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Knowledge of Nature and the Nature of Knowledge: Student natural history knowledge and the significance of birds

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Abstract

1. We studied the natural history knowledge (NHK) of students (18–19 years), considering the salience of nature expressed through the knowledge of names of organisms, routes for knowledge transmission and acquisition and the potential of specific taxa to represent a student's overall knowledge.
2. We report a 2-year study of the NHK of 149 UK-resident first-year biology students surveyed by means of a free-listing exercise, facilitating the assessment of salience, prior to participation in a residential field course run by the University of Oxford.
3. Each year, students anonymously completed a questionnaire asking them to name any five species in each of five taxonomic groups (birds, trees, mammals, butterflies and wildflowers) found wild in the British Isles, also stating if those named were native or introduced. Metadata were collected on the students' background and sources of knowledge (e.g. family, teachers, etc.).
4. Of the five taxonomic groups, birds were the best known by the students, while butterflies were the most poorly known group. However, although asked for names at species level, while 94% of students could name five British bird taxa, only 55.7% named them at species level, many giving folk generics such as 'duck' or 'seagull' instead. For butterflies, only 12.8% of students correctly named five British species, and 47% named none.
5. Family influences, self-motivation and knowledge of birds, rather than formal education, best predicted students' overall NHK. While urban/rural residency had a small effect on NHK, it strongly influenced the relative importance of other factors.
6. Factor analysis showed that NHK was best represented by knowledge of birds. Furthermore, the bird species named predicted students' total NHK as well as the students' knowledge of birds. Asked to name their favourite bird, students with family influence were significantly more likely to name native species.
7. We describe the complex interplay between context, family and formal education in developing nature salience; roles which we define as nature 'advocacy'. In the urban context, the advocacy of family and teachers was essential to engage young

people with nature, while this was not so in a rural context. We briefly consider the implications of our study for natural history education going forward.

KEYWORDS

birds, education, field studies, folk knowledge, indigenous knowledge, natural history, Traditional Ecological Knowledge, young people

1 | INTRODUCTION

It has become a common perception of environmental educators that young people lack the knowledge and experience of nature that they had at a similar age. The generality of this perception might be characterised by the finding that even in a biodiversity hotspot, school children are more familiar with exotic flagship species than with their local fauna (Genovart et al., 2013). Emotive phrases such as the 'extinction of experience' (EoE) express the growing concern that this perception raises among conservation practitioners (Leather & Quicke, 2010; Miller, 2005; Soga & Gaston, 2016). Since the publication of Richard Louv's seminal work *Last Child in the Woods* in 2006, evidence has continued to grow on the decline in natural history knowledge (NHK) and 'nature connectedness' among young people (Hughes et al., 2018; Soga & Gaston, 2016). While Louv drew public attention to this, and its causes and possible consequences, largely from North American evidence, it was already a concern to Conservation Biologists in the United Kingdom. In a much-cited letter to the journal *Science* in 2002, Balmford demonstrated that primary school children (age 4–11) had a significantly better knowledge of (i.e. ability to identify) Pokémon 'creatures' than of even the most common and charismatic species of native wildlife. Balmford concludes with the warning *'conservationists need to re-establish children's links with nature if they are to win over the hearts and minds of the next generation'*. Bebbington (2005) demonstrated the poor general ability of A-level students (16–18 years) in the United Kingdom to identify even the most common British plants, and echoed the concerns of the conservation community *'In teaching students to be responsible citizens and to care about their environment, a knowledge of at least the common organisms around them is vital'*. In light of the environmental movements spearheaded by young people such as Greta Thunberg in recent years (Figueres & Rivett-Carnac, 2020), we might question this assertion despite evidence in its support (Meeusen, 2014). Nevertheless, a justifiable concern remains that intergenerational loss of contact with nature from direct experience implied by many of these studies is likely to remove a significant source of motivation for environmental advocacy (Hughes et al., 2018; Waite et al., 2021).

Concerns surrounding EoE—affecting all ages—continue to be shared in many countries (e.g. Bashan et al., 2021), although the prevalence of EoE as a global phenomenon has been questioned (Novotný et al., 2020; Oh et al., 2020). Furthermore, the value of using contact with, or knowledge of, nature as surrogates or prerequisites for 'nature connectedness' and pro-environmental behaviour continues to be much debated (Colléony et al., 2020; Passmore et al., 2021; Richardson et al., 2020). Planetary health is not the only concern. The link between EoE with public health and wellbeing is a rapidly growing research field, which is highlighting the complex relationship between nature contact, nature connectedness and their associations with health, wellbeing and pro-environmental behaviours (e.g. Martin et al., 2020).

The findings from post-industrial societies may appear to contrast with ethnobiological research among indigenous communities whose children often demonstrate considerable knowledge of plants and animals around them (Hunn, 2002; Shen et al., 2012; Spoon, 2014). While perhaps exceptional, the botanical knowledge of Zapotec children in Mexico provides the starkest contrast since, by the age of 8, many can reliably identify hundreds of wild plants and recall associated culinary and medicinal knowledge (Hunn, 2002). Hunn (2002) noted that even 40 years ago this contrasted dramatically with the deficient botanical knowledge of undergraduates at Berkeley, California, whose knowledge was largely generic rather than specific (Dougherty, 1979). Nevertheless, the intergenerational decline in natural history knowledge is not limited to post-industrial societies. Numerous researchers working with indigenous communities have documented the decline and loss of local and traditional ecological knowledge, including natural history knowledge, reflected in a lost ability to name plants and animals (Batibo, 2001; McCarter et al., 2007; Nabhan, 1998; Pam et al., 2018; Spoon, 2014; Tang & Gavin, 2016; Wolff et al., 1999; Wyndham, 2010; Zent, 2001). However, the loss of knowledge should be regarded more broadly as a loss of salience of nature (Hunn, 1999). As expressed by both the Sherpa of Nepal, and the Western Shoshone and Southern Paiute peoples of the SW USA, Spoon (2014) noted a common concern: *'The elders lamented that younger generations did not care about this information'*.

There can be little doubt that the general knowledge of nature held by the wider population has declined in the United Kingdom. Abundant evidence supports the understanding that the British public had a passion for natural history in the 18th and 19th centuries (Allen, 1976), although the salience of specific taxa segregated on gender lines, with female attention focused botanically, while birds and other animals tended to be more salient to males (Jackson-Houlston, 2006). A study of English folknames of birds in use largely during the 19th century indicates not only a rich knowledge of nature among the country folk of the British Isles, but also that the salience of nature was not confined to the middle classes (Gosler, 2017, 2019). We have come, therefore, to understand the intergenerational decline in local and traditional ecological knowledge as a global phenomenon, framed within the conservation literature as the shifting baseline syndrome, in which each generation's perception of nature differs because of changing access to it, and experience of it (Pauly, 1995).

The loss of NHK has diverse causes. In his studies with Shoshone and Paiute people, Spoon (2014) states *'The elders also felt that the younger generations were faced with many distractions that they themselves had not had at younger ages'*. Research among indigenous communities has established a strong link between the loss of traditional and local ecological knowledge (TEK/LEK), which includes NHK, and the introduction and conduct of formal education (Shen et al., 2012). Since formal education is often conducted in a national language other than the local language in which the names of plants and animals are known, this can result in a sense that local knowledge and language is of less value than global knowledges taught in a curriculum in a national or foreign language (e.g. English, Spanish or Chinese: Park et al., 2020; Sillitoe, 2006).

