A Study on Children's Multi-sensorial Experiences of Nature: Design Approaches and Preferences for Primary School Architecture

Case studies in Glasgow, Scotland, UK

ABSTRACT

Purpose - Providing improved access to nature within educational settings can promote stronger child-nature connections and is conditional on making evidence-based decisions for the planning, design, and refurbishment of school architecture. The study offers insight into ways of reconnecting children with nature by examining the distribution and classification of diverse natural elements for enhancing children's visual and non-visual experiences of educational environments.

Design/methodology/approach - This study combines quantitative and qualitative analysis of data gathered through measurement and observation at three schools in Glasgow (N=75) to identify key issues influencing child-nature multi-sensorial connections within indoor and outdoor environments, and on building envelopes and layouts. It applies children's open-questions and diagrams to investigate children's discovery of nature, their feelings around natural attributes, and their environmental preferences within school contexts.

Findings – This study's findings reveal that architectural features and landscape settings have significant influence on the quantitative and qualitative degrees of children's natural exploration through visual and non-visual sensorial modalities and environmental preferences.

Research limitations/implications – The limitations of this study are that the data was gathered in the Spring season and with different groups of children from The Glasgow Academy who received the same educational curriculum. Thus, there is a need for further investigation on children's experiences of nature based on temporal and contextual differences, and varying educational-socio-cultural and economic factors.

Practical implications – The findings suggest that applications of natural diversity, accessible and flexible pathways and indoor natural settings, are potential approaches to connect children with nature within their study and play environments.

Originality/value – The authors provide a deeper understanding of how nature-based settings, including indoor and outdoor environments, constructively benefit children's multi-sensorial experiences, knowledge, and biophilic feelings toward nature.

Keywords – Primary school architecture; Children's multi-sensorial experiences; Children's environmental preferences; Nature diversity; Biophilic settings

Paper type – Research paper

INTRODUCTION

Acknowledging the importance of better connecting children with nature, nature-based proposals for educational buildings and landscape designs have been proposed as a way to nurture children's affinities for the natural world (Kellert, 2015; Louv, 2006). However, in industrialised and urban settings people, particularly children, are spending less time outdoors. It is becoming increasingly apparent in educational settings worldwide that this reduction of interaction with nature is being reflected in the experiences of children (Larson *et al.*, 2019). Nature-based pedagogies require that further investigations should focus on the impacts and potential approaches of the greening process in school settings (Kuo *et al.*, 2019). Previous research indicates that a greening process in school settings offers potential for positive contributions to children's cognitive development and performance (Dadvand *et al.*, 2015; Li and Sullivan, 2016), and to their health and wellbeing (Bagot *et al.*, 2015; van Dijk-Wesselius *et al.*, 2018). A number of studies focusing on primary school architecture, have examined the impacts of nearby urban configurations, spatial features of studying and playing environments on the child-nature connected intensity. Recent research on 'Child-Nature-Distance' by To & Grierson (2019) found that a well-planned and designed school could enhance children's proximity to nature, supporting findings that closer juxtaposition between primary school sites and urban green spaces provides more positive benefits to pupils through daily multi-sensorial experiences, and for various educational and recreational activities (Fischer *et al.*, 2019; Liu and Chen, 2021). Within school playground sites, it has been shown that information-rich natural features, in contrast to barren and artificial surfaces and settings, expand the diversity of playing opportunities within safer and friendlier environments (van Dijk-Wesselius *et al.*, 2018; Ndhlovu and Varea, 2018), enhance pupils' academic performance (Dadvand *et al.*, 2015), and increase environmental stewardship (Jansson *et al.*, 2014). In particular, providing a wide range of natural experiences contributes to a closer connection between children and their local natural environment (Danks, 2019). According to *Creating Excellent Primary Schools: A Guide for Clients* (CABE, 2010), important features for sustainable school environments in the UK are naturalized outdoor spaces that not only enhance various children's activities but also provide good indoor environmental conditions through natural lighting and ventilation. Providing contact with nature through openings within classrooms is important for natural lighting, views, and air quality that can positively influence students' health, academic performance, and behaviours (Küller and Lindsten, 1992; Li and Sullivan, 2016). Furthermore, previous studies also highlight benefits of natural settings in classrooms, such as indoor plants or vertical green walls (van den Berg *et al.*, 2017; Han, 2009). Given the growing evidence for positive benefits of natural-based settings, and considering the significant amount of time children spend at primary schools, exploring feasible architectural interventions that can provide children with multi-sensorial experiences of nature at school has become an imperative. The model of a 'forest school', where woodland is utilized as an entire school setting, presents a prominent example of advancing pupils' hands-on experiences of nature (Harris, 2021).

