream and Froebelian schools to engage on an intimate level with invertebrates. This hands-on experience subsequently drove them to notice the natural surroundings both inside and outside of school, further expanding their nature connectedness. Children and mainstream teachers stated that their gained knowledge of insects had encouraged the children's interest to explore nature and their enjoyment of science through outdoor learning in an informal setting. Teachers commonly have concerns about outdoor education detracting from the curriculum and leading to children becoming too excitable to teach (Marchant et al., 2019). However, if mainstream schools more commonly integrate outdoor education into the curriculum, it could alleviate teacher concerns, and lead to a positive relationship between motivation for learning (Bølling et al., 2018), as suggested from the focus group discussions.

The children reduced the number of non-specific neutral thoughts and facts as well as negative thoughts and incorrect facts about insects, following the interactive activities. Cho & Lee (2018) have previously shown that children experience biophobia, particularly when interacting with honeybees. The interview responses in our study additionally suggest that the activities aided children in overcoming these fears, through new knowledge as well as first-hand experiences of observing them intimately. Barthel et al. (2018) identified similar changes in children's views of salamanders, as the children underwent a positive behaviour change in their responsibility towards the environment as well as an increase in sympathy, concern and empathy for nature. As with our findings on insects, the children's negative views of salamanders decreased; as well as developing a more expansive, focussed knowledge in terms of observational facts (Barthel et al., 2018). These studies suggest that interactions with organisms previously deemed as fearful and perceived with negative connotations can be shifted over time. Learning and experiencing nature is critical for children to develop a relationship and empathy for these organisms, particularly at a time when invertebrate species are in significant decline (Sánchez-Bayo & Wyckhuys, 2019).

6.4.4 Strengths and Limitations

The findings from this case study demonstrate the differences in wellbeing and nature connection before and after interactive insect activities took place in mainstream educated school children and Froebelian educated children, which fully integrate the natural world into the children's education. It strengthens the knowledge base for schools and educational policymakers on the influence nature education has on children's wellbeing and nature connectivity through qualitative and quantitative assessment methods.

There are several limitations to review within the present study. Firstly, this research is a case study carried out on three individual schools. Therefore, the conclusions drawn from this study only reflect the differences between the investigated schools rather than the differences between the Froebelian and mainstream state and private schooling systems due to a lack of replication at school level. Furthermore, the schools participating in this study were from areas where fewer pupils (10.9 %) are eligible to receive free school meals than the national average (14.1%) (Department of Education, 2017). These schools would, therefore, be considered to be less deprived. Consequently, the transferability of the findings within the study may be limited and require further research to include samples over geographically broader populations to be fully representative of mainstream schooling within England. The different school systems were also not the only differences between the schools. The schools all had access to natural areas within the school grounds; however, the size of the areas differed between the schools. The state school had the smallest green area, the private school had access to the largest, and the Froebelian school had access to a range between the two mainstream schools. Therefore, future research needs to explore children's perceptions of nature within their school grounds and the implications of ease of access to natural areas throughout the school day may have on children. Finally, responses gathered from children and teachers were limited due to incomplete surveys or limited responses, as well as some children being more vocal during focus groups compared to others.

Despite the limitations, this study contributes towards the understanding of the influence nature can have on children and the importance of children's participation in fieldwork to enhance their educational experience. Schools which are interested in integrating outdoor education over the short or long term can use these three schools as case studies to illustrate the benefits fieldwork can bring to both the private and state sector. In this study, qualitative data was gathered to complement, strengthen, and provide more detailed information on children's wellbeing, connection to nature, perspective, and knowledge attainment in the mainstream and Froebelian schools. Further research to look at the influence outdoor education has on educational outcomes within different subjects of the curriculum would strengthen the knowledge base for schools to utilise outdoor education methods.

6.5 Conclusion

This study explored whether engaging with invertebrate-focussed outdoor education activities had an impact on children's mood, wellbeing, connection to nature, perspective, and knowledge; and whether this differed between the mainstream and Froebelian method of schooling. It was identified that time spent engaging with invertebrates through hands-on activities enhanced all children's mood (in mainstream and Froebelian schools), and connection to nature in mainstream school children who had initially low connectivity improved. Froebelian children were found to have the highest mood prior to the activities and had a connection to nature above the national average. Mainstream children were found to improve to levels similar to that of Froebelian children after the seven one-hour activities across two months. Additionally, knowledge and perspectives improved following the reduction in negative PMM scores, but Froebelian children had a more neutral view of insects before and after the activities compared to mainstream children.

This research highlights that outdoor education can support pupil wellbeing while developing essential empathy for the environment and tackle biophobia, as well as enable children to learn through informal interactive activities which enhance their knowledge and motivation to learn. Although there was a small sample size of children over a short time, a positive influence of the children’s mood and connection to nature was achieved throughout these activities in the range of schools. The study suggests that interactive biodiversity activities integrated throughout the curriculum can help children’s immediate wellbeing and education; as well as establish a connection to nature and encourage children to engage with nature in their free time and foster a pro-environmental lifestyle while mitigating pre-existing biophobia.

Chapter 7 : General Discussion

Through a series of outdoor education activities carried out in primary schools within the south-east of England, the impact of nature engagement within school grounds on children's mood, wellbeing, resilience, nature connection, perception and knowledge of nature has been investigated. The benefits identified through this research are of particular importance, as children spend over 50% of the year in school (Long, 2019), and should view nature as something that is in their everyday lives as opposed to only in nature reserves, documentaries and textbooks. Yet, schools are reported to be underutilising their grounds to support education and biodiversity (Harvey et al., 2019). Since there is a current crisis in young people's health and wellbeing (Pitchforth et al., 2018), as well as biodiversity in the UK (Hayhow et al., 2019), it is of particular importance to demonstrate that hands-on outdoor educational activities can be implemented within schools for the benefit of children and nature. These activities could be achieved at low-cost to support children's education in addition to their mood, wellbeing and resilience while inspiring them to connect with nature to foster pro-environmental perceptions and behaviour for a sustainable future.

7.1 Mood, wellbeing, and resilience

Improvement in children's mood was identified, on average, in children who participated in the nature engagement activities over the short and long term, irrespective of the type of school they attended, such as a Froebelian school (exposed to more outdoor learning activities in general) or mainstream state or private schools (both exposed to more classroom based learning in general). There was a sustained and significant improvement in mood after just an hour of engagement each week with a variety of flora and fauna throughout the academic year during different seasons; as well as exclusively during the short summer term study, specifically investigating invertebrates. The sustained increase in mood after every session each week suggests that the benefits of engaging with nature were achieved irrespective of taxa being investigated; such as well-known bird and mammal species (Lindemann-Matthies, 2005; White et al., 2018) or less charismatic fungi, plant, amphibian and insect species (Barthel et al., 2018; Cho & Lee, 2018).

These findings add to previous investigations conducted with adults that spending time in nature can positively influence mood (Barton & Pretty, 2010) and support conclusions drawn from small scale investigations on the impact of outdoor education on children and adolescents' emotions (Dopko et al., 2019; Han, 2017). Roe & Aspinall's (2011) research on a small group of children (n = 18, aged 11) participating in a forest school compared to a regular school over a period of five hours identified that the children's emotions (stress, energy, hedonic tone and anger) significantly improved when in the forest school. However, in the current research it was demonstrated that short term mood improvement can be achieved over a timeframe as limited as one hour per week, and if sustained weekly, continues to aid mood over a full academic year through benefiting positive and negative emotions.

Wellbeing and resilience were additionally found to improve significantly in children who participated in the outdoor education activities over the long term. In the initial yearlong study (Chapter 3) there was a significant improvement in wellbeing in all children who actively partook in outdoor education activities regardless of school type (state or private). At the same time, there was no significant improvement in the control group of children who did not participate in the activities. Further to this, Chapter 4 identified that children who had initially low wellbeing and resilience significantly benefitted from engaging with twenty-one hours of nature activities over a full academic year. In contrast, no such improvement was identified in control children who did not participate in the activities. These findings support other research that has identified neighbourhood greenery and activities partaken in natural areas can enhance wellbeing and resilience of young people (Flouri et al., 2014; McArdle et al., 2013; Passy, 2014). The findings in the current research suggest that hands-on outdoor biodiversity teaching does influence wellbeing and resilience and could be particularly effective in helping young people with low wellbeing and resilience. Outdoor education centred around biodiversity in school grounds is of notable importance when the loss of flora and fauna is increasing and children's mental health and wellbeing continue to worsen (Department of Education, 2019; Frith, 2016). As more people are living in urban areas dominated by human-made environments with reduced green spaces, it has minimised the opportunities for children to engage with nature. Therefore, outdoor biodiversity education, such as employed in this research, has the potential to support their wellbeing throughout their school years.