The link between NHK, local experience and language, and their importance in curbing the decline in biodiversity are well established (e.g. Bonta, 2010; Park et al., 2020; Wilder et al., 2016), and their loss are recognised as victims of globalisation. When characterising the loss of knowledge in post-industrial societies as the 'extinction of experience', Soga and Gaston (2016) summarised the causes in terms of the loss of opportunity and the loss of orientation. They related these trends, in particular, to increasing effects of urbanisation. However, the relationship with urbanisation is not a simple one. Urban areas are rarely homogeneous, often offering contrasting opportunities for experiencing nature over short distances. For example, availability of tree cover, parks and private gardens in towns and cities has been associated with increased frequency of visits to private and public green spaces (Oh et al., 2021; Shanahan et al., 2017). Social surveys continue to show that recreational visits to green spaces and natural areas in towns and cities remain highly popular, accounting for nearly half of all outdoor visits in England, although age, social status, ethnic background and levels of deprivation all influence the frequency of such visits (Hunt et al., 2016; Passmore et al., 2021). It is also likely that the purposes of those visits have shifted in recent decades with less time being spent by families on specifically natural history or nature-related activities. For example, only 2% of visitors, including families, taking part in recent visits to natural areas (including urban parks) in England reported 'wildlife watching' as one of the purposes for their visit (Natural England, 2015). Additional contributory trends to a general decline in NHK could include the growth in 'ecophobia' (Strife, 2012), the increasing influence of the internet and social media (Jacobson et al., 2019) as some of the 'distractions' alluded to by the elders reported by Spoon (2014), and the decline in opportunities for direct contact with nature in schools, particularly at upper secondary level (Tilling, 2018).

From these diverse studies we identify four key areas where data remain scarce, especially in post-industrial societies: (a) knowledge loss across generations; (b) modes of knowledge transmission; (c) the importance of context for knowledge acquisition; and (d) the relative importance of specific taxa, either as a focus for knowledge acquisition, or as representative of a person's knowledge or interest in nature (i.e. nature's salience). This paper reports on a 2-year study of the NHK of British (UK-resident) biology students preparing for a residential ecology field course. The study contributes to our understanding of points b–d, and provides a baseline for comparative studies related to point 'a'. In respect of points b and c we investigate both the extent of students' knowledge and the sources of their knowledge, evaluating the relative contributions of family, of schoolteachers and of context (rural or urban) to their knowledge, as well as the complex interplay between these influences. In respect of point d, we undertake a formal analysis to determine whether knowledge of specific taxonomic groups might be used to summarise, characterise or represent a student's overall NHK.

As with any knowledge domain, an individual's NHK might be defined in several ways, depending for example on the focus of investigation. These might include the ability to name and/or identify organisms (e.g. using pictures, objects etc. as Bashan et al., 2021) or demonstrate specific kinds of knowledge about organisms, their status or ecology. The means of assessment will naturally follow from the way in which the specific domain is defined. Given previous research we were interested not only in what students knew, but also in the salience that natural history in general, and certain taxa in particular, might have for the students. This is because while the salience that a domain has for an individual will be related to their level of specific interest in the subject, it is not identical to it. For example, although nature will be salient to an individual with a specific interest in it (e.g. birds and birdwatching), individuals may still be aware of and enjoy birdsong without knowing the names of the birds they are listening to. Hoping also for quantifiable data, we therefore chose a free-listing approach used by ethnobiologists to assess the salience of taxa (e.g. Anderson et al., 2011; Newing et al., 2011). This powerful method, which asks respondents to choose from their own knowledge of taxa and to list them, has two substantial advantages. First, it does not prejudice assessments by imposing the researcher's own prior preference biases (although identification-based methods are often necessary, such as when working with young children e.g. Balmford, 2002). Second, it allows some qualitative as well as quantitative analysis of the taxa recalled. We therefore defined NHK for present purposes as the ability to name taxa at a specific taxonomic level, but freely chosen from the students' own knowledge of five major taxonomic groups (see Section 2), while also testing whether they knew the status of each chosen taxon as native or introduced.

It might be asked whether studies of biology undergraduates are representative of the wider society from which they are drawn. Recognising the biases inherent in any social survey (Hammersley & Gomm, 1997), which can suggest that no sample is ever representative, we justify our approach as follows. An undergraduate student year group represents a coherent and definable set of people who can be followed through time, whose cohorts can be compared over time, and whose chosen domain of study (biology, and especially behavioural, ecological and evolutionary biology), in which they have demonstrable ability, includes a significant element of natural history. Our study therefore offers an important baseline for future research (sensu Pauly, 1995). As for whether such a cohort demonstrates a level of NHK representative of the wider population that would require further sampling.

In a commentary on the perceived declining engagement of young people with natural history, Barkham (see Moss, 2014) quoted the esteemed biologist, the late Emeritus Prof. Brian Moss of Liverpool University, who wrote "*Deep down, there's just as much interest in natural history as there ever was, and a lot of evolutionary ecology and animal behaviour studies depend on it, but it has to be dressed up in theory to make it into the prized journals. It's probably true that students' knowledge of the basic biology of living organisms is now deficient. I get asked questions like 'What exactly is a lichen?' and 'What is basic insect structure?' But all this is anecdotal. I would need to design an objective survey with lots of sophisticated statistics to be sure!*" In tribute to Professor Moss and honouring both his contribution to, and concern for, the future of natural history, our study helps to fill that evidence gap.

2 | METHODS

The study is based on an anonymous questionnaire survey designed to assess the NHK (as defined above) of biology undergraduates in the United Kingdom, immediately prior to a residential ecology field course. The work was undertaken with approval from the Central University Research Committee (CUREC) of the University of Oxford (Ref: SSD/CUREC1A/13-084). Students consented through their participation to research use of the data, although this was not required by our CUREC approval since the data were fully anonymised (student identity was unknown during analysis and cannot be discerned from this report). The questionnaire employed a free-listing approach in which students were asked to name five species of their choice within each of five taxonomic groups (details below). The decision to ask for five names reflects the need to devise a test that could be undertaken within 10 min, that assessed knowledge across a range of taxa, that was readily analysed, and which examined salience of taxa without being overly burdensome to the students. Field testing with natural history special interest groups (including church groups and a local RSPB members' group), not reported here, also indicated that the choice of five gave a good measure of knowledge and salience. Further justification of the survey method was given above.

The ecology field course, which formed part of the B.A. degree in Biological Sciences at the University of Oxford U.K., took place in May of the students' first year of study at the Orielton Field Studies Centre, Pembrokeshire (see: https://www.field-studies-council.org/ and https://www.field-studies-council.org/locations/orielton/). Students remained anonymous in this survey. While this denied us the possibility of following up our analyses with an ethnographic interview-based approach (e.g. Spoon, 2014; Tang & Gavin, 2016), it was considered important in this initial study to emphasise to the students that this exercise played no part in their formal academic assessment. To maximise the coherence of the sampled population in terms of childhood experience we focused on British, that is, UK-resident, students. British students are here defined as those who, by their own assessment, had spent more than half their childhood in the United Kingdom. In 96% of cases, these students were also born in the United Kingdom. No UK-born students spent less than half of their childhood in the United Kingdom. The sample therefore includes some non-UK nationals. We thus assessed the knowledge of 149 (2013: n = 97; 2014: n = 52) first-year students prior to the field courses in their years.

2.1 | Questionnaire presentation

Students were asked to complete the questionnaire immediately after a short lecture about the field course given in Oxford before they left for Orielton. Although a lecture theatre may not be the ideal context for the recall of NHK (Smith & Vela, 2001), it was important to standardise the context for assessment and not wait until we reached Orielton to make this prior assessment (Bogner, 1998). The introductory lecture included no taxonomic or biological information other than the habitats or 'themes' of the 5 days that they would study on the field course, but focused on logistical details such as travel and accommodation. Immediately before filling in the questionnaire, the students were instructed on what was required of them and advised that it was not a formal test, but for analytical reasons they were required to fill it in under exam conditions with no conferring. To test the possible influence of mind frame in aiding memory recall (Christianson, 2014), in 2014, approximately half the students received their questionnaires with an additional sheet stapled to the front. This carried a single question: What is your favourite bird? Questionnaires with or without this sheet were roughly alternated (due to logistical details related to seating) across the cohort of students so that every student's neighbour had a different form of questionnaire. Through a comparison of scores for students with or without this additional question, we aimed to test whether invoking an emotional connection to nature might affect the scores of students.