However, in the majority of situations, children from urban areas, and in particular from low-income households, do not have opportunities to attend such schools. A possible response is, however, emerging through the application of biophilic design principles developed from the theory of biophilia. According to Dr Stephen Kellert (2018), notable features of biophilic design in educational architectures (e.g. natural lighting, wetlands, swales, courtyards, interior connections to the outside environment shapes and forms inspired by nature, and natural-rich materials) could both upgrade the environmental qualities for all children's activities and enrich natural connections while still ensuring safety and security for them. These recent perspectives suggest that, in the design of a new school, or the retrofitting of an existing school, children's multi-sensorial experiences of the natural environment can be considered a priority design requirement to foster integral and beneficial goals of sustainable development (Bolten and Barbiero, 2020).

Nevertheless, the current lack of research evidence linking the physical characteristics of school settings and the intensity of children's non-visual sensorial connections with natural features (other than greenery) suggests the need for further study (Franco et al., 2017). A holistic understanding of multi-sensorial experiences of natural elements and stimuli can successfully delivery natural benefits for children because not all exposure to nature is pleasant (Ratcliffe, 2021) to children and their specific activities. This is one of the central issues of environmental psychology, how different architectural and natural attributes within a spatial environment provoke different affective states and interactions in various types of individuals, such as reactions of liking or disliking, engaging or averse, exciting or boring. In addition, it is important for us to understand children's perspectives of ideal environments at primary schools to identify design features that can enhance their attraction and desires for nature (Ghaziani et al., 2021).

This study asks the key question: "What are differences in children's experiences of nature through visual and non-visual senses, including their discovery of nature – feelings towards nature and environmental preferences, according to various spatial-natural features in primary school environments?" We have undertaken an investigation into the association between the natural and physical characteristics of school settings located in different contexts, and have adopted child-centred analytical methods required for a comprehensive understanding of how school design can help to foster children's natural experiences (Deppeler and Aikens, 2020). Our aim is to support future decision-making for the design of primary school environments that can help to foster a reconnection between children and nature, which we consider an imperative. Existing policies and frameworks in the UK provide the context for the study regarding wilderness school environments, namely: Area guidelines for mainstream schools: Building Bulletin 103 (DfE, 2014), Building Better Schools: Investing in Scotland's Future (COSLA and The Scottish Government, 2009), and Creating Excellent Primary Schools (CABE, 2010), although these are suggestive rather than mandatory in the way designers currently practice.

RESEARCH DESIGN

Responding to this imperative, we offer an exploration of how pupils (from 7 to 12 years old) experience nature, including the way they directly perceive nature through multiple senses, and how they express their environmental preferences at primary schools. Contextual differences allow us to identify the significance of particular site settings and architectural features. Here, we have adopted multiple case studies in various spatial scales and contexts of primary schools in Glasgow, Scotland with two main research objectives:

(1) to explore children's multi-sensorial and affective dimensions toward perceived nature viewed as the basic core constructs of their natural consciousness and behaviour (Linzmayer *et al.*, 2014). Distinct features of natural classifications were clarified through children's own perspectives, and particular features of natural environmental stimuli that compose sensory variety and variation explored (Moore, 1989; Sebba, 1991).

(2) to understand children's demands and preferences with regard to nature and places at schools. The relationship between children's perspectives and spatial-natural features helps to encourage children to positively engage with nature. This requires exploration of *where* – children's favourite places, *why* and *what for* – their needs in the desired natural and built environments. Thus, an application of the child-centred method provides opportunities for children to express their environmental and spatial perspectives and interests increasing their subjective well-being (Mustapa *et al.*, 2015).

Together these objectives define key factors influencing the child's multi-sensorial natural experiences, and provide insights into ways of reconnecting children and nature within an educational context.

RESEARCH METHOD

This study combines quantitative and qualitative analysis of data obtained by children's open-questions and diagrams to identify the matrix of natural elements and stimuli that children perceive within their classrooms and playgrounds, the descriptor terms for sensory notations based on their feelings, and natural and non-natural features of their favourite to spaces. These methods were used to create fun environments that encourage children to work on tasks and express their views without pressure, and to offer sufficient information and in-depth details for analysis (Grant, 2017; Punch, 2002).

Selections of case studies

Children were recruited from three private primary-schools of The Glasgow Academy (TGA) in Scotland, including Kelvinbridge (TGA_K), TGA_Milngavie (TGA_M), and TGA_Newlands (TGA_N). These schools were selected since children groups were taught with the same educational curriculum within considerably different learning environments (e.g. distinct locations

in urban settings, spatial configurations, and architectural features of classrooms and playground settings) (see Figure 1). With these differences, this study anticipated exploring the influences of school physical and landscape settings on child-nature multi-sensorial experiences through children's nature exploration and perception on nature. While acknowledging that the selected schools belong to a particular socio-cultural and economic context that will influence the child-nature connection, the researchers believe that the focus of this current study on applying a method for identifying sensory determinants of natural and non-natural spaces is transferable to educational architecture more widely.