In addition, this study identified that higher wellbeing and resilience were found in children that perceived higher numbers of trees and other plants. Previous studies have found that there is a significant positive relationship between psychological wellbeing in adults and species richness of plants in green urban areas (Fuller et al., 2007). My findings support the concept that merely offering a green space (such as a playing-field) may not support children's wellbeing and health adequately. Consideration of the quality of the green space, as opposed to the quantity, can allow multiple benefits to prosper for people and the environment (Schebella et al., 2019). It is known that children can gain physical health and wellbeing through green exercise in schools (Barton et al., 2012); however, enhancing biodiversity and providing opportunities for contact with flora and fauna can also improve psychological health and wellbeing.

The research conducted within this thesis identified that activities focussed around biodiversity within school grounds elicited a significant improvement in mood, wellbeing and resilience as a result of children physically interacting with the natural environment, as opposed to remaining sedentary in a classroom environment. Previous research has investigated adventure activities and games outside school grounds that have centred around building positive group relationships (Berger, 2008; Doucette, 2004; McArdle et al., 2013). As the outdoor education interventions implemented during this research were focussed on engagement with nature through biodiversity activities in their school grounds, the impact of nature on mood, wellbeing and resilience can more definitively be concluded.

7.2 Connection to nature

Although previous research has identified that only 21% of children in the UK have a connection to nature deemed appropriate, the children within the present studies on average were identified to have good nature connectivity prior to any intervention through various methods of measuring nature connectivity (Hughes et al., 2018; Nisbet & Zelenski, 2013) and girls were found to have a higher connection to nature compared to boys (Chapter 6), as identified in previous research (Bragg et al., 2013; Kerr, 2015). Children that were identified as having a low connection to nature were found to improve significantly after the nature engagement activities. Additionally, children within the Froebelian school that has an ethos focussed on developing a bond with nature had no children with a low connection to nature, unlike mainstream state and private schools. Nature connection is formed from a young age as children are often developing emotional attachments to what they recognise and understand (Bilton, 2014b; Weilbacher, 1993), which may reflect why the Froebelian children's nature connectivity was higher compared to mainstream educated children, who have a limited outdoor education experience. The evaluation questionnaires demonstrated that children and teachers felt their connection to nature had improved after an academic year of hands-on nature engagement activities in their school grounds. The investigations carried out within this thesis strengthens previous conclusions that have identified a bond with nature can be nurtured with outdoor education (Braun & Dierkes, 2017a).

The security of the environment over future generations can only be safeguarded if a connection to nature is established in younger generations to ensure an emotional attachment and pro-environmental attitudes and behaviours are adopted into adulthood (Bilton, 2014a; Frantz & Mayer, 2014). In the current research, children who perceived a greater number of birds than actually present, had a higher level of nature connection. This is supportive of Fuller et al. (2007) who identified bird species diversity correlated with the emotional attachment to nature of people who used green spaces. Previous research has identified that strengthening a connection to nature through environmental education in children below the age of 11 results in a sustained connection, more so than older pupils (Liefländer et al., 2013). Therefore, the current research into the age of 8-12 years old is of importance as it presents findings that show those with a low level of nature connectivity can be improved upon to ensure that ecological values are adopted for a sustainable future (Barrera-Hernández et al., 2020).

Although a connection to nature can be established through watching nature documentaries (Florian et al., 2014), children are growing up prioritising virtual exotic species over local biodiversity as a result of the media (Ballouard et al., 2011). As there is an expansion of urban areas, fewer children have access to private green spaces (Hand et al., 2017) to engage with nature and spend much of their time indoors on technology (McCurdy et al., 2010). Therefore, studies presented in this thesis are essential to explore whether a connection to nature can be developed through biodiversity activities incorporated into the curriculum on school grounds, to encourage an emotional attachment to local biodiversity to ensure future conservation, while supporting wellbeing and mitigating teacher concerns of travelling outside of school for outdoor education (Marchant et al., 2019; Navarro et al., 2020).

7.3 Perception and knowledge

Children have a poor perception of biodiversity in their school grounds. This is in contrast to a study which reflects adults have a fairly accurate perception of biodiversity in their local environment (Fuller et al., 2007), and may be reflective of children's extinction of experience as less children spend time engaging with nature on a daily basis compared to the 1970's (Natural England, 2009b). Children's extinction of experience was demonstrated as they perceived higher levels of vertebrates and plants compared to invertebrates and had more negative perspectives and incorrect knowledge of invertebrates compared to vertebrates and plants. These findings also suggest biophobia of insects is common in children which has similarly been indicated by Cho & Lee (2018) when investigating honey bees due to children's mis-informed pre-conceptions of honey bees being 'scary' and 'kill people with stings'. Furthermore, despite best efforts through outdoor education, although children perceive higher levels of biodiversity (regardless of whether they are from state or private schools), they continue to favour large vertebrate organisms, such as mammals and birds and continue to underrepresent invertebrates. Early childhood factors may play a role in this, as children's books primarily feature birds and mammals (More, 1979). As children's perceptions are strongly reliant on memory (Susan, Clayton & Myers, 2011), these distorted childhood schemas of the local environment may be why children have an unrealistic perception of biodiversity. Therefore, it may be necessary to teach children through outdoor biodiversity education at an earlier age group than investigated in this research to prevent misconceptions forming between the ages of 4 and 8 years old, and reduce the extinction of experience (Patrick & Tunnicliffe, 2011).

Previous research in Tokyo by Soga et al. (2016) found that certain animal species generated various feelings of biophilia (love of nature; e.g. bird and butterfly) and biophobia (fear of nature; e.g. earwig and bee), which varied depending on the frequency they encountered them. The findings in the thesis were similar to Soga et al. (2016) as children had more negative attitudes and perspectives towards insects than the other taxa groups. Furthermore, as the research was carried out over an entire academic year, the results (Chapter 5) show an increase in neutral perceptions of the various taxa explored. This may demonstrate that nature engagement can reduce biophobia but may also reduce the new excitement of experiencing nature when carried out for a sustained period. However, it is interesting to note in the short term study with hands-on invertebrate activities (Chapter 6), the children from the Froebelian school who interact with nature throughout their daily curriculum also had a greater number of neutral perspectives compared to mainstream educated children. These findings suggest that, as children learn more about nature and engage with it more frequently, their perceptions become less extreme and they focus more on their factual knowledge. Despite this, greater knowledge and understanding can lead to more emotional attachment (Balmford et al., 2002; Bilton, 2014a).

In addition to the poor perception of local biodiversity, it was identified in my research that children have poor identification skills of British wildlife and have weak understanding of taxa and the different characteristics that make up the various classes. This supports previous research focussed on species identification which found that children have poor identification skills and have a better knowledge of cartoon characters and exotic species (Balmford et al., 2002; Huxham et al., 2006; White et al., 2018). Yet, knowledge is essential to be aware of local biodiversity to ensure conservation of local wildlife, as there is a danger species could disappear from people's awareness, which could lead to these organisms more likely to become threatened.

Although the outdoor engagement programme was found to positively impact children's mood, wellbeing, connection to nature and biodiversity perception regardless of whether the children attended state or private schools; there were some comparative findings identified between the schooling systems on children's knowledge and attitudes towards taxa. A variety of factors may have been involved in this, such as children's socio-economic and cultural background. Previous studies have identified a socio-economic inequality and academic gap between private and state educated children in England (Jenkins et al., 2008; Ndaji et al., 2016). Inequality in academic achievement can result firstly from fee paying schools utilising admission criteria based on academic ability. As private schools are fee-paying, these schools can also utilise resources in a different manner to state schools. Private schools often have designated science teachers who may be more effective at teaching specialist scientific topics on nature and present a more enthusiastic view of the natural environment. Additionally, due to this, private school teachers may promote extra learning on these topics due to their scientific interests in the field which may enhance their knowledge and attitudes in a positive manner more so than non-specialist primary teachers in state schools (Davies & Davies, 2014; Lindemann-Matthies, 2006). Furthermore, due to more competitive salaries as a result of school fees for private schools, there is the potential to hire more experienced and effective teachers which can influence children's attainment (Davies & Davies, 2014).