2.2 | The NHK questionnaire

The questionnaire itself consisted of two sides of a single A4 sheet (see Appendix 1). The first side asked students for no personal information, but to record the date and where they received the questionnaire (for our purposes of comparison with tests of other cohorts), and then to give the names, as specifically as possible (e.g. 'house sparrow' is more specific than 'sparrow', 'red fox' than 'fox') of any five British birds, any five British trees, any five British butterflies, any five British mammals and any five British wildflowers other than trees. The concepts of 'wild' and 'British' were defined as clearly as possible (see Appendix 1). In addition, students were invited to tick a box stating whether they thought the named taxon was native to the British Isles, introduced by humans or they did not know. These terms also were defined. The assessment of names was treated liberally; hence if a student provided a scientific name rather than a standard English name (especially butterflies) it was accepted if correct, as were common folk names (e.g. *conker tree* for horse chestnut) of organisms. Both these situations occurred in a few cases. In monotypic cases in which the standard name for a species is commonly known by a single name (e.g. robin for European robin *Erithacus rubecula*, heron for grey heron *Ardea cinerea*, swallow for barn swallow *Hirundo rustica*) the single name was accepted as specific for the purpose of assessment. We ignored misspellings of names where it was clear what the student intended (e.g. cole tit instead of coal tit *Periparus ater*). Substantially incorrect names (e.g. *penguin*, even listed under birds) received no marks, as did a blank entry or incorrect classification with respect to the native status of taxa. Finally, with regard to introductions, while many introduced species are well-established in the British Isles, for example, sycamore *Acer Pseudoplatanus* and little owl (*Athene noctua*) these were treated strictly as introduced taxa for purposes of this survey. The second side of the questionnaire obtained anonymous data about the individual, including age, gender, nationality, rural or urban background, education and sources of NHK etc. (see Appendix 1). These constituted the metadata for analysis.

2.3 | Questionnaire assessment

Names were assessed and marked as follows. A non-specific, but otherwise correct, name in the correct taxonomic group, for example, 'duck' or 'oak' under birds or trees respectively, was awarded a name score (*N*) of 2 marks. A correct specific name, for example, 'tufted duck' or 'pedunculate (or English) oak' under birds or trees respectively (upper or lower case were ignored), was awarded a name score of 3 marks. A further mark was awarded for a correct classification of the taxon as native or introduced, while we allowed flexibility in the awarding of a single mark for a name if, for example, if it was partially correct. For example, we awarded 1 mark for Monarch Butterfly (*Danaus plexippus*), which is a very rare non-breeding vagrant to the British Isles (a few occurring most years) from North America, but which has erroneously been presented by the BBC (British Broadcasting Corporation: BBC *Springwatch Butterfly Special* (2013): https://www.bbc.co.uk/programmes/b037k5vp) as a British species (many students named Monarch as a British Butterfly). Marking for a few more complex cases is explained in Appendix 2. In this way, we awarded up to 4 marks for each of the 25 names and so calculated four statistics: (a) the number of substantially correct taxa named in each taxonomic group (out of 5); (b) the number of substantially correct taxa named across all taxa (out of 25); (c) the total score for names in each taxonomic group (out of 20) and (d) the total score for all names (out of 100).

2.4 | Data analysis

The four datasets (a–d) described above constituted the dependent variables for data analysis, either examining correlations among the dependent variables themselves or used in combination with the metadata 'influence' variables listed on the back of the questionnaire (Appendix 1) as predictors. Based on our review of the literature, we have been especially interested to assess the relative importance of family versus formal education, and urban versus rural. From the full list of possible influences listed (Appendix 1 and see Section 3), a stepwise inclusion procedure (alpha to enter 0.05) based on the Akaike information criterion (Table S3) selected the following predictors for particular investigation: Self-taught, parents or grandparents (entered as a covariate of 0 = neither parents nor grandparents, 1 = either parental or grandparental influence and 2 = both parental and grandparental influence), urban or rural, teacher in a formal capacity as principal source of knowledge, gender and family friend. Student age was excluded as all were 18–19 years of age.

In combination with metadata, following a stepwise inclusion procedure (alpha to enter 0.5) based on the Akaike information criterion, the combined data across taxa (datasets b and d—score totals and name totals) were included as predictors in generalised linear models (GLMs with logit link function) to determine which were the strongest positive determinants of overall scores and the numbers of taxa named. Principal component factor analysis (PCFA) derives a series of new 'factors' based on the variation and covariation between a group of correlated variables. Examining correlations among taxon data (datasets a and c), and assuming that knowledge data for each taxonomic group reflected an underlying factor which represents the overall variation in NHK, PCFA was carried out to determine which, if any, of the five taxon groups best reflected total NHK (represented by the first principal factor). All statistical analyses were undertaken using MINITAB Release 19, means are given ± 1 *SD* unless otherwise stated and minor reductions in sample size for some analyses have resulted from a few students not responding to questions (e.g. three students did not answer the urban/rural question).

Following the results of the PCFA (above), to examine further the 'quality' of the knowledge exhibited by the students two more analyses were undertaken. A value was placed on the names of birds (found in PCFA to be the best predictor taxon) offered by the students based on their relative salience. The principle followed is that correct taxa named by many students are of lower value than those named by few or a single student (i.e. name value is proportional to its rarity). To calculate this, we first assessed the salience of a taxon as the number of students naming the same taxon. Name value (*V*) was then calculated as name score (*N* described above, see Appendix 2 for further detail) divided by salience (S). For analysis the mean name value of names offered by each student was then calculated. A full list of the bird names offered by students is presented in Appendix 2. This shows a few anomalies (e.g. kite and red kite are the same species, as are great spotted woodpecker and greater spotted woodpecker). However, we decided to treat these as distinct values in order to reflect the students' original responses, while also noting that their name values are similar and have a trivial effect on the students' mean name values used for analysis. In 2014 the bird taxa named as favourite species could easily be divided into either native species or non-native taxa (including 'penguin', 'kakapo' and 'ostrich', see Appendix 3). NHK scores for students in these two groups were compared using ANOVA, as were the name values of the bird taxa named (other than their favourites) to assess its potential as a crude measure of a student's nature connectedness (the argument being that a native favourite bird more likely suggests first-hand experience of the bird).

3 | RESULTS

Descriptive statistics for 149 UK students questioned in 2013 (n = 97) and 2014 (n = 52) show substantial differences in knowledge of the five taxonomic groups (Table 1). Note that we found no significant year effect in any analyses involving the 2013 and 2014 cohorts and so the pre-course assessment data have been pooled across these 2 years. With a mean of 4.85, most students (n = 141, 94.6%) could provide five names for British birds. However, Table 1 (see also Tables S1 and S2) shows that only 83 (55.7%) students could provide five correct (as leniently defined in Section 2) names at species level. The situation differed greatly across taxonomic groups, with only 19 (12.8%) students able to provide five correct butterfly names (Table 1; Table S2). Intermediate figures were obtained for the other taxa, in order: mammals (81, 54.4%), flowers (37, 24.8%) and trees (36, 24.2%).

3.1 | Urban versus rural context

Overall, whether students lived in the town or country made a significant difference to their total NHK ($F_{1,145}$ = 7.97, p = 0.005). The mean score for urban students was 60.01 ± 18.34 SD, n = 106, but for rural students was 69.39 ± 17.34 SD, n = 41. However, the stepwise analysis (Table S3) indicated that several influences on student knowledge differed between urban and rural contexts in their significance.