TGA_K – is located in a high-density area of Glasgow; however, its site is surrounded by a river landscape and diverse green spaces. Three pupil groups (grade 7 – aged 11-12, grade 4 – aged 8-9, and grade 3 – aged 7-8) completed the natural exploration tasks within outdoor spaces that stretch from the entrance gate to the trim-trail playground area (K_a). The central hard-surfaced ground areas featured a flower-bed, flower-plant pots, and wooden benches (K_c and d) while remaining areas had artificial grass-surfaced ground and higher degrees of greenness (K_b). Regarding three studied classrooms, the pupils of grades 3 (K_3_I) have outstanding naturalness values for visual and non-visual connections due to its large window system opening directly to outdoor greenspace while the classrooms of grades 4 (K_4_I) and 7 (K_7_I) have natural connections via looking and hearing only because of their closed windows during survey times.

TGA_M – is within a residential area in the suburb north of Glasgow; it offers substantially higher multi-sensorial naturalness than TGA_K and TGA_N due to a surrounding river landscape and a wilderness area which are parts of the school's facility. Children completed outdoor tasks in the area at the entrance gate (M_a) which is decorated with many flower-plants and surrounded by many high trees and bushes, and in the wild area (M_b) that is significantly featured with the earthy ground, high trees, bushes, and diverse plants. Here, there was only one investigated classroom (M_I) where pupils of grades 3 and 4 (aged 7-9) participated and had only natural connections via looking and hearing. It is featured with a large area of glass-window at the side which is connected via an open-viewed corridor adjacent to outdoor space (e.g. bushes and wooden plants as hedgerows), a glass area above on another side, and indoor flower-plants for decoration.

TGA_N – places in the residential area of Mansionhouse Garden estate side and is covered by crossroads and private houses. There was only one group of grade 3 pupils (aged 7-8) who did the task within their classroom and a central playground. Within this central hard-surfaced playground, each particular functional area is divided by different colours and play facility settings (N_b and N_c). The external landscape is designated with a hedgerow comprised of shrubs and high trees, some flower-plant pots, and a flower bed for decoration (N_a). Consequently, fewer naturalness values and natural diversity for multi-sensorial experiences occur in this school playground. Regarding the studied classroom (N_I), it has two sides connecting directly to the outside through large glass-window systems at an approximate height (in closed position) for

looking and hearing; besides, this room was featured with caterpillar glass boxes for indoor studying activities.