Similarly, the private schooling system have more resources available per pupil compared to the state schooling system. As a result, the class sizes are smaller, leading to more attention received per pupil (Davies & Davies, 2014; Jenkins et al., 2008). Moreover, state schools have a higher pupil premium (pupils that have access to free school meals). They, therefore, have a higher number of children living in food poverty (19% of British children live in households that cannot buy food essential for a healthy diet), and as a result attend schools hungry which has a direct impact on their learning and educational attainment (Wilkinson, 2019.)

English schooling systems have also been identified to have an uneven distribution of children from different cultural backgrounds (Jenkins et al., 2008). Feelings and attitudes towards the natural environment are influenced by socio-cultural perspectives and environment (Fox & Xu, 2017). Evidence has shown that science education which incorporates socio-cultural perspectives on scientific topics promotes children to have a positive attitude towards science (Jegede & Okebukola, 1991). As state schools have a more diverse cultural background with 32.1% of primary pupils from minority ethnic origins, it may be more difficult to incorporate the diverse socio-cultural perspectives (Davies & Davies, 2014; Department of Education, 2017; Jegede & Okebukola, 1991). Therrefore, as private schools are less diverse and have greater flexibility in resources for tecahing these may have impacted the children's knowledge and perspecitives identfied within the studies. Further studies should consider socio-economic and cultural backgrounds with regards to knowledge and attitudes as well as wheher this can influence the impact of wellbeing and nature connectivity.

7.4 Future of outdoor education

The current coronavirus (COVID-19) crisis has led to the need for schools across the UK to identify how to best leverage space by migrating their learning outdoors to mitigate the spread of the virus (Scottish Government, 2020). Outdoor education with hands-on learning can be a beneficial asset to teaching and learning while enhancing health. My research demonstrates that there are benefits to implementing outdoor education more widely across schools in a manner that does not merely reduce virus transmission. I have shown there are various wellbeing and knowledge attainment benefits that can be achieved through outdoor learning while instilling an appreciation of nature which is essential for a sustainable future.

As not all children have access to nature at home (Hand et al., 2017), an outdoor education programme incorporated into the curriculum throughout the academic year has the potential to benefit the children significantly as they spend the majority of the year at school. Currently, there is a gap in the British curriculum to encourage children to connect with the natural environment, through the reduction in natural history teaching and fieldwork (Tilling, 2018). Although changes are being discussed to tackle the reduction through a Natural History GCSE in schools (OCR, 2020), this may only engage children who are already interested in the natural world and is not targeted at the younger age group which has been identified to be more susceptible to develop a connection to nature over the long term (Liefländer et al., 2013). There is an opportunity to include outdoor learning and first-hand nature experience in the curriculum in earlier age groups (Harvey et al., 2020; Marchant et al., 2019). Introducing aspects of natural history to pupils in primary school years can connect more children to nature and develop their interest of the natural world to ensure a sustainable future. Children are becoming increasingly concerned at the state of the environment (Strife, 2012; Wollaston, 2020); therefore it is important they are appropriately informed to help them effectively engage in the debate and actively contribute to protecting the environment for their future wellbeing.The current research could help to influence policy to adopt an outdoor education experience in schools, thus supplementing the curriculum while supporting children's mood, wellbeing, resilience and connection to nature, similar to the *udeskole* in Danish schools (Bentsen et al., 2010) but carried out in school grounds. *Udeskole* is a weekly or bi-weekly 'outdoor school day' for 7-16-year olds for outdoor education in natural habitats through inductive learning which helps add value to normal classroom teaching, while supporting children's wellbeing. Additionally, putting more emphasis on implementing outdoor education through support for teachers will enable teachers to be appropriately trained in taking learning outside and supported through a cultural change as well as a policy change to apply outdoor learning in schools (Passy et al., 2019). In addition to policy, this research could help to encourage legislation to rewild more green spaces in urban areas, and prevent schools from selling off school grounds for urban development (Education & Skills Funding Agency, 2018).

7.5 Strengths, Contributions, Limitations & Future Research

There were a number of strengths in the research. Firstly, the study had a multipronged approach exploring various elements on the impact of nature on children and their view of the natural world, which provided converging results. Secondly, the use of mixed methods with qualitative and quantitative approaches allowed the various data gathered to strengthen the conclusions due to providing more detailed information on the children's benefit to interacting with nature and their relationship, knowledge and perception of various aspects of nature. Additionally, the research involved longitudinal studies with a large number of children over full academic years to explore the long-term benefits of nature education and to demonstrate that it can be incorporated into the weekly curriculum.

The research has also made valuable contributions to the field of primary science education in private and state school education. Firstly, these studies are some of the first research to investigate the attitudes of a large number of children, which demonstrates that children are able to share their view at a very young age and that their perception and attitude should be taken into consideration to improve the current trend of declining positive attitudes to science throughout their education (Childwise, 2019). Additionally, the perceptive difference between children's knowledge, thoughts and ideas shared through the interviews, drawings, quizzes and PMMs demonstrate the importance of using a variety of methods to measure these aspects. A variety of methods used is important to ensure that children with difference strengths can share their knowledge in manners that may be not be identified through a traditional style of assessment. A further contribution of this research is due to identifying ceiling effects in the popular nature connection surveys and may have identified a need for more appropriate methods to be developed to measure children's connection to nature. The CNI and the NR6 measures were both developed in 2013 and may be outdated in the current time to measure children's connectivity due to the increased awareness young people have about the importance of the natural world and the climate crises with rising young figures such as Greta Thunberg and the popularity of David Attenborough with younger generations.

There were several limitations to acknowledge from the research when considering the findings. The main limitations during the study were around recruitment of control groups and missing or inaccurate data. It was not possible to match the number of children in the control groups and the children participating in the outdoor engagement activities. This was primarily due to participating schools wanting the activities to be accessible to all children due to the schools liking the activities and appreciating the opportunity presented for outdoor education. Additionally, incomplete responses in the questionnaires reduced the sample size. This was difficult to avoid as children were given the freedom to choose to not answer any question to ensure they felt at ease and to prevent them from feeling any discomfort. As many children changed their choice of gender (male, female, or other) and ethnicity responses in their questionnaires before and after, these factors were not able to be included in much of the analysis which limited the understanding of the sample demographics and generalisability.

Another limitation is the area in which the research was conducted. As the participating schools were from regions in the South East of England, pupils eligible to receive free school meals (10.3%) are below the national average in England (14.1%) (Department of Education, 2017). Therefore, these areas would be considered to be less deprived, and thus the transferability of the results within the research may be limited and require additional research to include samples over geographically broader locations to be fully representative of England.

A further possible limitation was social bias that children and teachers may have felt when completing the questionnaires. Social desirability bias can occur when the participating individuals answer the questionnaire in a manner that is believed to be more socially acceptable and may have resulted in the higher than UK average connection to nature scores. However, I attempted to minimise social bias by assuring children the questionnaires were not a test and ensuring all questionnaires were completed anonymously.

During the research, longitudinal studies were carried out over a full academic year. However, as no studies were done after the intervention had ended, it would be beneficial to further the current research to investigate whether there is a legacy effect of interventions on children over a subsequent academic year at three, six and twelve months post-intervention.

It would also be interesting for future research to explore the impact of frequency and timespan of nature engagement on children's perceptions, through investigating the impact of less frequent interventions during the academic year as well as having more frequent measurements to explore when there is a change in children's perceptions and whether a process of habituation takes place (Tighe & Leaton, 2016; White & Heerwagen, 1998). This could give a better understanding as to whether children benefit more from short term interventions or sporadic activities over the long term. However, much of the previous literature focuses on short term studies and, to the best of my knowledge, my research are some of the first studies to explicitly explore children's perception and knowledge towards taxa before and after first-hand engagement with nature in their school grounds over the long term. In addition to more frequent measurements of children's perceptions through questionnaires, qualitative methods such as focus groups, throughout the academic year may help to identify when and how the children's perceptions change, and whether there is an impact on biophilia and biophobia.

A greater use of qualitative methods would also aid further research as it can help address challenges of questionnaires to answer the more complex questions through open-ended questions in interviews and focus groups with teachers and children. The use of focus groups and interviews would help explore the subsequent effect of the hands-on outdoor education activities on their school experience and family life in more detail than in the wellbeing questionnaires.

Moreover, it would be of interest to further assess children's knowledge and perspectives of taxa through contextual analysis of the detail of children's drawings before and after an intervention; for example, assessing the number of legs and antennae children draw when presenting how they perceive insects. The use of drawings were used to explore children's perception of local biodiversity in this research; however, for children who struggle to write in quizzes and PMMs, a visual representation of their knowledge change through a drawing may better demonstrate the impact of outdoor education.