3.2 | Sources of knowledge

Students reported a range of influences or sources of NHK, several of which made little difference to their overall scores. Nevertheless, most students reported a principal source. Table 2 lists the sources for students reporting a principal source of knowledge. Self-teaching (motivation) was overwhelmingly reported as the principal source, after which parents, formal education and grandparents were listed as significant sources. When self-teaching was the principal source of knowledge, students scored no more highly in their total NHK than others either in urban ($F_{1,104}$ = 0.95, p = 0.333) or rural contexts ($F_{1,39}$ = 0.22, p = 0.645). However, while the same was true of all rural students who reported self-teaching as a source, that is, non-principal source ($F_{1,39}$ = 0.21, p = 0.651), for urban students self-teaching added significantly to their knowledge ($F_{1,104}$ = 10.05, p = 0.002, mean score without: 50.96 ± 15.95 SD, n = 28; with: 63.26 ± 18.14 SD, n = 78).

As expected, a student's total score was highly predicted by the number of taxa that they named (r_{147} = 0.844, p < 0.001). However, scores for taxonomic groups differed in their ability to predict the total scores (Figure 1; Table S4). Figure 1 shows the relationship between a student's total score and individual taxon scores, and total number of named taxa and individual totals for birds, trees, butterflies, mammals and wildflowers. Also indicated on these graphs is whether the student named one or more parents and/or grandparents as influences.

3.3 | The influence of family

Overall, parents and/or grandparents were highly significant positive influences on student total NHK scores ($F_{1,147}$ = 13.29, p < 0.001, Figure 2). However, the significance of the parental and/or grandparental influence differed markedly between the urban context, where it was strong ($F_{1,104}$ = 10.99, p = 0.001), and the rural context, where it was not significantly detectable ($F_{1,39}$ = 1.06, p = 0.309).

TABLE 1 Summary statistics (see also Tables S1 and S2) for NHK for 2013 and 14 years combined showing correlations between total NHK score and taxon scores, between number of taxa named, mean number of taxa named etc

2013/14 combined N = 149 United Kingdom only	Corr. (r) total score versus taxon score	Corr. (r) total taxa versus N taxa named per taxon group	Mean and SD N taxa named	Number and % of students correctly naming none	Mean ± SD N correctly named to species	Number and % of students correctly naming five species
Birds	0.872	0.736	4.85 ± 0.742	2 1.3%	4.22 ± 1.136	83 55.7%
Trees	0.872	0.688	4.69 ± 0.847	11 7.4%	2.91 ± 1.623	36 24.2%
Butterflies	0.804	0.687	2.53 ± 1.814	70 47.0%	1.52 ± 1.826	19 12.8%
Mammals	0.815	0.689	4.75 ± 0.861	4 2.7%	3.98 ± 1.397	81 54.4%
Flowers	0.798	0.779	4.42 ± 1.321	9 6.0%	3.15 ± 1.499	37 24.8%

TABLE 2 Principal influences when named by students defining their background as urban and rural in 2013/14, ranked in order of frequency

	N urban	% urban	*N* rural	% rural
Self	30	34.48	10	31.25
Mother	18	20.69	10	31.25
Father	10	11.49	8	25.00
Teacher formal	16	18.39	1	3.13
Teacher informal	5	5.75		
Grandfather	2	2.30	1	3.13
Grandmother	1	1.15		
Brother	1	1.15		
Friend	1	1.15		
Godmother	1	1.15		
NR volunteer	1	1.15		
TV	1	1.15	1	3.13
Book			1	3.13
Total	87		32	
Not reporting	20		6	

The role of a family friend, when listed was found to be a highly significant contributor to a student's NHK for both urban and rural contexts (F_{147} = 12.06, p = 0.001), overall contributing nearly 20% to NHK (mean score$_{without}$ = 61.31 ± 17.89, n = 137; mean score$_{with}$ = 79.92 ± 16.56, n = 12). However, the likelihood of a family friend being listed was disproportionately distributed among families in which parents, or both parents and grandparents, were also listed as sources ($\chi^2_{df=2}$ = 9.53, p = 0.009, Table S5) so the overall influence includes a general family effect (Table S3). We found no association between family influences and the likelihood of a student reporting that they were self-taught, either if considering each student cohort or separately for urban or rural students.

3.4 | The influence of schoolteachers

The complexity of the influence of formal education needs similarly to be considered. Two important questions were asked in respect of the role of teachers: were they significant contributors to NHK either in a formal (i.e. as part of a curriculum) or informal (e.g. running Natural History Clubs in school) capacity; and the same question if teachers were the principal source of knowledge. We found no significant contribution of teachers, either in a formal ($F_{1,147}$ = 1.99, p = 0.16) or informal ($F_{1,147}$ = 0.18, p = 0.67) capacity towards the total NHK score of students. Indeed, in the former case, students who listed formal education as a source of knowledge did slightly worse than those who did not (with teacher mean score: 60.89 ± 17.9 *SD*, n = 82, without teacher 65.16 ± 18.9 *SD*, n = 67). This result was unchanged if considering students from urban versus rural situations or when parents or grandparents were added to the models. However, a strikingly different result was found for those students who stated that teachers in formal education were their principal source of knowledge. Of 41 students identifying as rural, only two (4.9%) stated teachers were their principal source of knowledge, whereas 14 of 106 (13.2%) urban students gave formal education as a principal source. While we found no effect in the rural context, urban students giving formal teaching as a principal source had significantly poorer scores (mean score 47.43 ± 16.07 *SD* vs. 61.92 ± 17.98 *SD*, $F_{1,104}$ = 8.10, p = 0.005, Figure 3). Furthermore, we noted a significant interaction between the tendency to list formal education as a principal knowledge source and whether parents and/or grandparents were listed as sources of knowledge ($\chi^2_{df=2}$ = 10.171, p = 0.006, Table 3), indicating that formal education becomes the principal source if the family influences are weak. Hence separating the urban students' dataset according to whether or not students reported formal education as the principal source of knowledge is illuminating. For students who did not report education as a principal source of NHK, both parents and/or grandparents ($F_{1,89}$ = 13.28, p < 0.001) and self-teaching ($F_{1,89}$ = 14.56, p < 0.001) are strong predictors of total NHK. However, for students who name formal education as the principal source of NHK, neither was a significant predictor (parents and/or grandparents: $F_{1,11}$ = 1.33, p = 0.274; self-taught: $F_{1,11}$ = 3.08, p = 0.107).

3.5 | The influence of gender

Finally, while student gender was listed as a significant predictor of total NHK in the stepwise model, this was a weak effect. Table 4 shows mean NHK scores for male and female students separately for urban and rural contexts. Although in every case male students had a slightly higher score than female (see Table 4), the absolute value differences were small and only (weakly) statistically significant for urban students in respect of birds, butterflies and the total NHK scores. No differences were statistically significant for rural students. Among urban students, we found no significant interaction effects of gender in respect of self-teaching, parents and/or grandparents or whether formal education was cited as a principal source of NHK. Our results are therefore neither consistent nor conclusive in respect of gender differences, and more likely reflect contexts of learning rather than inherent differences between genders (see Section 4).