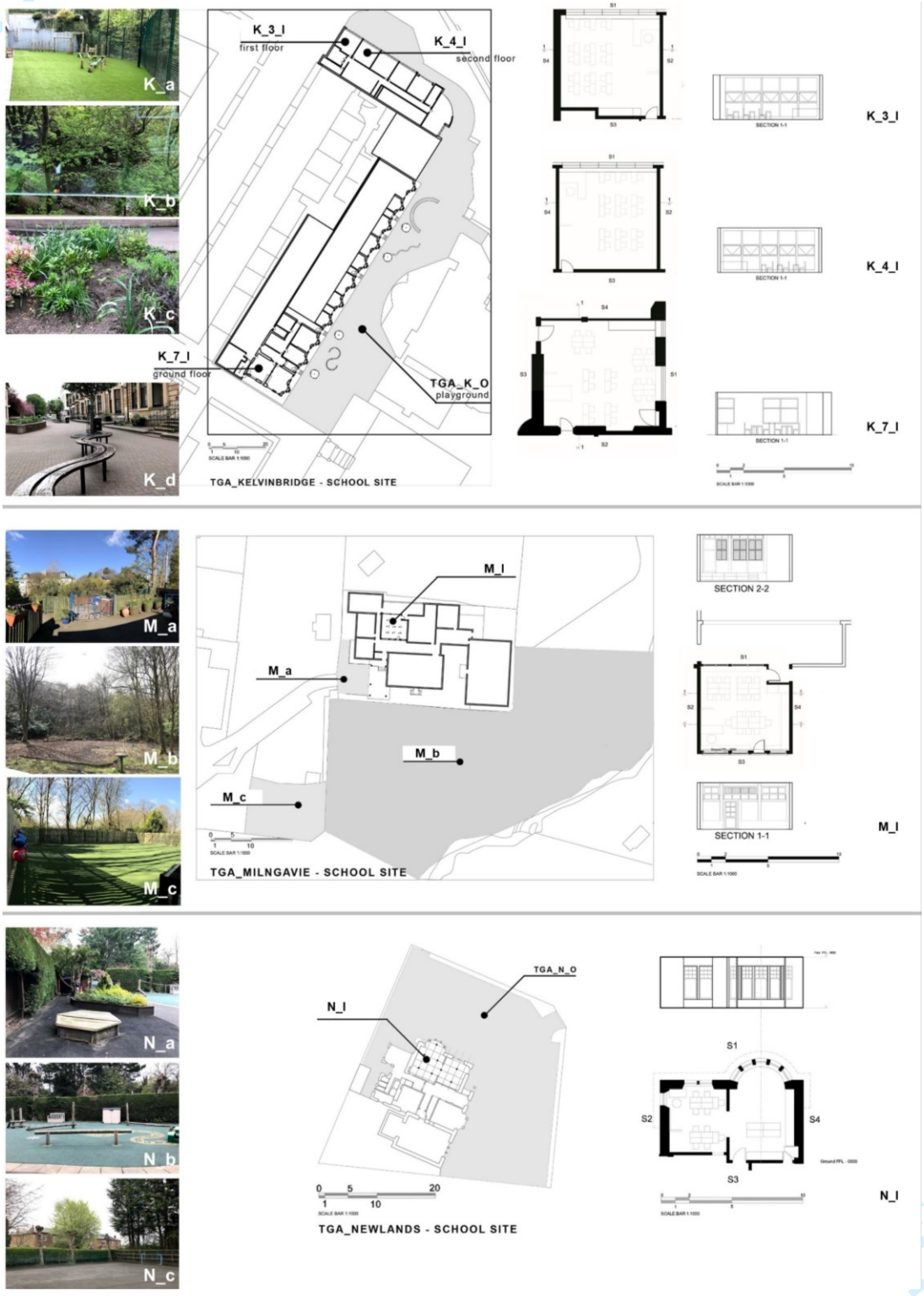

Figure 1. Investigated classrooms and playgrounds of three TGA schools

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Participants

The participants were 75 pupils without special needs (53% males, 47% females) with all children being aged between 7 and 12 years (Mage = 8.92 years, SD = 1.50).

Ethics

This study received ethical clearance from the University of Strathclyde Ethics Committee. School approval, parental consent, and pupil assent forms were obtained before surveys were undertaken.

Data collection

The data collection period was between April and May 2018, springtime in Scotland, UK. Children had two working papers with a similar format: the classroom and playground tasks. Children were encouraged to provide written statements or produce drawings that would illustrate their perception of natural elements. In keeping with previous research findings, self-selected participation methods varied (Literat, 2013). Generally, children with a less developed vocabulary, preferred to draw whilst other children, who were perhaps less confident in their drawing abilities, preferred to produce written responses. The child-friendly format questionnaire was developed with support from an educational expert, working as a manager and teacher in the three schools, to ensure appropriate, clear, and consistent communication with children. The children's paperwork was structured as follows:

(1) Firstly, children responded to questions:

- "*What Nature do you see/ hear/ touch/ taste/ smell in your classroom/playground?*",
- "*What does it look like (colour/ shape/ action)?*", and
- "*How do you feel?*"

Pupils were asked to observe and identify names of natural objects corresponding with each sense, and then briefly describe their emotional feelings.

(2) Following, questions related to pupils' favourite natural elements and places at their schools are:

- "*What parts of nature do you like most in the school playground and garden?*",
- "*What is your favourite place at your school?*", and
- "*Tell me why you like this place?*"

With the support of teachers, short meetings with students were held before conducting surveys within the studied contexts. Work with each participant group occurred within a period of 50 and 60 minutes, including 10 minutes for the introduction and guidelines, 15 minutes for children working in the classrooms, then 5-10 minutes moving from the classrooms to playgrounds, and lastly, between 20 and 25 minutes for the outdoor tasks and collections. In classrooms, children positioned themselves as their regular daily activities. During working time, the researcher interacted and discussed with children whilst teachers only viewed from a distance. When pupils

struggled and asked for help, the researcher had short conversations with them following the structure of the survey to avoid them having biased opinions under the influence of the researcher. These conversations started with the researcher's repeating the question and asking the child what nature he/she wanted to report. Then, the researcher asked questions about how a particular natural element looked like, and how he/she felt about it. When the child responded with words describing a characteristic of a natural element or stating their feelings, the researcher repeated this and guided him/her to write it down.

Data analysis

This study argues that children have physical contact with nature through multi-sensorial experience. "*Nature*" is defined as natural settings, ranging from those that are independent of the human-built environments (a wilderness) to those that are within human-designed and constructed landscapes according to Kellert's descriptions of children's physical natural experiences (Kellert, 2002). The natural attributes, are synthesized from facets of the environmental education (National Association for Environmental Education (NAEE), 2016; Palmer, 1998), nature and landscape design (Dansereau, 1975; Williams, 1985), and biophilic design (Browning *et al.*, 2014; Kellert, 2008; Kellert and Calabrese, 2015), include: air, astro-sky, minerals, water, weather, wind, light, fauna species, and flora species.