An additional beneficial area of research could be teachers' knowledge and connection to nature and how they correlate with their children to see how much impact a teacher has on their class. This would provide evidence of how teachers could be supported to implement outdoor education while positively influencing children's connection and perception of nature.

As there was a ceiling effect with the nature connection questionnaires, the development of a more sensitive children's questionnaire to measure nature connectivity would be of use to investigate how nature connection may be more closely related to wellbeing and resilience in children. Finally, evaluation of current outdoor education programmes with fully matched control groups would be beneficial to further the research, as well as research into the ease of access of green areas in school grounds.

7.6 Concluding remarks

The research conducted in this thesis demonstrates the benefits children can experience from outdoor education, centred around practical nature engagement activities delivered in school grounds. It has been identified that children's mood wellbeing, resilience and nature connection can be enhanced, and is particularly beneficial to children with low wellbeing, resilience, and nature connectivity. Furthermore, it has been shown that hands-on outdoor education throughout the curriculum can improve children's educational experience whilst remaining in the school grounds and does not require time consuming and costly trips out with the school. It was also found that children have a poor knowledge and perception of British wildlife, although children's knowledge and awareness of local flora and fauna improves through outdoor education. Outdoor education curricula could be easily carried out across British schools by making use of the outdoor space that the schools have available to ensure children can be inspired to immerse themselves in nature and adopt a healthy lifestyle for themselves and the environment.

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Appendices

Appendix 1: Biodiversity Activities

Week	Theme	Activity
1	Trees & Other Plants/ Lichen & Fungi/ Insects & Other Invertebrates	Look at lichen, fungi, hedgerows, trees, and plants with phonescopes and investigate deadwood for lichen, fungi, invertebrates with lichen guides.
2	Trees & Other Plants/ Lichen & Fungi/ Mammals/ Birds	Tree surveys: identify species of trees, measure height, girth and estimate age, bark rubbings, draw around leaves, look for fruits, lichen, moss, nests, insects, and signs of leaf miners on trees.
3	Mammals/ Lichen & Fungi	Make hedgehog homes and looking for signs of animals using tablets to document findings. Place cultivated mushrooms to be picked and investigated for fly larvae as weeks go on and see how change over months. *Recurring cultivated mushroom check.*
4	Mammals/ Amphibians.	Camera traps and make mammal hair and footprint tunnel to explore native and invasive mammals. *Recurring camera traps and moving footprint tunnel.* Build sink ponds.
5	Insects & Other Invertebrates/ Lichen & Fungi	Review camera traps and investigate tree wet hole samples with phonescopes to explore different organisms. Different species of lichen collected and hung in sunlight to explore changes in colour.
6	Birds	Bird survey with binoculars to explore different species.
7	Birds	Build bird boxes and discuss importance and difference in species eggs and brood parasitism.
8	Birds/Mammals	Make coloured bird feeders with recycled plastic bottles and bird seed with food colouring to explore preference of different colours and build mammal feeder with camera trap.
9	Insects and Other Invertebrates	Investigating life in leaflitter, identifying what is found and using phonescopes to look at species details.
10	Amphibians/ Insects & Other Invertebrates	Water testing of pond water and how organisms move in water. Looking at water as a habitat with virtual pond quiz.
11	Birds	Build bird tables, put out different food and put out camera traps. *Recurring feeding.*

12	Trees & Other Plants	Tree surveys: catkins, buds and identify with tree guide and use phonescopes to look at structures in detail. Look at difference between native and invasive bluebells.
13	Trees & Other Plants/ Insects & Other Invertebrates	Planting lavender and daffodil bulbs in vertical gardens (pots attached to pikes that the children can decorate) and wildflower seeds were planted in appropriate areas and discussed importance for pollinators. *Recurring watering.*
14	Mammals/ Birds/ Amphibians	Owl pellet dissection to look at mammal skull structures within and discuss food chains. Make clay footprint trays to look at different structures of feet and use camera traps. Look at frogspawn.
15	Insects and Other Invertebrates	Looking closely at stag beetle larvae, lesser stag beetle larvae, rose chafer larvae, woodlice, moths, snails, and locusts. Search for invertebrates.
16	Amphibians/ Insects and Other Invertebrates	Look at tadpoles and frogs/ toads/ newts to discuss process of metamorphosis. Build wormery and talk about importance of soil.
17	Insects and Other Invertebrates/ Birds/ Trees and Other plants	Tree beating to investigate invertebrates. Make plasticine caterpillars and attach to oak tree to investigate predation rates from other invertebrates and birds. Checked predation marks two and six weeks later. Brought in garden tiger caterpillars and emperor hawk moth caterpillars for children to explore changes into moths as they hatch.
18	Insects and Other Invertebrates	Sweep nets and moth traps to investigate difference between day and night flying moths/ butterflies and other pollinators.
19	Amphibians/ Insects & Other Invertebrates	Pond dipping to explore frogs/ toads/ newts/ tadpoles and aquatic invertebrates and how they move in the water. Build pitfall traps to see what invertebrates fall into pit to discuss different between terrestrial and aquatic invertebrates and whether they are insects or not.
20	Birds	Build and fly paper birds with different wing structures to explore wing shape of difference species and bird calls with call and response from speakers.
21	Trees & Other Plants/ Lichen & Fungi/ Birds/ Insects & Other Invertebrates/ Mammals/ Amphibians	BioBlitz using tablets and apps to identify as much biodiversity in school grounds as possible and identify invasive and native species.

Appendix 2: Parent/ Guardian Opt-in Consent Form

Dear Parent/Guardian,

Your child is taking part in a research project being carried out by Royal Holloway, University of London, to investigate whether learning about nature and science in the outdoors could help to improve their wellbeing, mood, educational attainment, connection to nature, and whether background characteristics might influence this.

Emotional and social difficulties in children and young people are becoming increasingly more common. In this project we will visit your child every week, to work with your child, and their class/ group, in the school grounds/ local green urban area on projects designed to help them learn about the species and habitats in the grounds in a fun and interactive way. During each visit, we will measure how they feel about being outside and how much they enjoy it by answering a mood survey.

Additionally, the children will answer validated surveys on how connected they feel to nature, and how they feel about their physical health, mood, feelings, family, free time, friends and school. We will also conduct random interviews to see how the children feel the project has helped them and what knowledge they have gained. All data collected will be stored in a safe and secure location with an anonymous code with no way of tracing it back to your child.

This project has been approved by the University Research Committee. Your child's involvement in this study is important as it will help us to learn more about how schools can help to support emotional, psychological and physical development during the educational process.

If you have any questions or would like to discuss any aspect of the project, please feel free to contact us. The project is being carried out by Dr Deborah Harvey, Dr Dawn Watling and Louise Montgomery (PhD student).

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Thank you very much for your support in this project. Please note that to answer this consent form you should be the parent or primary carer (e.g. grandparent/legal guardian) of a child taking part in our outdoor learning study.

All your child's information will be kept completely anonymous, and your decision to give consent will not affect your child's education in any way. You are free to withdraw your or your child’s responses at any time during or after the project.

Please indicate (circle):

I confirm that I have read the information sheet about the study (YES/NO)

I understand that my child’s participation is voluntary and they are free to withdraw at any time. (YES/NO)

I understand that you will use your reasonable endeavours to preserve anonymity. (YES/NO)

I understand that this information will only be used by the researchers stated above and any collaborations they make for publication. (YES/NO)

I agree to my child taking part in surveys. (YES/NO)

I agree to my child giving a recorded interview. (YES/NO)

I agree my child’s words can be deposited in an archive. (YES/NO)

I agree to my child to take part in the research on the above conditions (YES/NO)

School: Name of participant:

Name of person giving consent:

Signed: Date:

Appendix 3: Participant Opt-in Consent Form

Dear Student,

We are conducting research into how learning about nature and science in the outdoors make young people feel. We would be extremely grateful for your participation in this research project. We will visit you several times this term to do some activities outdoors and ask you to complete some tasks and answer some questions. Your participation will help us to understand how being outside could affect children's wellbeing and learning.

For this research we will ask you to complete some questionnaires about your current mood, how you feel about nature, and how you feel about your life generally. You should **not** put your name anywhere on this study, as all your individual responses will be confidential, and we will not be discussing your responses with your parents or teachers. If you feel at any point that you do not want to answer a question, you may skip the question or questions. Also, if you feel at any point that you want to stop or to withdraw from our survey, you may do so at any time.