3.6 | The significance of birds

The factor analyses determining the relative potential of each taxonomic group to represent overall NHK indicated a significant role for birds. The first principal factor for taxon scores (0–20) captured 70.1% of the variance, with the greatest loading contribution coming from the bird score (Loadings in rank order for scores: Birds 0.902; Trees 0.892; Mammals 0.842; Flowers 0.802; Butterflies 0.737). Similarly, while the first principal factor based on number of taxa

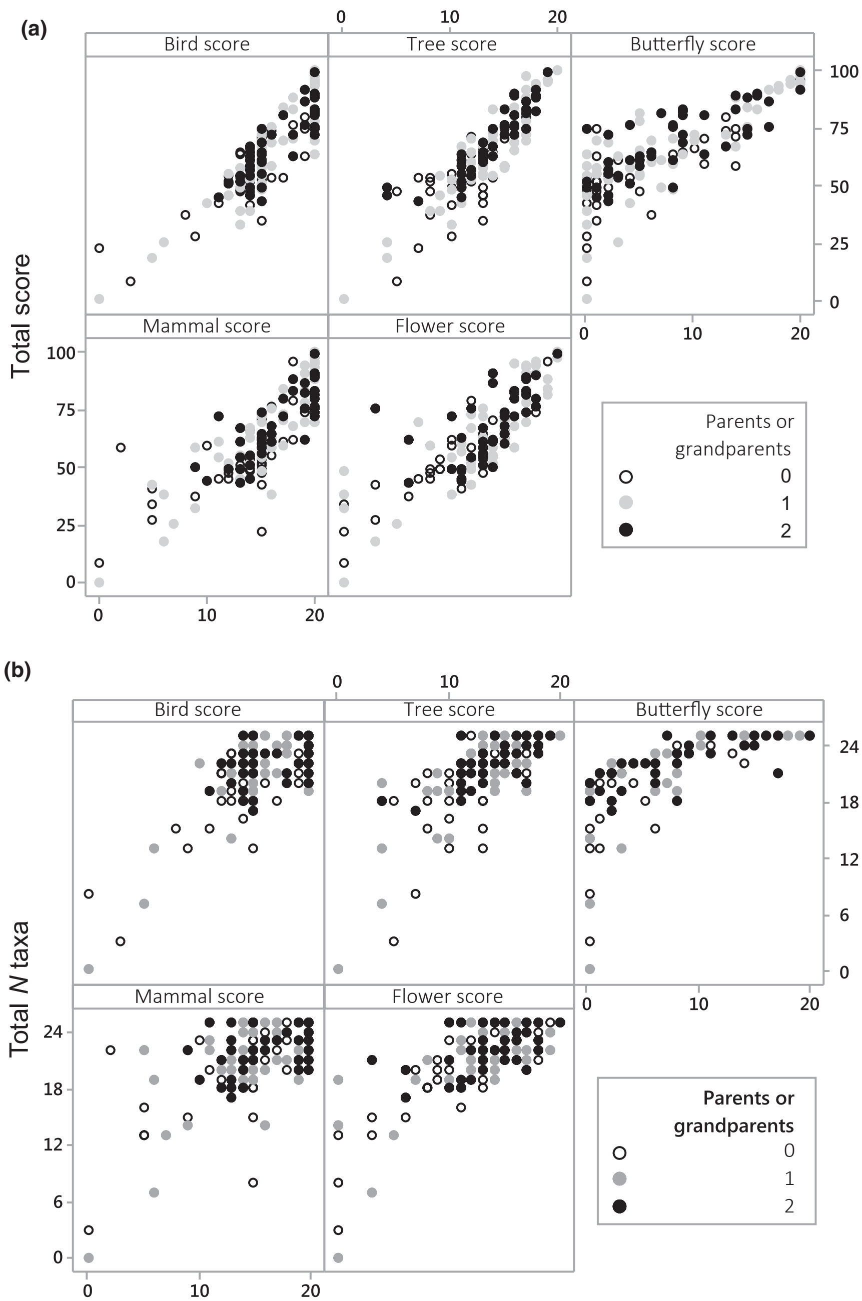

FIGURE 1 The contribution of taxon-specific knowledge scores (a) and number of taxa named (b) to overall NHK and taxa named in 2013 and 2014 questionnaires. Colour coding of the markers indicates whether students listed parents and or grandparents as influences on their NHK learning. Students listing neither scored 0, those listing both scored 2

(0–5) named captured 55.2% of overall variance, the greatest relative contribution again came from birds (Loadings in rank order for *N* Taxa: Birds 0.855; Mammals 0.787; Trees 0.781; Flowers 0.780; Butterflies 0.435). Although the differences in knowledge of taxonomic groups other than butterflies are small, on the basis of these analyses we argue that a knowledge of birds is broadly representative of overall NHK, at least as here defined with respect to the salience of nature to students. This is supported by the results that now follow. The full results of the PCFA showing the relative loadings of individual taxon scores and number of taxa named in each taxonomic group on their first principal factors are given in Table S6.

Of 123 bird taxa named by students in the 2 years of study 95 are specifics representing 94 distinct biological species, 19 are generics, six familial (e.g. duck), two non-UK taxa and one domesticated (chicken). The full list is presented in Appendix 2 together with their relative salience, name score and name value. In a GLM with bird name value as dependent, and urban/rural, parents and/or grandparents, and self-taught as predictors, the only significant predictor was whether the student declared as self-taught or not ($F_{1,143} = 10.18$, $p = 0.002$) although the whole model explained only 7.7% of the variance.

The relationship between total NHK scores and total number of taxa named (minus the bird data respectively to avoid autocorrelation) and the name value of birds named by students is shown in Figure 4. Both relationships are well-represented by an exponential regression (scores: $F_{1,147} = 56.7$, $p < 0.001$, and *N* taxa: $F_{1,147} = 85.2$, $p < 0.001$), indicating that a quantitative measure of NHK is related to a qualitative measure of bird knowledge. The bird knowledge

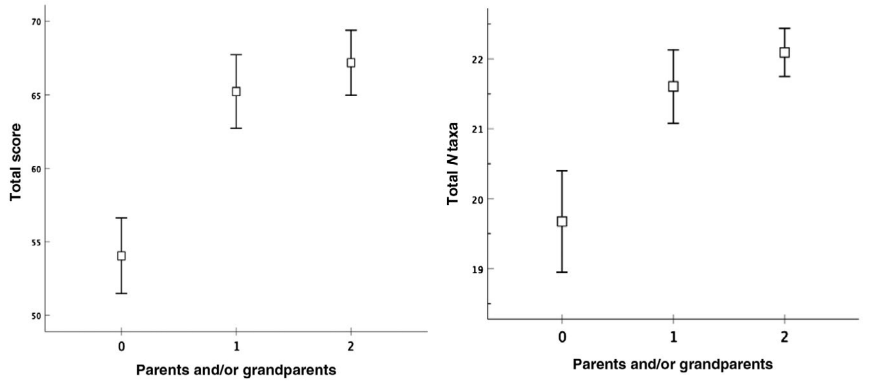

FIGURE 2 The contribution of parents and/or grandparents to the NHK scores (left) and number of named taxa (right) of UK students in 2013/14. Familial influence is scored as 0 neither, 1 parent(s) or grandparent(s) listed, 2 both parent(s) and grandparent(s) listed. Means are shown ±1 *SE*. Due to the additive effects shown here the variable 'parents and/or grandparents' was entered in analyses as a covariate

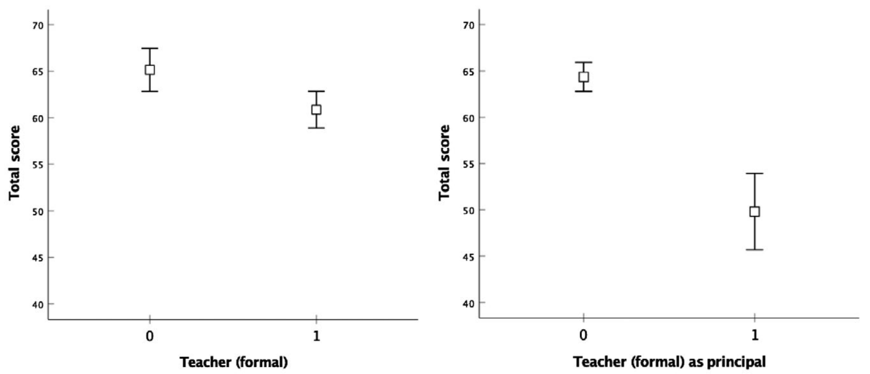

FIGURE 3 The influence on UK students' total NHK of Teacher (formal) reported as a knowledge source (left) and reported as a principal source (right). Negative responses were scored as 0, positive as 1. Means are shown ±1 *SE*