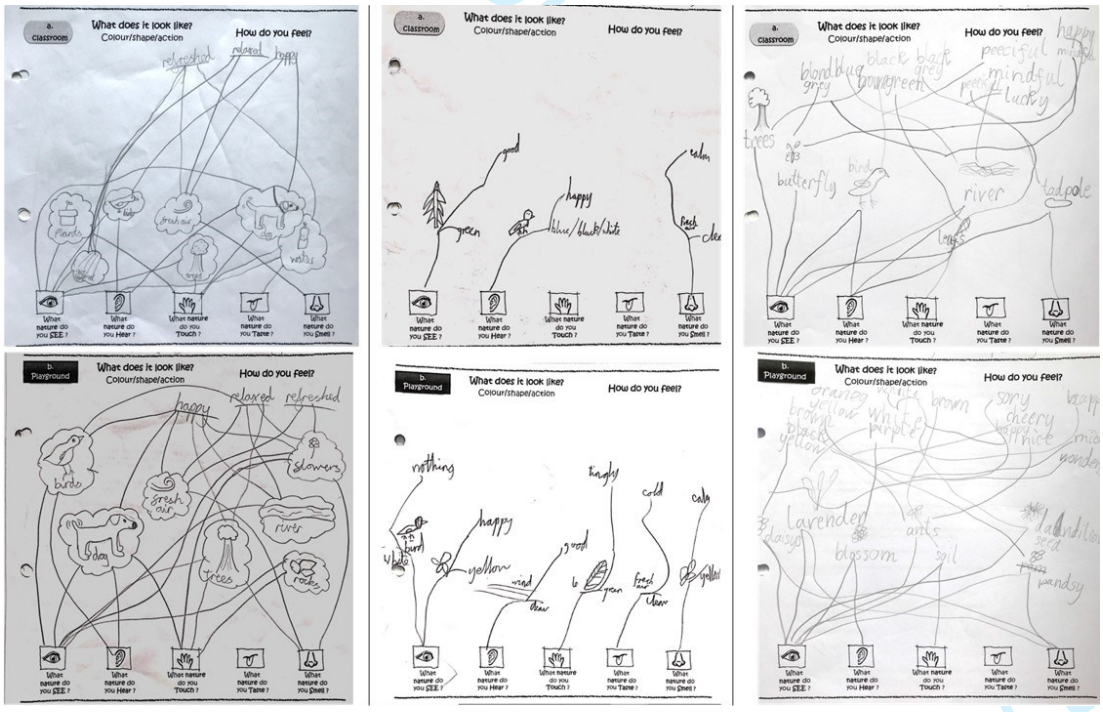

Figure 2. Examples of children's reports in classrooms and playgrounds

Firstly, a matrix of children's multi-sensorial experiences with nature and the descriptor terms for emotional notations is explored through the children's reports (see Figure 2 for examples of paper-works collected after surveys from children). The natural elements reported in words or

images were arranged into classifications as mentioned above while responses that were incompatible with these designated natural attributes (for example, football (net), fence, climbing frame, rope, people, plane, litter, ear, bench, teddy, tea, desk, and paper) were excluded from the data analysis. The perceived extent of each natural type is demonstrated through frequencies of the coding technique.

Next, children's responses regarding their emotional feelings toward recognized natural elements, from the raw data, the relevant themes, short descriptions, and representative keywords were recorded and categorized for coding according to the concept of the circumplex model of affective appraisals (Russell, 1980). These themes were categorized into pleasant-unpleasant responses ranging from high to low stimulus (as shown in Table 1), including surprise, excitement and joy, satisfaction, appreciation, relaxation and calmness, boredom, sadness, craving, disgust, anxiety and fear.

Table 1. Themes of affective feelings related to perceived nature

Features of feelings		Coding Categories	Relevant words
Pleasant	High arousal	Surprise Excitement	*different, surprised, weird, strange, odd, exotic* *cool, excited, excited, exciting, welcome*
	Moderate – high arousal	Joy	*happy, very happy, joyful, delighted, funny*
	Moderate – low arousal	Satisfaction	*fresh, nice, fine, refreshed, lucky, good*
	Low arousal	Appreciation	*new, alive, mindful, make … positive, helpful, like, refreshing, fresh, cool, warm, colourful, cheery, wonderful, lovely, loving, cute, love, gentil: beautiful*
		Relaxed Calmness	*relaxed, relax* *calm, peaceful*
		Boredom	*normal, nothing, blank, tired*
Unpleasant	Moderate – low arousal	Sadness	*sad*
	Moderate – high arousal	Craving	*jealous, hungry*
	High arousal	Disgust Anxiety, Fear	*yucky, grumpy, not to good, dirty, disgusting, sick* *alarmed, a bit scarred*

The final questions related to pupils' environmental preferences at their school were examined based on distinctive design features in relation to their own choice of words. A favoured environment was evaluated through children's concerns about physical, natural, emotional, and social meanings of learning and recreational activities at schools. Indoor environments were treated as a composite group, whereas outdoor environments included sub-categories according to different features of playground areas within three primary schools, as shown in Figure 1.

Data management and the quantitative-qualitative analysis of data collected from children were performed using Excel and NViVo 11 programs.