Please let us know if you have any questions.

If you are happy to participate, please complete the consent form on the next page. If you have any questions please let us know. You can also contact us after today if you have any questions or would like feedback on the results of the study when it is completed using the email addresses below.

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Thank you very much for your support in this project.

All your information will be kept completely anonymous and private, and your decision to give consent will not affect your education in any way. You are free to withdraw your responses at any time during or after the project.

Please circle whether you have:

Read the information sheet about this study?	(YES/NO)
Had the opportunity to ask questions?	(YES/NO)
Got satisfactory answers to your questions?	(YES/NO)
Understood that your participation is voluntary?	(YES/NO)
Understood that you are free to withdraw from the study at any time, without giving reason and without effecting your education?	(YES/NO)
I understand that you will use your reasonable efforts to keep my information private and anonymous.	(YES/NO)
I understand that this information will only be used by the researchers stated above and any collaborations they make for publication.	(YES/NO)
Do you agree to take part in the study?	(YES/NO)

School: Name of participant:

Signed: Date:

Appendix 4: Mood survey

Mood survey

We need you to have a special code that keeps you anonymous.

This is the **first letter of your first name**, the **first letter of your last name**, and the date of the **day of your birthday** in the month and **your class**.

For example, for a student called **Anna Brown born on the 1st of September in class 7A, the code would be AB017A.**

Please work out what your code is in the same way and write it in the box below.

Code:

____

Date:

____

Before or after session:

○ Before

○ After

School name:

Please think about how you feel **right now.**

Circle a number from 1-5 for each emotion, where 1 means that you do not feel like this at all and 5 means that you feel like this very much. Circle how much you feel:

Annoyed

 1	2	 3	4	 5

Bored

 1	2	 3	4	 5

Calm

 1	2	 3	4	 5

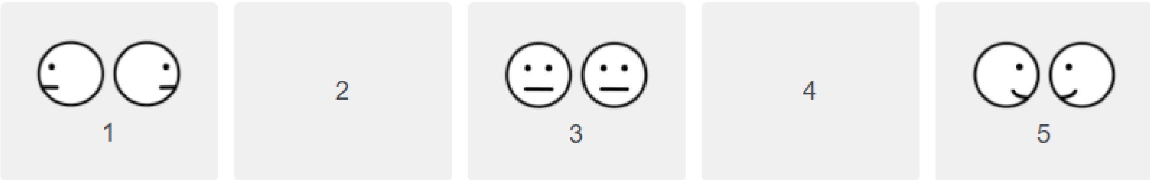
Cheerful

Cross

Excited

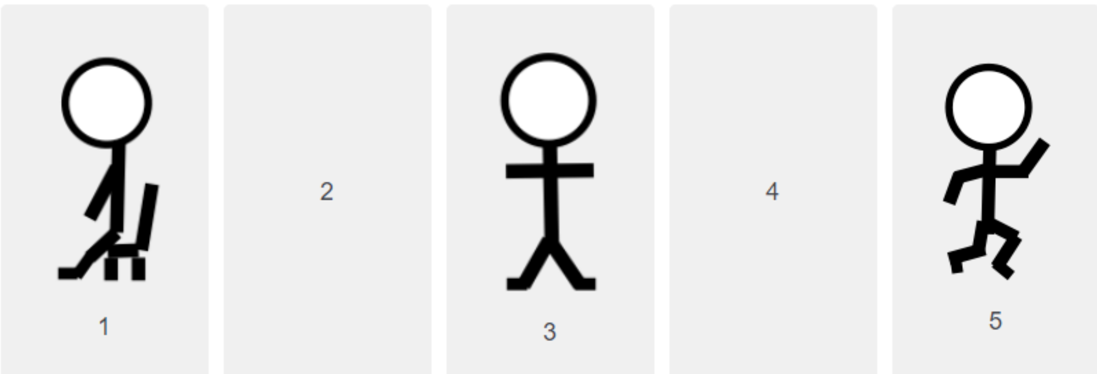
Fearful

Friendly



Happy

Active



Lonely

Pleased

Sad

Tired

Appendix 5: Demographics questionnaire

Please read every question carefully.
Choose the box that fits your answer best and select it.

Remember: This is not a test so there are no wrong answers.

You will have a personal code so nobody knows the answers you give are linked to you.

For your personal code please put your first initial of your first name, the first initial of your surname, the day of your birth and your class.

For example: Jane Smith born on 2nd April in class 5C will have the code JS025C

Code:

Todays date:

School:

How old are you?

Are you female or male?

Female	Male	Other
○	○	○

What do you feel you are?

White British	White Other	Black British	Black Other	Asian British	Asian Other	Other	Rather not say
○	○	○	○	○	○	○	○

Appendix 6: Kidscreen-27 questionnaire

1. Physical Activities & Health

In general, how would you say your health is?

poor	fair	good	very good	excellent	don't know
O	O	O	O	O	O

Thinking about the last week, have you felt fit and well?

not at all	slightly	moderately	very	extremely	don't know
O	O	O	O	O	O

Thinking about the last week, have you been physically active (e. g. running, climbing, biking)?

not at all	slightly	moderately	very	extremely	don't know
O	O	O	O	O	O

Thinking about the last week, have you been able to run well?

not at all	slightly	moderately	very	extremely	don't know
O	O	O	O	O	O

Thinking about the last week, have you felt full of energy?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

2. General Mood and Feelings about Yourself

Thinking about the last week, has your life been enjoyable?

not at all	slightly	moderately	very	extremely	don't know
○	○	○	○	○	○

Thinking about the last week, have you been in a good mood?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you had fun?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you felt sad?

always	very often	quite often	not often	never	don't know
○	○	○	○	○	○

Thinking about the last week, have you felt so bad that you didn't want to do anything?

always	very often	quite often	not often	never	don't know
○	○	○	○	○	○

Thinking about the last week, have you felt lonely?

always	very often	quite often	not often	never	don't know
○	○	○	○	○	○

Thinking about the last week, have you been happy with the way you are?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

3. Family and Free Time

Thinking about the last week, have you had enough time for yourself?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you been able to do the things that you want to do in your free time?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have your parent(s) had enough time for you?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have your parent(s) treated you fairly?

never	not ofen	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you been able to talk to your parent(s) when you wanted to?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you had enough money to do the same things as your friends?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

Thinking about the last week, have you had enough money for your expenses?

never	not often	quite often	very often	always	don't know
○	○	○	○	○	○

4. Friends

Thinking about the last week, have you spent time with your friends?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

Thinking about the last week, have you had fun with your friends?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

Thinking about the last week, have you and your friends helped each other?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

Thinking about the last week, have you been able to rely on your friends?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

5. School and Learning

Thinking about the last week, have you been happy at school?

not at all	slightly	moderately	very	extremely	don't know
O	O	O	O	O	O

Thinking about the last week, have you got on well at school?

not at all	slightly	moderately	very	extremely	don't know
O	O	O	O	O	O

Thinking about the last week, have you been able to pay attention?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

Thinking about the last week, have you got on well with your teachers?

never	not often	quite often	very often	always	don't know
O	O	O	O	O	O

Appendix 7: Resilience questionnaire

Please circle one answer for each question

	No	Sometimes	Yes
Do you have people you want to be like?	○	○	○
Is doing well in school important to you?	○	○	○
Do you feel your parent(s)/caregiver(s) know a lot about you (for example what makes you happy/ scared?)	○	○	○
Do you try to finish activities that you start?	○	○	○
When things don't go right can you fix it without hurting yourself or others (for example by hitting out or saying nasty things) ?	○	○	○
Do you know where to go to get help?	○	○	○
Do you feel you fit in with other children ?	○	○	○
Do you think your family cares about you when things are hard (for example, if you are ill or have done something wrong) ?	○	○	○
Do you think your friends care about you when things are hard?	○	○	○
Are you treated fairly ?	○	○	○
Do you have chances to show people you are growing up and can do things by yourself?	○	○	○
Do you like the way your family celebrates things (like holidays)?	○	○	○

Appendix 8: Good Childhood Index questionnaire

Please say how much you agree or disagree with each of the sentences.

PLEASE TICK ONE BOX

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
My life is going well	O	O	O	O	O	O

Please say how much you agree or disagree with each of the sentences.

PLEASE TICK ONE BOX

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
My life is just right	O	O	O	O	O	O

Please say how much you agree or disagree with each of the sentences.