TABLE 3 Numbers and % of urban students reporting familial influences on their natural history knowledge, and whether formal education was a principal source of natural history knowledge. Formal education is chiefly seen to be a principal source when the family influences are weak or absent, but note that in these cases a student's knowledge is poorer than that encouraged by familial influences (see text on the influence of school teachers)

Family influence noted			Formal education not principal	Formal education as principal	All
Neither parents nor grandparents	0	Count	20	9	29
		%	68.97	31.03	100.00
		Expected	21.74	60.00	27.10
Parents or grandparents	1	Count	45	5	50
		%	90.00	10.00	100.00
		Expected	48.91	33.33	46.73
Parents and grandparents	2	Count	27	1	28
		%	96.43	3.57	100.00
		Expected	29.35	6.67	26.17
All		Count	92	15	107
		%	85.98	14.02	100.00
		Expected	100.00	100.00	100.00

score (BK) is similarly well-predicted by the exponential curve BK = 17.5273 * bird name value$^{0.093}$ ($F_{1,147} = 100.1$, $p < 0.001$).

The bird name value of birds named by students who named five birds was significantly greater (mean = 0.42 ± 0.68) than those naming fewer than five (0.069 ± 0.15, $F_{1,743} = 13.06$, $p < 0.001$). However, while in both groups of students the salience of names given was highest for the first bird named and declined through the task (regression of salience on order: $F_{1,716} = 8.94$, $p = 0.003$), Figure 5 shows that salience started higher for the less knowledgeable students (difference between groups $F_{1,716} = 4.82$, $p = 0.029$) and also declined more steeply with name order (interaction $F_{1,716} = 3.83$, $p = 0.051$).

Thirty-one alternately selected students were asked in 2014 to name their favourite bird before starting the main questionnaire. No significant difference in either total NHK score or bird name value was found between students asked to name their favourite bird, and

Urban	Female students	Male students	Test
Bird score	14.32 ± 3.82 $n = 63$	16.53 ± 2.59 $n = 42$	$F_{1,103} = 3.87$, $p = 0.052$
Tree score	12.10 ± 3.58 $n = 63$	13.29 ± 3.78 $n = 42$	$F_{1,103} = 2.66$, $p = 0.106$
Butterfly score	4.81 ± 4.96 $n = 63$	7.69 ± 7.73 $n = 42$	$F_{1,103} = 5.41$, $p = 0.022$
Mammal score	14.19 ± 3.96 $n = 63$	14.74 ± 4.48 $n = 42$	$F_{1,103} = 0.43$, $p = 0.512$
Flower score	11.79 ± 4.77 $n = 63$	13.09 ± 4.13 $n = 42$	$F_{1,103} = 2.08$, $p = 0.152$
Total score	57.21 ± 16.55 $n = 63$	64.57 ± 20.21 $n = 42$	$F_{1,103} = 4.17$, $p = 0.044$
Rural			
Bird score	15.96 ± 3.67 $n = 26$	16.53 ± 2.59 $n = 15$	$F_{1,39} = 0.28$, $p = 0.599$
Tree score	13.58 ± 3.78 $n = 26$	14.53 ± 2.92 $n = 15$	$F_{1,39} = 0.71$, $p = 0.404$
Butterfly score	8.46 ± 5.81 $n = 26$	11.27 ± 5.79 $n = 15$	$F_{1,39} = 2.23$, $p = 0.144$
Mammal score	15.81 ± 4.17 $n = 26$	16.73 ± 2.60 $n = 15$	$F_{1,39} = 0.60$, $p = 0.443$
Flower score	13.46 ± 3.97 $n = 26$	14.00 ± 4.91 $n = 15$	$F_{1,39} = 0.15$, $p = 0.704$
Total score	67.27 ± 18.05 $n = 26$	73.07 ± 15.95 $n = 15$	$F_{1,39} = 1.06$, $p = 0.309$

TABLE 4 NHK scores of male and female students in 2013 and 2014 indicated that while differences were statistically significant (weakly) for butterflies and total scores in the urban context, across all taxa and in both contexts, males had a slightly higher score. While we stress the importance of the fact that the differences are largely non-significant, and that weakly significant differences could have resulted from type 1 error associated with the use of multiple tests, the statistical significance by sign test (10 of 10 tests $p = 0.00157$) suggests that further research might be valuable

those that were not. All taxa named by the students as their favourites are listed in Appendix 3. The names provided fell clearly into two groups with 18 students naming native species, and 13 naming exotics. We found no significant correlation between naming an exotic and any measure of NHK, including mean bird name value of birds named in the test. However, the name values of taxa named as favourite were themselves significantly higher for students naming a native species ($F_{1,29} = 6.94$, $p = 0.013$). This tendency was yet stronger if 'Crane' was listed as native (see Appendix 3, $F_{1,29} = 12.23$, $p = 0.002$). In other words, native named favourites were more likely to be at species rather than generic or a higher order level of taxonomy. Furthermore, a binary logistic regression model demonstrated that students naming parents and/or grandparents as influences on their NHK, were significantly more likely to name a native species as favourite ($F_{1,29} = 6.35$, $p = 0.012$), and that this was a graded response such that the more parents and or grandparents (i.e. 0–4) a student listed, the stronger the probability of naming a native bird as favourite ($F_{1,29} = 9.22$, $p = 0.002$).

4 | DISCUSSION

The well-documented and growing concern for the intergenerational loss of NHK around the world (e.g. Louv, 2006) is associated with the loss of opportunity for encounter with nature (Soga & Gaston, 2016), as well as with the changing nature of formal education in relevant subjects such as biology (Tewksbury et al., 2014; Tilling, 2004, 2018). Changing priorities in education are, however, as much a reflection of changing priorities in society as they are a driver of them. Whichever way we might define nature and natural history, this decline can be more broadly categorised as a loss of salience (Gosler, 2017; Hunn, 1999; Spoon, 2014). In this paper, while we have sought to quantify the extent and nature of NHK held by a definable cohort of young people with relevant interests, we have also sought to demonstrate the complex interplay between their background (what we characterise as the contexts of learning), the family and formal education. Considering these factors, and others, indicates the complexity of knowledge transmission, the importance of context for knowledge acquisition, and the relative importance of specific taxa, such as birds, for knowledge acquisition. Through this, has come a recognition of the danger of making assumptions about the background knowledge of people, be they a class of students or an audience for conservation advocacy. As educators, we have learned that we can no longer assume, as once we might (Barkham, 2014), that all involved—even those choosing apparently related biological science subjects—are familiar with robins (the UK's national bird—Mathiesen, 2015) or oaks (logo of the National Trust).

Through our necessary decision to maintain the anonymity of students in this study we lost the opportunity to follow-up with individuals, through interview, or to repeat as a longitudinal study, although that would present its own difficulties because students would have prior knowledge of the study. Such qualitative analysis as we have undertaken (e.g. on the bird names given, although quantified as a name 'value') yielded substantial information. While the lack of more extensive qualitative data from interviews is a drawback, and we would recommend that its inclusion would be a natural next step (e.g. Spoon, 2014; Tang & Gavin, 2016), we have high confidence in the robustness of our findings, which proved repeatable across years. We now consider key findings from the study.