ANALYSIS AND INTERPRETATION

"Perceived" Nature by children's multi -sensorial experiences within school environments

The distribution and classification of nature according to particular sensorial experiences, obtained from children's reports, are presented in Figure 3 (the colours represent the frequencies of natural attributes children perceived through five senses within classrooms and playgrounds). From the charts, it can be seen that pupils reported higher numbers of natural elements and types of each and total sensorial experiences at playgrounds than in classrooms. Children in classrooms, with the exception of looking, reported more perception of nature via hearing and touching than tasting and smelling. At playgrounds, the greater natural values were experienced by touch whereas tasting was least noted. The results also revealed that flora and fauna species were the dominant attributes that children responded to, with 53.0% and 24.9% in total responses respectively. The results are circumstantially described as follows.

TGA_K

Regarding classroom results, the group of K_7_I pupils head the amounts of natural elements and diversity even though this classroom involves fewer advantages of direct experiences of nature than rooms of K_4_I and K_3_I. They explored nature primarily through looking and hearing and offered the highest ratios of plants and animals. With the advantages of opened windows confronted to greenspace and water landscape, weather conditions (with and without wind), and available indoor natural setting for study ("*tadpoles"*), the amounts of perceived natural elements and types that K_3_I pupils reported were much higher than children of K_4_I room. The notable outcome was a dominance of animal species and flora species in regards to senses of look, hear, and smell.

Moving to outdoors, flora species was the most significant natural feature that was figured out by five senses, especially looking, touching, and smell by both three groups. The oldest group K_7_O continued heading the capacity of exploring nature within their playground. They also highlighted in looking and hearing sound of dogs and birds. With surrounding water landscape, they not only saw and heard sounds of water features but also figured out mineral elements while younger groups paid more attention on the flower bed area, especially the K_3_O pupils who head the proportion of flora-related answers. Besides, the windy and gentle rainy situation during the survey time of K_3_O group influenced the variety of nature children could experience with additions of "rain drops" and "wind" that were perceived through both visual and non-visual senses compared to results of K_4_O group.