PLEASE TICK ONE BOX

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
I have a good life	O	O	O	O	O	O

Please say how much you agree or disagree with each of the sentences.

PLEASE TICK ONE BOX

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
I have what I want in life	O	O	O	O	O	O

Please say how much you agree or disagree with each of the sentences.

PLEASE TICK ONE BOX

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
I wish I had a different kind of life	O	O	O	O	O	O

How happy are you with your life as a whole?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with your relationships with your family?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with how much choice you have in life?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with the things that you have (like money and the things you own)?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with your health?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with your relationships with your friends?

PLEASE TICK ONE BOX

Very unhappy — Not happy or unhappy — Very happy

0O 1O 2O 3O 4O 5O 6O 7O 8O 9O 10O

How happy are you with your appearance (the way that you look)?

PLEASE TICK ONE BOX

Very unhappy				Not happy or unhappy						Very happy
0 O	1 O	2 O	3 O	4 O	5 O	6 O	7 O	8 O	9 O	10 O

How happy are you with what may happen to you later in your life (in the future)?

PLEASE TICK ONE BOX

Very unhappy				Not happy or unhapppy						Very happy
0 O	1 O	2 O	3 O	4 O	5 O	6 O	7 O	8 O	9 O	10 O

How happy are you with the home that you live in?

PLEASE TICK ONE BOX

Very unhappy				Not happy or unhappy						Very happy
0 O	1 O	2 O	3 O	4 O	5 O	6 O	7 O	8 O	9 O	10 O

How happy are you with the school that you go to?

PLEASE TICK ONE BOX

Very unhappy				Not happy or unhappy						Very happy
0 O	1 O	2 O	3 O	4 O	5 O	6 O	7 O	8 O	9 O	10 O

How happy are you with the way that you use your time?

PLEASE TICK ONE BOX

Very unhappy				Not happy or unhappy						Very happy
0 O	1 O	2 O	3 O	4 O	5 O	6 O	7 O	8 O	9 O	10 O

Appendix 9: RSPB Connection to Nature Questionnaire

rspb giving nature a home

Connection to nature questionnaire for 8–12 year olds

Please tell us how much you agree or disagree with each of the following statements, by putting a tick in the relevant box.

Statements	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I like to hear different sounds in nature					
I like to see wild flowers in nature					
When I feel sad, I like to go outside and enjoy nature					
Being in the natural environment makes me feel peaceful					
I like to garden					
Collecting rocks and shells is fun					
I feel sad when wild animals are hurt					
I like to see wild animals living in a clean environment					
I enjoy touching animals and plants					
Taking care of animals is important to me					
Humans are part of the natural world					
People cannot live without plants and animals					
Being outdoors makes me happy					
My actions will make the natural world different					
Picking up trash on the ground can help the environment					
People do not have the right to change the natural environment					

For more information about children's connection to nature and using this questionnaire, visit **rspb.org.uk/connectionmeasure**

Please share your findings and experiences with us, either by e-mail: **connection.measure@rspb.org.uk** or on Twitter using the tag **#getoutdoors**

Appendix 10: Nature Relatedness Scale

Please circle the extent to which you agree with each statement, using the scale from 1 to 5 as shown below. Please respond as you really feel, rather than how you think "most people" feel.

1) My ideal vacation spot would be a remote, wilderness area.

1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

2) I always think about how my actions affect the environment.

1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

3) My connection to nature and the environment is a part of my spirituality.

1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

4) I take notice of wildlife wherever I am.

1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

5) My relationship to nature is an important part of who I am.

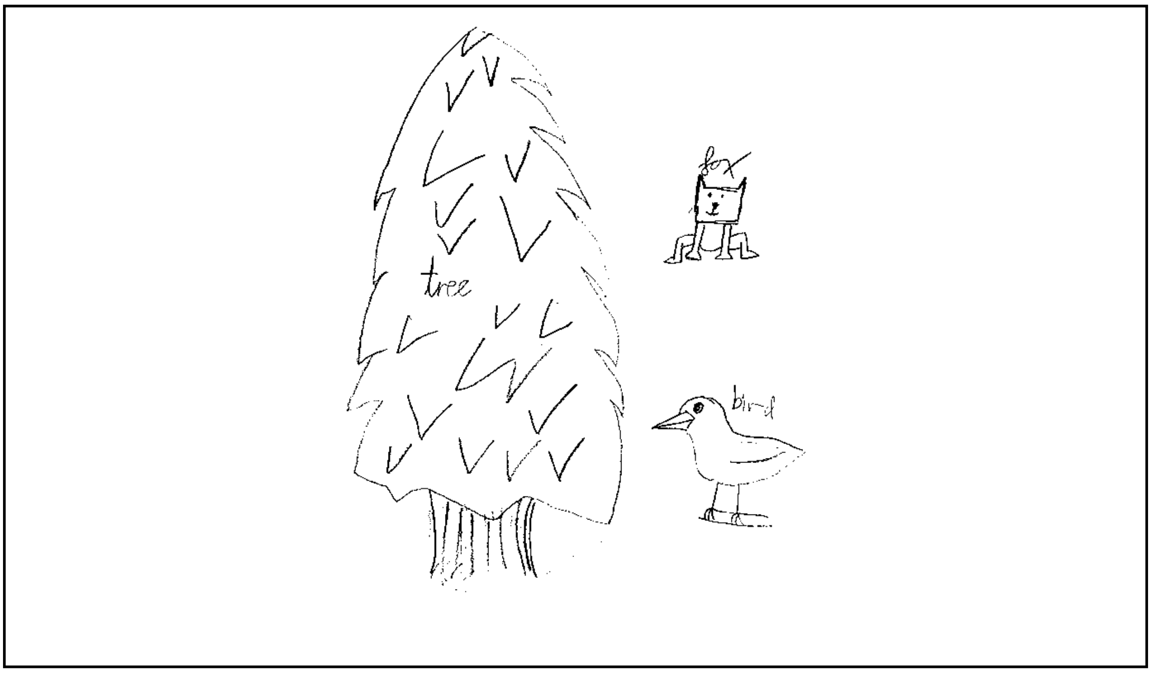
1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

6) I feel very connected to all living things and the earth.

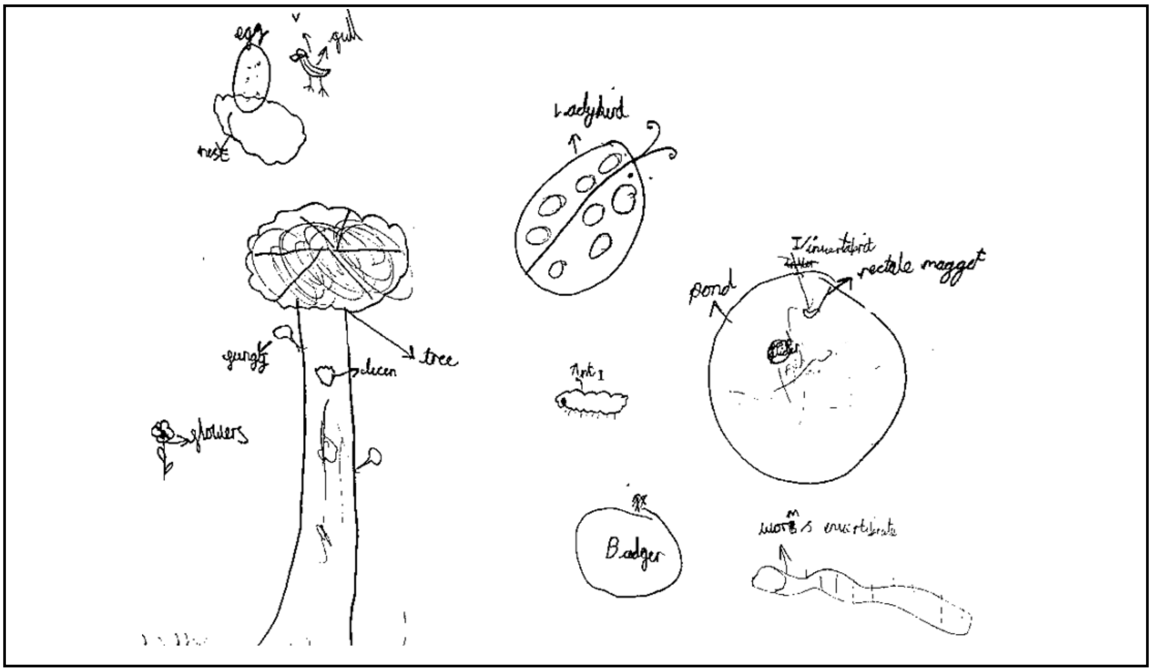
1 Disagree strongly	2 Disagree a little	3 Neither Agree or disagree	4 Agree a little	5 Agree strongly

Appendix 11: Example of children's biodiversity drawings

Before



After



Appendix 12: Children's post-intervention evaluation form

School name

____

Code (e.g. LM025C)

____

Tick either yes or no for how you feel about each question:

Do you feel more connected to nature than you did a year ago?