4.1 | Contexts of learning

The significance of context for learning and recall was strongly indicated by our findings. Whether students defined their background as rural or urban made a considerable difference to their knowledge of natural history, and also to the roles played by family and teachers. While the greater biodiversity available to children in the rural context is a likely factor, we must acknowledge the role of parental anxiety, which has increased over the past 30 years in both rural and urban contexts, in constraining the opportunities children

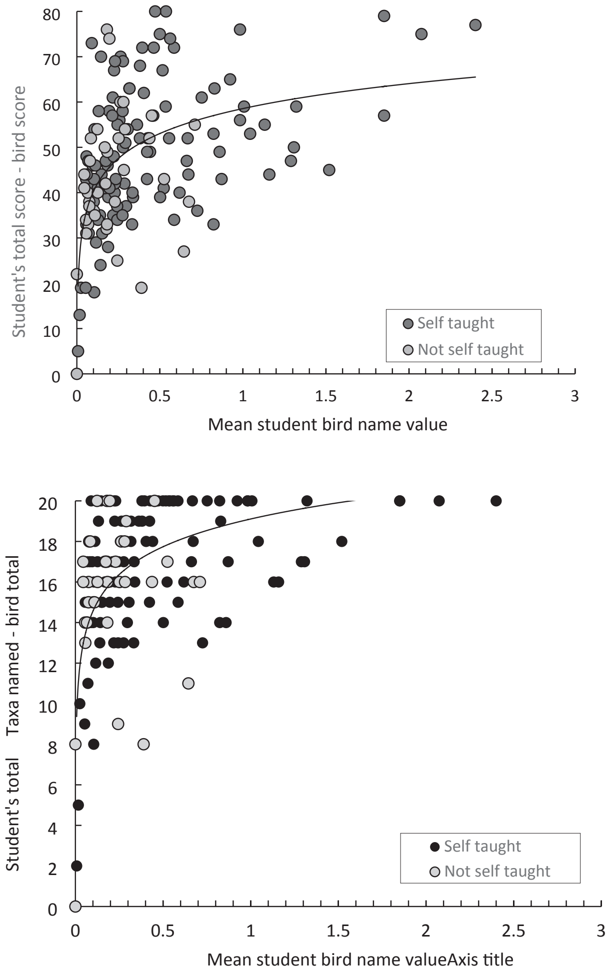

FIGURE 4 The mean value of bird names given by a student reflects their total NHK other than birds (upper) and the number of names of taxa other than birds (lower). Note that in cases where a student named fewer than five birds, missing names were given value zero in calculating the mean name value. Note also that self-teaching is reflected in the value of names offered. The exponential trendlines $Y = 18.724 * X^{0.0936}$ (upper) and $Y = 18.7239 * X^{0.0936}$ (lower) are highly significant fits (see text) accounting for 39.0% and 36.7% of variance respectively

have for independent play outdoors, and therefore their access to nature and biodiversity (Tillberg Mattsson, 2002; Valentine, 1997; Valentine & McKendrick, 1997; Waite et al., 2021). Motivation of the students themselves was most often reported as the principal source of knowledge, but only in the urban setting was this a significant contributor to their overall knowledge score. The role of advocates therefore in sparking a child's interest, whether nature itself, which may be as simple as the sounds of birds in the soundscape of a baby during the formative years of language-learning (Prathera et al., 2017), family or subsequent formal education, will be significant. Once ignited, evidence suggests that continuing interventions need to maintain and reinforce natural history interest throughout early years childhood and adulthood to ensure a prolonged interest (Cleary et al., 2018). That is more challenging in urban environments, where fewer opportunities are likely to exist for either formal, or informal intergenerational family-based learning in preferred, safe, and accessible spaces (Freeman et al., 2021). Creating such spaces in towns and cities continues to be a pressing need for urban planners engaged in bringing nature back into cities (Mata et al., 2021).

Our attempt to influence students' recall by inciting an emotional connection with nature through the 'favourite bird' experiment, made no difference, although our small sample size, and the way in which that test was conducted, may have rendered the results inconclusive (e.g. neighbouring students may have been influenced by being presented with different procedures).

While few of the comparisons showed statistically significant differences, the tendency for males to score more highly across all taxonomic groups and in both urban and rural contexts is itself significant using a sign test (10 of 10 tests, $p = 0.00157$). This is an intriguing result. Previous research with children has shown a tendency for male students to have a more pronounced 'object' view of nature, whereas female students often have a more elaborate 'relation' view of nature, and greater levels of environmental concern (Carrier, 2010). Although this previous research involved primary school children (as is true for most educational research in the field of 'nature' or environmental education) it suggests that the underlying reason for any gender differences observed in our study is more complex than an interest in natural history simply being more attractive to male children/students as a knowledge domain. For example, it is possible that during childhood males have more informal opportunities to encounter nature in urban settings, leading to enhanced NHK (O'Connor et al., 2017). We found no evidence for well-defined gender differences in focus as existed in the 19th century (Jackson-Houlston, 2006). Further research would be necessary to discover whether the contexts of learning might be adjusted to provide better opportunities to engage female children/students (Reiss, 2018). For example, adopting outdoor science education (OSE) in schools and colleges could have multiple benefits, supporting and building girls' general engagement with biology and science education and, more specifically, NHK knowledge and 'nature connectedness' (Stevenson et al., 2021).

4.2 | The role of family

The strong connection between the level of 'nature connectedness' of parents and guardians and that of children in their care is well known. It can override other child, adult and other area-level characteristics (Passmore et al., 2021). The advocacy role of family in our study was especially strong in the urban context where family was a highly significant contributor to student knowledge. In an urban context, with fewer opportunities to encounter nature, this advocacy may simply take the form of legitimating the exploratory or enquiring behaviour of young children towards natural objects, for example by setting up bird feeders (Clark et al., 2019). However, the foundational role of family in stimulating young peoples' interest in nature is underlined by the compensatory listing of teachers as a principal influence when familial influence was lacking (Table 3). Furthermore,

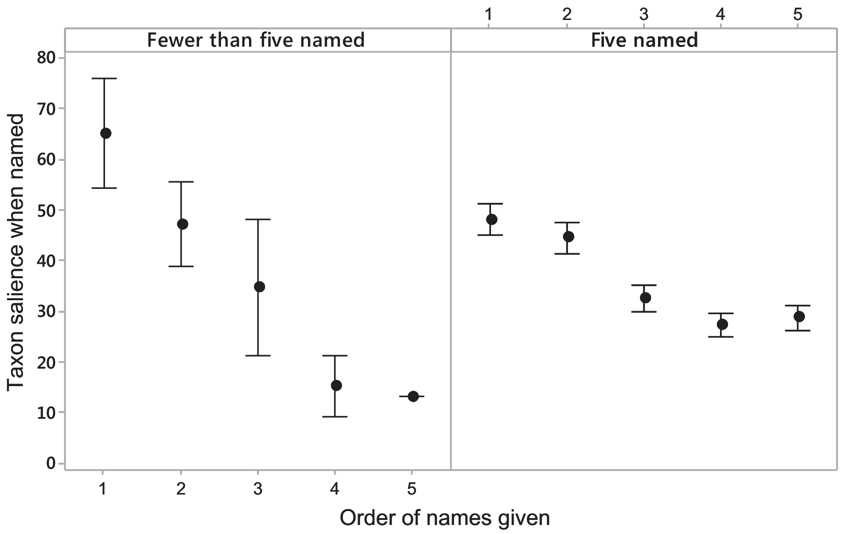

FIGURE 5 Change in bird name salience with bird name order for students correctly naming five birds to species level, and those naming fewer than five at species level (note that a few individuals in this group gave five names but not all to species level). In both groups salience declined through the task, but a significant difference in slope indicates that the 'five named' group was better able to maintain the consistency of name value through the task. Means are shown ±1 *SE*

the familial influence was additive: students who listed either parents or grandparents as influences scored more highly than those with neither, but less well than students who listed both parents and grandparents as influences. Such families might be said to have a nature-oriented culture. Such families are also likely to have friends with NHK who add further to the young peoples' knowledge, as indicated by our data (Table S5).