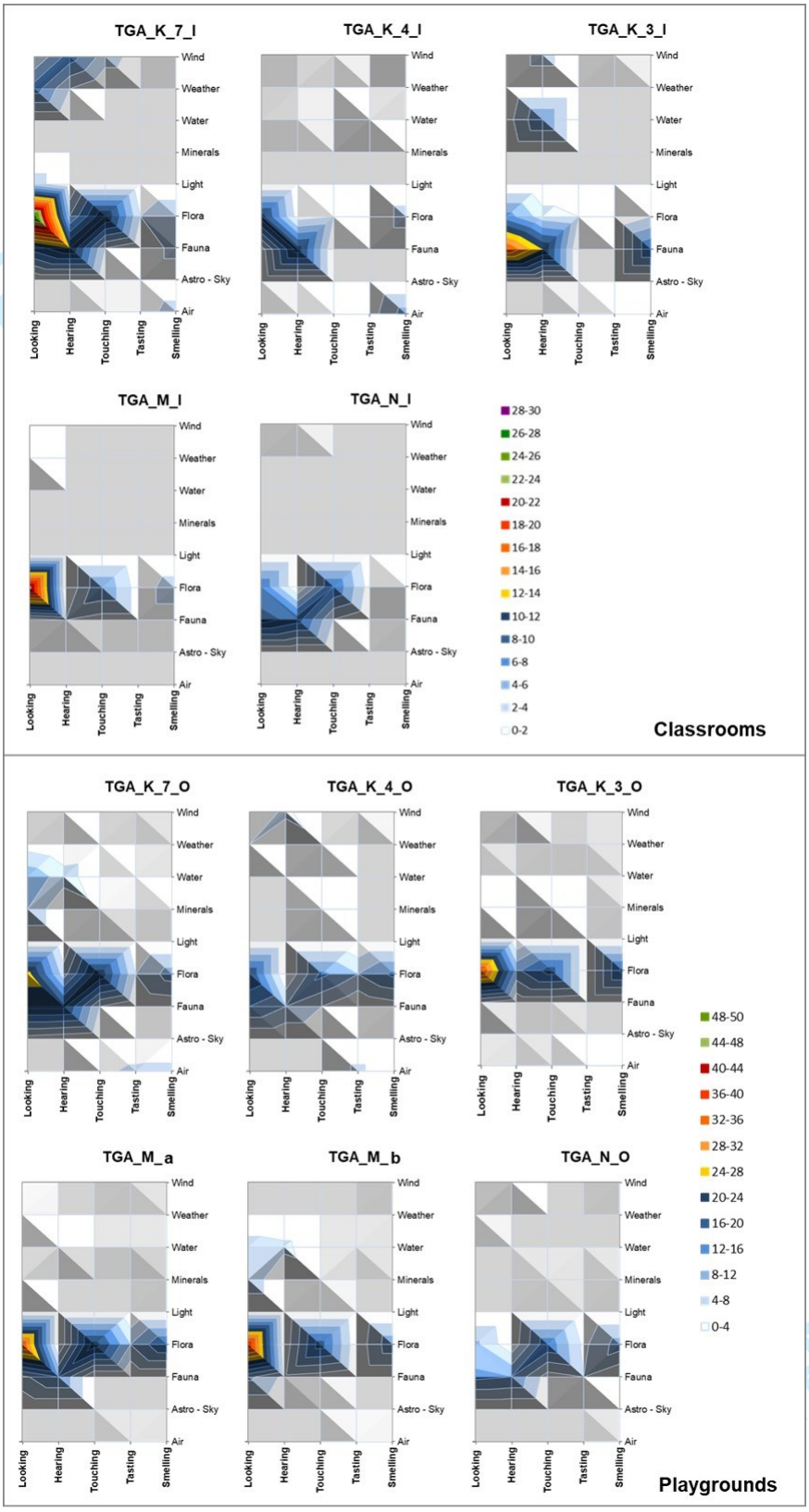

Figure 3. Distribution and classification of "perceived" nature according to the places (classrooms and playgrounds) and the experienced senses

TGA_M

Pupils at Milngavie explored the least numbers of natural elements and types within classroom. The proportion of flora-related responses significantly lead the experienced natural types and primarily distributed into vision. Pupils here remarkably noted indoor-decorative flower-plants.

Within the entrance gate area (M_a), the results showed the dominance of the flora group that was mainly distributed into the exploration of looking, touching, and smelling. Although moving to wilderness area (M_b), the total figure of perceived natural elements was slightly lower than within the entrance gate area. What stands out here was a greater numbers of insect species, more plentiful botany, and mineral elements, that were experienced through looking, touching, and smelling, than within the other sites. Additionally, "*lake*" and "*river*" were water features that children explored through all senses except smell.

TGA_N

Within the classroom of Newlands, two primary perceived natural groups were fauna (e.g. "*birds*", "*squirrel*", and "*caterpillar*" boxes) and flora species (e.g. "*leaf/leaves*", "*wood*", and "*tree(s)*") that were mostly collated into looking, hearing, and touching experiences.

Related to outdoor exploration, the discrepancy between visual and non-visual experiences was not significant like other TGA school cases despite the highest ratio of vision. Flora and fauna head the proportions of perceived natural types. Children had the greatest concerns of five sensorial experiences with trees, plants, and flowers while responses of animals were mainly sorted into looking and hearing.

Children's feelings and favour toward perceived nature

Overall, results showed pupils exhibit both pleasant and unpleasant feelings toward nature through direct multi-sensorial exposure within school environments and also indicated the dominance of positive feelings, including senses of surprise, excitement, satisfaction, appreciation, relaxation, and calmness from children (Table 2).

Vegetations and animal species accounted for the highest percentages of positive responses according to their large frequencies of explorations. In particular, trees, plants with leaves, and colourful flowers mostly generated senses of happiness, satisfaction, and aesthetical appreciation through looking, touching, and smelling. Pet-orientated species (e.g. dog, cat, birds, and squirrels), and insects (e.g. butterflies, minibeasts, caterpillars, tadpoles, bug, ants, bees, and worm) predominantly incur pleasant feelings of looking and hearing. With regard to water, most responses from Kelvinbridge and Milngavie pupils indicated a greater distinct attribute of the water element with a lower arousing degree than stimulus from other natural types. Children reported their relaxation and calmness when looking and hearing divergent moving states of water. In

contrast, unpleasant feelings were described when they directly tasted, smelt, or touched other natural elements, for instance, "*tired*" – smell a flower, "*grumpy*" - smell a leaf, "*sick*" – look at skunk cabbage, "*sad*" – look at the green bushes and brown leaves, "*a bit scared*" – see a woodlouse, "*dirty*" and "*yucky*" – touch, taste and smell soil. Through the children's descriptions here it might be deduced that sensorial emotions vary with greater natural diversity. And pleasant and unpleasant feelings, ranging from low to high arousal levels, are evoked when their explorations are unlimited.

Table 2. Ratios of TGA_children's affective feelings according to perceived natural types and senses