- o Yes
- o No

Do you think you have learnt a lot from the lessons outside?

- o Yes
- o No

Do you like nature more than you did a year ago?

- o Yes
- o No

Do you like insects more than you did a year ago?

- o Yes
- o No

Do you like birds more than you did a year ago?

- o Yes
- o No

Do you like mammals more than you did a year ago?

- o Yes
- o No

Do you enjoy science more than you did a year ago?

- o Yes
- o No

Do you notice nature more when you go outside?

- o Yes
- o No

Would you like to take part in this project again next year, if you had the choice?

- o Yes
- o No

What has been your favourite part of the project?

____

Appendix 13: Teachers post-intervention evaluation form

Do you feel more confident about teaching children about nature outside of the classroom?

- o Yes
- o No

Do you think your knowledge of the natural environment has improved?

- o Yes
- o No

Do you feel you have or will integrate some of the themes/ methods of teaching in your lessons or extra-curricular activities? Please tell us why

- o Yes ____
- o No ____

Do you feel you have developed a better connection to nature over the last year?

- o Yes
- o No

Do you feel the children's knowledge has benefited from participating in the project?

- o Yes
- o No

Do you feel the children's wellbeing has benefited from participating in the project?

- o Yes
- o No

Would you recommend the scheme to other teachers in your school/network?

- o Yes
- o No

Would you like to take part in this project again next year, if you had the choice?

- o Yes
- o No

What have you enjoyed most /least about the project?

____

____

Please add any other comments you have about the project:

____

____

Appendix 14: Teachers interview

Tell me about whether the project has had an impact on the children's mood and wellbeing, whether positive or negative?

How do you feel the project has impacted the children's education?

How do you feel the project has impacted the children's view or feelings about nature?

How has outdoor education impacted the children's learning experience?

Appendix 15: Children focus group questions

Introduction:

I would like to have a little chat today with you all to learn about what you think and feel about some things we have done outside. Over the last few months each week I have visited you here at school and we have gone outside to do activities together in the natural environment, mostly focussing on insects because it's been perfect weather for it over the summer months. And so, what I want to know, whether this has changed how you feel about things. There are no right or wrong answers, and everyone is welcome to share their thoughts and feelings.

Main questions:

Do you enjoy being outside and listening to nature more or less so now, compared to a couple of months ago and why?

Where do you prefer to learn, indoors or outdoors, and why?

How do you feel about nature and your relationship with it?

How do you feel about insects now compared to before I came to your school?

Probing questions:

Repeat answer to them as a question.

What does anyone else think/ feel?

Appendix 16: Supplementary thematic analysis of Chapter 6

Theme: Personal support

A key theme from the pupil and teacher views on outdoor educational activities was ‘personal benefit’. This theme comprised of three sub-themes including ‘buffer stress and anxiety’, ‘confidence boost’ and ‘first-hand experience’.

Subtheme: Buffer stress and anxiety

Teachers felt that outdoor education helped the children to tackle their stress and concerns. The outdoor activities appeared to help reduce performance anxiety in class through nature acting as a relaxant, as well as help those children that have special educational needs (SEN).

“I feel when outside and engaging with nature the children undoubtedly have their stresses and worries momentarily taken away. As there is little need to perform and learn for a test etcetera the children can simply take part and enjoy what they are doing.” (Private school teacher)

“In most circumstances, the outdoor activities reduce stress and anxiety. This has been particularly noticeable for SEN children.” (Froebelian teacher)

Teachers further highlighted the outdoor education as a form of escape to help their wellbeing as something that can break up their structured classroom time;

“they know the day isn’t going on forever, and they look forward to this, so it helps.” (State schoolteacher)

Additionally, mainstream pupils highlighted that looking at nature and being surrounded by nature allowed them to develop a coping mechanism to relax and calm down, which was something they weren’t aware of previously;

“I feel better when I look at nature because I never used to look at nature this much.”

“When you’re raging you can just go outside and look at nature.” (Mainstream school children)

Froebelian pupils shared that they like working outside as part of their school subjects because it helps them to relax while working due to listening to the sounds that surround them in nature;

"I like working outside because I like listening to all the sounds and it makes me feel really peaceful." (Froebelian pupil)

Subtheme: Confidence boost

Teachers believed the freedom of the outdoor education allowed the children to be more confident to express themselves among their peers and staff, which in turn may enhance their educational attainment and social network;

"Some of the children who don't usually speak up in lessons are noticeably more vocal when outside taking part in the activities, so I hope that in turn, this has allowed their confidence to grow." (Private school teacher)

Teachers also believed outdoor education activities provided the children with the opportunity to explore areas outside of their comfort zone and develop the confidence to realise they can achieve more than they initially thought they could;

"It helped her get out of her comfort zone and get out and do it herself." (State schoolteacher)

The Froebelian children commented that they had confronted their biophobia and had the confidence to engage with parts of nature that they previously were too intimidated by;

"I also have more courage to hold insects"

"*I really enjoyed it because before sometimes little animals can be more scary than bigger animals so when you actually hold them like the moths, they don't really hurt or anything and they're much more beautiful when you look at them up close than from the sky."* (Froebelian school pupils)

Subtheme: First-hand experience

Furthermore, teachers shared that the activities allowed the children to explore opportunities first-hand that they would not otherwise have the chance to do, which aids their education as well as their wellbeing;

"It gives them an opportunity to experience new things and also lots of things can become boring when you follow plans and because they're not doing that and not sitting inside, they're out and about and physically engaging and exploring what they are doing, as opposed to

looking at slides or listening and writing- so they're happier because of that." (State school teacher)

The Froebelian teacher commented their method of schooling puts a lot of emphasis on these first-hand experiences outside throughout their education to develop independent skills and is fully engrained within the Froebelian ethos;

"Discovery learning is very important for us as well. We put a lot of emphasis on the children developing independent learning and skills. […] For Froebel, seeing children out in the natural world was very important so that's why the forest school, the area, the meadow, the area where we've just been- these activities are very important." (Froebelian teacher)

Theme: Relationships

Another theme that emerged from the transcripts included 'relationships' with peers, the community and nature following outdoor education activities.

Subtheme: Empathy

The outdoor activities that the children participated in, allowed them to develop their relationships with their peers in the class through a less structured environment outside the classroom;

"led to them being more empathetic with their immediate peers." (Private school teacher)

Additionally, outdoor activities centred around hands-on experiences has allowed the children to develop empathy for nature as well as their peers through sharing these experiences;

"I think because they're actually seeing things for real, it helps their empathy. I know this is quite a well to do area and so a lot of kids do get a lot. But a lot of them also don't." (State school teacher)

Subtheme: Teamwork

Moreover, the hands-on activities each week have strengthened their ability to work effectively with their peers and develop a better rapport with their classmates to work together more effectively;

"When you do the activities, they get a little bit better working together so because they're doing activities together most weeks because they learn through doing and doing it a lot more than ordinary, they're getting better at it." (State school teacher)

The hands-on outdoor activities in a group allowed the children to expand their teamwork skills further than within the school curriculum.

"We are very focussed on collaboration at B but working together on the activities most certainly practices this skill." (Private school teacher)

Subtheme: Sense of community

As the children had been working collaboratively together each week, they developed a sense of community and passion for nature together which has allowed a sense of community to grow.

"I feel that the free flow way in which the activities take place has allowed the children to spend more time with each other in a more social way." (Private school teacher)

As the children experience new things together it enabled them to support each other to overcome reservations or difficulties they had which strengthened bonds between classmates.

"the big stag beetles she was freaking out but because of the others doing it, it helped her." (State school teacher)

Theme: Lesson support

In the mainstream method of schooling, the children had improved wellbeing through a change in school structure from sedentary classroom-based learning to empowering the child with first-hand experiences. This, in turn, helped develop their concentration and behaviour within the classroom as well as enhance their knowledge and enthusiasm for science by learning through these direct experiences.