Students reporting family influences were also more likely to name British bird species rather than exotics as favourite birds, indicating the first-hand experience brought through family advocacy. The pre-eminence of the family as a principal knowledge source for biology students suggests that, rather than being the knowledge of formal education, NHK in the United Kingdom has the character of folk knowledge, whose transmission depends on the culture of the family (Wyndham, 2010). It will also depend on socio-economic influences, including access and proximity to appropriate outdoor locations where the most effective transmission can take place (Waite et al., 2021). Barriers to 'outdoor advocacy' in natural areas are, therefore, always likely to be most pronounced in urban areas, particularly if access to preferred and safe sites, with strong family attachments, is patchily distributed (Freeman et al., 2021).

Although family-based 'knowledge structure' was not explored here, we recognise the potential for inter-generational NHK to flow both ways: in a family which is predisposed to sharing NHK, children and young people may become the educators (e.g. Greta Thunberg), initiating knowledge exchange, concern and action linked to environmental issues (Figueres & Rivett-Carnac, 2020). It is possible, therefore, that where a gap already exists within a family in the potential for inter-generational influences this may steadily widen if children and young people do not receive compensatory influences from outside the family, such as from schools, peers etc. (Lawson et al., 2018). There is also a danger that a significant disconnect could exist between parents and teachers regarding the purpose and opportunities for children learning outdoors (Parsons & Traunter, 2020).

4.3 | The role of birds

Our results indicated that birds held a particular significance in that a student's overall NHK was best characterised by their knowledge of birds. Similarly, the salience of knowledge reflected in the 'value' of bird names given, also predicted their overall NHK. For example, a student who listed 'little egret', qualified his statement that it was native with a sentence in the margin on the role of climate change in its recent addition to the British avifauna, also scored highly on all other taxa. The significance of birds should be unsurprising if, as we argue, that what is required to peak a child's interest in nature more generally is a focus to raise its salience, since even a short time spent in the field is sufficient to improve young peoples' overall appreciation of nature (Bogner, 1998). For many reasons, birds provide the most accessible focus. For many, birds may represent our first encounter with wild nature (Prathera et al., 2017). And this can begin at home; a bird feeding table provides an early and prolonged focus for many children and young people in many households (Clark et al., 2019). Unsurprisingly then, the cultural significance of birds is itself of a different order in the affairs of humans than that of any other taxa (Tidemann & Gosler, 2010). From Grey (1927) to Lack (1965), Alexander (1974) to Hickling (1983) and Dickinson and Bonney (2012), the advocacy role of birds in engaging people with nature, environmental science and conservation, is well-documented. With 1.1 million members (RSPB 2019/20) including 195,000 youth members, the significance of birds is also reflected in the membership statistics of the UK's principal bird conservation organisation. This compares favourably with the 850,000 members of the UK's 46 wildlife trusts covering all taxa, including birds (RSWT 2020). The significance of this focus on birds for pioneering the concept of Citizen Science is also well-documented (Dickinson & Bonney, 2012; Greenwood, 2007). In 2016, some 500,000 people took part in the RSPB's Big Garden Birdwatch. Our findings have practical significance, since they imply that a simple enquiry to name five wild bird species and to indicate whether they think they are native, coupled with a salience analysis of the names given, is sufficient to gauge an individual's general interest in the whole natural history domain.

4.4 | The role of schoolteachers

While biology undergraduates are not representative of all young people, they do represent a group with a demonstrable interest in the science of life. Furthermore, the QAA benchmark for university biosciences includes the statement *'A deeper understanding of biology and biological processes is essential to appreciate the complexity of life and our impact on the planet; to be able to feed ourselves, while working to maintain biodiversity and a stable and sustainable environment'* (QAA, 2019). Hence if this interest is not translated into a knowledge of nature, and a concern for its preservation, biology education in schools and universities is failing to deliver its stated aims and principles (Ofqual, 2019; QAA, 2019). Our findings suggest that formal education in the United Kingdom today plays a complex role in developing nature awareness or salience and the acquisition of NHK. Students who reported teachers as a source of knowledge performed slightly worse than those who did not, but students who reported teachers as their principal source of NHK performed significantly worse. The nature of NHK for these students as folk knowledge, transmitted principally by the family has serious implications.

Rather than being abstract, such knowledge (known to ethnobiologists as Traditional Ecological knowledge or TEK, Anderson et al., 2011) is held in a context in which it is relevant. In a study of Rarámuri Children's Plant Knowledge in Mexico, Wyndham (2010) found that cultural and use aspects were easier for children to remember than names, and that family influences were more significant than formal education. Working in Tibet, Shen et al. (2012) demonstrated how formal education to a syllabus that failed to connect with local language and experience of nature devalued locally born knowledge and undermined children's developing concern for nature.

We cannot overemphasise the importance of relevance in the acquisition of NHK. The finding that students giving teachers as a principal source were significantly more likely to have come from urban backgrounds is further evidence that the teacher role must act to compensate for the lack of familial education, but the fact that these students did significantly worse indicates the inadequacy of that compensation. This is unfortunate because evidence from primary schools shows that immersion in outdoor nature-linked activities is effective, for example, in raising awareness of birds and their identification (White et al., 2018). These experiences can also boost subsequent attainment inside the primary classroom (Kuo et al., 2018). Reassuringly, primary school teachers in urban settings have been teaching across a greater variety of outdoor locations in recent decades (Prince, 2019). It is at secondary level where biology teachers struggle the most to boost NHK acquisition. They may lack NHK knowledge themselves (Bebbington, 2005), have inadequate training and preparation (Lock & Glackin, 2009) or be unaware of, or disinclined to use, local opportunities to teach in situations leading to NHK acquisition. For example, Glackin (2007) highlights the poor uptake of field teaching opportunities in inner-London secondary schools. The current proposal to launch a new GCSE in Natural History in the United Kingdom is in part a response to the demise of fieldwork in schools, but the very low recruitment to other related subjects such as environmental science in upper secondary schools in recent decades, suggests that the new subject may struggle in competition with traditional core subjects. Given the long-lasting trends nationally towards reducing the field-based content of biology courses in secondary schools our expectations for pre-university education are not high (Tilling, 2004, 2018).

Finally, an anecdote from the 2013 exercise points to a concern over the status of NHK within Biology. A student who later identified as the one who wrote the sentence on little egret and climate change (noted above), and therefore was found to be the only student to have scored 100% on NHK, thanked us for conducting the questionnaire. The ground for those thanks became clearer after conducting the bird name 'value' analysis. Faced with an anonymous test which contributed nothing towards their degree, students did not simply list the first birds that came to mind, the cognitively low-hanging fruit, as one might expect in a timed exercise. Rather, they sought to demonstrate their deeper knowledge of the subject. We suggest that the failure to recognise the culturally transmitted knowledge of nature held by young people studying biology does a dis-service to those students. Education practice should be more ready both to affirm such knowledge and to identify its source and inspiration since it provides the firmest base on which to build.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

A.G.G. was involved in conceptualisation, investigation, data analysis and writing—original and revised drafts; S.M.T. was involved in literature review and writing—review and editing.

DATA AVAILABILITY STATEMENT

Original data are archived at Oxford Research Archive: https://doi.org/10.5287/bodleian:KOykbrbvb (Gosler, 2022).

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