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

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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 and DW carried out the analysis, ACG, DW, DJH, HH and LM edited the manuscript.

**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 lower 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

**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, p.6). The 2019 State of Nature Report (Hayhow et al., 2019, p.6) 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, Wood, Barton, & Pretty, 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. We chose the Nature Connection Index (Chen-Hsuan Cheng & Monroe, 2012) to measure connectivity, since it had been validated for children in our target age group and reported by Bragg et al., (2013) as being easy to complete, as judged by the children and teachers in their study sample, and statistically reliable.

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 and 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, Belton, Raymond, & Giusti, 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.

**2. Methods**

*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 1.

*Table 1.* Demographic characteristics of the final sample.

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

*2.2 Procedure*

*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.

*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 (α = 0.88; comparable to that of the original validation of the full scale α = 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 (see Supplementary Materials). 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.

*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 2.2. All analyses were carried out in R 3.5.2 (R Core Team, 2018). We carried out Wilcoxon signed rank tests on the baseline scores of each measure to investigate whether there were any systematic effects of privately versus state-funded school type on their scores. None of these three tests of school type were significantly different (all *p* > .30), confirming that the results were not contaminated by better facilities or higher average student socio-economic status at privately-funded schools. We therefore do not consider this any further. We also compared the change scores of intervention and control groups within schools where applicable. None of these tests reached significance; however, this is likely because none of these tests are adequately powered according to our power analyses (reported above), and the mean scores indicated numerical trends in the same direction as we observed in the full analyses reported below (in *Results*). We therefore do not believe that this is a cause for concern about the reliability or validity of our results across all schools. For all Wilcoxon tests we calculated effect size *r* based on the calculation Z/sqrt(N). For ANOVAs we report generalised eta squared. For all means we report 95% confidence intervals.

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 connectivity and wellbeing), using paired Wilcoxon signed rank tests (due to non-normality of data; Shapiro-Wilk tests p < 0.05). For the intervention group only, we carried out a within-subject ANOVA (2 timepoints before/after session x 21 sessions) to investigate whether the effect of participation in the nature sessions on mood changed over the 21 weeks of the project. 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. Results**

*3.1 Wellbeing*

Overall, the children’s average wellbeing score was 108.47 (95% CIs 106.65, 110.28); which is in the normal range for children of this age (8-11; KIDSCREEN Group Europe, 2006). Complete data sets for those taking part in the biodiversity program included 274 children, for the control group included 42 children. There was no significant difference in wellbeing scores for children in the program and control groups at baseline (before starting the sessions); *Z* = -0.51, *p* = .61, *r =* 0.03 (mean difference *M* = 1.70, CIs = -5.74, 2.34). Children in the program group increased their scores significantly more than those in the control group; *Z* = -2.86, *p* = .004, *r* = -0.16 (mean difference *M* = 6.87, CIs = 1.01, 12.74). At the end of the program, children who had taken part in the sessions had significantly higher wellbeing than those in the control group; Z = -2.96, *p* =.003, *r* = 0.17 (mean difference *M* = 5.17, CIs = -0.95, 11.29).



*Figure 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 95% confidence intervals here and in all following.

*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; *Z* = 6.43, *p* < .001, *r* = 0.34 (mean improvement *M* = 0.09, CIs = 0.05, 0.13). The average mood score before and after the sessions can be seen in Figure 2 (before *M* = 4.38, CIs = 4.33, 4.43; after *M* = 4.47, CIs = 4.42, 4.52).



*Figure 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 95% confidence intervals.

To investigate whether the different activities carried out each week had any impact on the beneficial effect that the program had on children’s mood, and to assess if the effect on mood was stable across the duration of the program, a two-way within-subjects ANOVA was carried out between session number (21 levels) and survey time-point (2 levels; before or after the session). The results showed that there was an improvement in mood (*F*(1, 2809) = 72.49, *p* < 0.001, ηG2 = 0.01) between the two timepoints, but this was not affected by the session number (no interaction, *p* = 0.39); although overall mood did fluctuate slightly over the weeks; F(20, 2809) = 2.58, *p* = 0.001, ηG2 = 0.02).

*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* = 4.35, CIs = 4.29, 4.41; control group *M* = 3.99, CIs = 3.82, 4.15). 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 (*Z* = -0.26, *p* = 0.79, *r* = -0.02; mean change *M* = -0.01, CIs = -0.08, 0.05) or the control children (*Z* = -1.16, *p* = 0.25, *r* = -0.18; mean change *M* = 0.09, CIs = -0.06, 0.26).

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 lower 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 (*Z* = 2.95, *p* < 0.01, *r* = 0.37; mean change *M* = 0.24, CIs = 0.06, 0.42; see Figure 3); whereas this was not the case for the children with the higher initial connectivity (*Z* = 0.44, *p* = 0.66, *r* =0.06; mean change *M* = -0.05, CIs = -0.11, 0.02; see Figure 3).



*Figure 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 95% confidence intervals.

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 (higher or lower 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 (see Table 2). This was due to there being a relationship between these two variables for those with lower initial connectivity (interaction term *t* = 2.42, *p =* 0.02; *rho* = 0.23 for lower connectivity group and *rho* = 0.002 for higher connectivity group).

*Table 2.* Regression model predicting change in wellbeing scores.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Est. | SE | t | p | CIs |
| Intercept | -2.61 | 21.67 | -0.12 | 0.90 | -45.38, 40.15 |
| Connectivity index | 1.37 | 4.78 | 0.29 | 0.78 | -8.07, 10.81 |
| Connectivity subgroup (low) | -74.70 | 34.18 | -2.19 | 0.03 | -142.15, -7.25 |
| Interaction | 20.42 | 8.43 | 2.42 | 0.02 | 3.77, 37.06 |

**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 lower. 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).

*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 of 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.

*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.

*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 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. 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.

**5. 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 programme, 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 different 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.

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. 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).

**6. 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.

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