Subtheme: Concentration

A mainstream school teacher feels outdoor time engaging with nature has enabled the children to have better behaviour and concentration when returning to the classroom setting.

"I feel that any time outside of the classroom engaged in the outdoors helps children to concentrate more when they are in the classroom. This is difficult to assess but simply movement as opposed to sitting on chairs constantly seems to help with concentration and behaviour." (Private school teacher)

The change of classroom structure also enabled the children to focus more in class, as they are aware, they had a change in setting with their outdoor education.

"They know they have something fun coming up, so they don't mind getting stuck in before or after." (State school teacher)

Froebelian children feel that working outside is more enjoyable and in turn, may aid their concentration as the classroom setting produces a build-up of noise due to the confined spaces which may otherwise distract them;

"I like working outside because if you're like writing or reading or something, you're still doing it, but you can hear as well" (Froebelian children)

Additionally, the Froebelian teacher felt the beneficial use of the outdoors to aid the children's education and concentration is apparent from past experiences of teaching in a conventional setting;

"I also find coming from a state background and coming to A, the concentration spans of the children here are far greater than my experience of this age group in other settings." (Froebelian teacher)

Subtheme: Learning by seeing and doing

The teachers feel the outdoor learning sessions have aided their science teaching as both the children and teachers are able to refer to the practical activities the children have done which the children continue to refer back to.

"has enhanced teaching as we can make links to some of the things we have studied outside. This has carried on with the children who took part in the project last year; they still make references to what we did last year when they were doing the biodiversity project." (Private school teacher)

Teachers also felt that being outside and physically touching and engaging with nature helped their education more than passively observing something on a screen or book.

"Being outside, touching animals, collecting things, whatever may be- making stuff- it gives them a direct link rather than just seeing a picture." (State teacher)

The Froebelian method of teaching puts a lot of energy into the children learning through actively exploring in fun and engaging ways;

"We have a lot of emphasis on the children physically playing and exploring." (Froebelian teacher)

Children also felt that actively seeing and exploring habitats and organisms outside allowed them to learn about the natural environment in a manner that helped them retain the information.

"I think we should do it outside because then we're actually learning about it in nature, so we can learn it better while we see it." (Froebelian pupil)

Children also found this method of learning by seeing and doing was more enjoyable than how they learn in the classroom by passively being told what to do and copy down in their jotters.

"It's more fun, rather than like someone telling you what to do and you write down." (Mainstream school pupil)

Subtheme: Enthusiasm for learning

The teachers have noted an increase in enthusiasm for their lessons as part of the weekly outdoor activities and the enthusiasm that is carried over into their regular lessons.

"The children always seem very keen to take part in the activities each week. They are excited to go outside and if the weather isn't good there is always disappointment! It is difficult for me to comment on their mood in general as I only teach them for Science for 3 hours a week. The smiles I do see in Science lessons most certainly indicate an engagement and enthusiasm for the subject." (Private school teacher)

Teachers have also commented that because most of the time the teachers are following formal lesson plans, they sometimes lack engaging methods of learning, so these hands-on informal outdoor activities help to bring the children's enthusiasm back, as well as inspire the teachers for future lessons.

"Actually, seeing the different things that can be done and the different ways of actually engaging the children and actually that it isn't that difficult to do the fun, interesting, engaging stuff outside." (State school teacher)

Pupils also commented that they found the hands-on outdoor education method of learning more enjoyable compared to their classroom-based lessons, helping them to enjoy their education more, and in turn, their educational attainment.

"Although it's still work, I found it better!" (Mainstream school pupil)

As outdoor learning is instilled throughout the Froebelian ethos, Froebelian pupils had greater enthusiasm for learning about nature and science;

"I like learning about nature because I find it really interesting." (Froebelian pupil)

The Froebelian methodology of teaching additionally allowed the children to have great enthusiasm for some subjects taught outside while appreciating the need for some lessons to also be taught inside for the benefit of their learning;

"I prefer maths inside for some reason. And literacy outside and reading outside. […] science outside!" (Froebelian pupil)

Theme: Nature awareness

The final theme identified within the transcripts was nature awareness in relation to the children's oneness with nature, the children's wider concern for the natural environment and how their development in knowledge further enhanced their interest to learn and do more to help the natural environment.

Subtheme: Oneness with nature

Teachers believed the outdoor activities have changed the way the children perceive nature and the organisms within the natural environment;

"It's changed the way, I think, how they see nature." (State school teacher)

Further to this, the children's comments convey their connection to the natural environment flourished and their perceptions towards nature and themselves have changed;

"We are animals as well."

"I never knew nature was so interesting" (Mainstream school pupils)

Additionally, some of the Froebelian children that perceived themselves as less connected to nature previously felt their connection to nature had improved following the hands-on insect activities which empowered them to feel more connected and explore nature in their free time;

"I usually don't spend time outside, because I usually play upstairs in my room. And being outside and learning about insects is a way for me to get outside, and so now when I go outside, I look and identify things in my garden." (Froebelian pupil)

As the Froebelian ethos strives to have a strong connection throughout the children's education, outdoor activities solely focussed around the environment to develop the bond the children have with nature are carried out as weekly lessons, in addition to other lessons taught through outdoor learning;

"I mean a lot of people say, we do forest school, which could mean, once for three sessions a term you take them out and do forest school activities. Whereas at A, where we have uh…a weekly event and sort of lots of other times daily like we've just done now, out in the environment. Uh…we are aiming for a deeper connection with the natural environment…um…and also...um the integration of the curriculum as well." (Froebelian teacher)

Subtheme: Enhanced knowledge- enhanced interest

Children voiced that as their knowledge has grown in relation to the natural environment, so has their interest in nature and in turn, they are aware of more when they go outside and physically seek nature out to explore it;

"Now I know more about it like I'm seeing more things!" (Mainstream school pupil)

Froebelian children shared that as their knowledge became greater from the outdoor activities, they found the topic more interesting and so became more enthusiastic about the lessons as well as enhancing their interest.

"I find it more interesting because when you look at them from far away, they just look like little insects but when you look at them close up, they're actually really cool." (Froebelian pupil)

Subtheme: Wider nature concern

The private school teacher commented that the children come back to school and speak of their own experiences and what they have done in their own homes or local areas to help wildlife or what they have seen once they had been participating in outdoor activities;

"Children have spoken about what they have seen in their own gardens." (Private school teacher)

The Froebelian children had great awareness and concern for nature and the impacts that humans can have on the environment through engaging with nature frequently throughout their curriculum;

"I think we should keep wildlife alive because some kinds of animals could go extinct." (Froebelian pupil)

Additionally, the pupils within the mainstream schools have developed an understanding of the devastating impacts it can have on people if humankind does not care for the environment;

"We should stop cutting down the trees that we need for building space because otherwise if we cut down all the trees, we won't survive…we are part of nature." (Mainstream school pupil)

Appendix 17: Surveying methods to estimate abundance and diversity of each investigated category

Category	Survey description
Trees & Other Plants	5 x 50 m transect across school grounds to look at all vascular and non-vascular plants present along fenced areas, planters and bedded areas (Buckland et al., 2007).
Lichens & Fungi	4 (N, S, E, W facing) x 20cm x 20cm quadrats on 20 trees to estimate the percentage cover of common fungi and lichen species at each tree. Additionally, interrupted 50 cm x 50 cm quadrats were used along 5 x 20 m transect to estimate fungi count across ground level areas (Buckland et al., 2007; OPAL Air Centre, 2005).
Mammals	Counts of molehills, burrows, faeces, fur and tracks across 5 x 20 m transects along and across school grounds and camera traps left over a week to identify the presence of mammals in four different areas (Wearn & Glover-Kapfer, 2019).
Birds	Stationary point count in four separate sites in the school grounds facing N, S, E, W over 15 minute periods (Lynch, 1995).
Insects & Other Invertebrates	5 x 20 m transects, with 20 cm x 20 cm quadrats every 5m. Leaf litter was collected in 45cm x 30cm bags per m^2 of leaf litter, equating to roughly 20 bags per school to identify invertebrate species. Additionally, deadwood (over 20 cm in diameter) was turned over and broken open when possible to identify and count invertebrates over a 5 x 20 m transect (Southwood & Henderson, 2000). Dip-net sweeps were additionally carried out to identify water invertebrates within leaf litter, as described above (Semlitsch et al., 2015).
Amphibians	10 x dip-net sweeps with 30 x 20 cm dip-nets across approximately 1.5m in length (Semlitsch et al., 2015).