			Fauna							**Flora**								
	Senses	**Air**	Pets	Insects	Birds	Total	**Astro - Sky**	**Light**	**Minerals**	Tree, plant	Flowers	Leaves	Grass	Others	Total	**Water**	**Weather**	**Wind**
Pleasant – High arousal	L	-	.32	.60	.14	.26	1.0	-	-	.31	.44	.11	-	.14	.31	.14	.20	-
	H	-	.18	-	.36	.25	-	-	-	.13	-	-	-	-	.01	.09	-	.19
	To	.05	.09	-	-	.02	-	-	-	.12	.02	.11	-	-	.07	-	-	-
	Ta	-	-	-	-	-	-	-	-	-	.02	.07	-	-	.02	-	-	.06
	Sm	.14	-	.13	-	.02	-	-	-	.04	.12	.07	-	-	.07	-	.20	.06
Pleasant – Low arousal	L	-	.23	-	.10	.11	-	1.0	.44	.27	.12	.21	1.0	-	.19	.32	.40	-
	H	-	-	.07	.36	.22	-	-	-	.04	-	.04	-	-	.02	.27	-	.44
	To	.05	-	-	-	-	-	-	-	.10	.12	.11	-	-	.10	-	-	.06
	Ta	.27	-	-	-	-	-	-	-	-	-	.07	-	-	.01	.05	-	-
	Sm	.41	-	.07	-	.01	-	-	-	.06	.10	.04	-	.29	.08	-	-	.06
Unpleasant – Low arousal	L	-	-	-	-	-	-	-	-	.02		.04		.29	.03		.20	
	H	-	-	-	.02	.01	-	-	-	-	-	-	-	-	-	-	-	-
	To	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.09	-	.06
	Ta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sm	-	-	-	-	-	-	-	-	.00	.02	-	-	-	.01	-	-	-
Unpleasant – High arousal	L	-	-	.07		.01	-	-	.11	-	.02	-	-	.29	.02	.05	-	-
	H	-	.14		.02	.05	-	-	-	.02	-	-	-	-	.01	-	-	.06
	To	-	-	-	-	-	-	-	.22	-	-	.04	-	-	.01	-	-	-
	Ta	.09	-	-	-	-	-	-	.11	-	.02	.04	-	-	.01	-	-	-
	Sm	-	.05	.07	-	.02	-	-	.11	-	.02	.07	-	-	.02	-	-	-
		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Notes:
Pleasant – High arousal: Surprise; Excitement, Entrancement, Interest; Joy
Pleasant – Low arousal: Appreciation, Adoration, Admiration, Awe, Satisfaction; Relaxed, Calmness
Unpleasant – Low arousal: Boredom, Sadness
Unpleasant – High arousal: Disgust, Craving; Anxiety, Fear

Following the predominant positive feelings, flora and fauna groups were mainly favoured with 63.9% and 29.3% respectively. Among these, the beauty of colourful flowers were strongly identified. With regard to more unusual site conditions, river and brook were identified by pupils of Kelvinbridge and Milngavie. Warm weather was identified by some pupils expressing their

feelings of comfort during the spring season; weather conditions and thermal comforts ultimately influences children's perceptions on natural favour. This is an important feature of experiences within natural environments in a cold climate and should be considered in designing schools since a windy space can diminish children's comfort and therefore their willingness to use outdoor spaces for hands-on experiences.

Children's preferences on places within school environments

The results indicated that outdoor areas for various recreational activities are the predominately favoured places with 72.5% of the respondents. Regarding TGA_K, the oldest group K_7 had a significant inclination toward indoor spaces (65%); their least favourite option was the sport playground. Oppositely, approximately a half of younger children selected outdoor spaces, especially the adventurous playground (K_a). At Milngavie, a half of participants reported the main artificial grass-surfaced playground (M_c) as the place they like most, while a minority group (20%) selected the wilderness area (M_b). In Newlands, two different areas for playing outdoor, including the general setting for all pupils (N_b) and a particular setting for playing sports (N_c), accounted for equal importance (38%), while 23% of participants preferred indoor places.

Beyond the place designations, children's reasons for favouring particular places revealed that they selected a place for at least one reason regarding their comfort, interests, habits, and the need for social interactions; including:

> **Togetherness** – interact with other peoples: … *talk to friend, … hang out (with my friend), … get to talk to friends, … like being with my friend there, … my friends play with me …, … we have a very good teacher, …for everyone*;
>
> **Natural concerns** – mentioned nature in their responses: *a lot of sun …, it is sunny …, … has sun, … you get air, … the tree in the corner, it's quiet, … you can climb tree*;
>
> **Functional satisfactions**: *… do science, … we get food, … we can eat there, … where you get food, … ha big stage, … has a trim-trail, … can watch funny videos, … good for my Parkour, … there are very cool thing, … helps us be fit and healthy, … get lots of parties*;
>
> **Recreational satisfactions**: *… get a break from our work, … it means no work, … you can relax, … play (football), … run around*;
>
> **Challenges**: … *get to explore, … get to lose part here, … a bit tricky*;
>
> **Fun and enjoyment**: *… have fun and it's enjoyable, ... enjoy it, … (very) fun, … just happy*;
>
> **Comfortable satisfactions**: *… cosy and spacious, … quiet, … lots of space, … big, … warm*.

Collectively, the important results of children's environmental preferences are as follows:

- **Indoor environments**: children demanded individual activities, specific functions, and artificial facilities. They highly noted features of spaces for their comfort satisfaction (for example, big, warm, quiet, cosy, and spacious) while natural concerns were less given.
- **Outdoor structured playing areas**: children mostly stressed physical activities and interactions with others; they felt fun here. The challenges of playing were also mentioned by children who favoured trim-trail or adventured playground for non-natural facilities.
- **Wilderness areas**: they mentioned specific activities, such as climb trees, explore, and play loose parts there. Their descriptions showed the differences between wilderness spaces and outdoor developed spaces relating to higher creative, challenging levels; the former addressed that nature was playing facilities for their activities while the artificial settings were related to the latter.

Features of children's age and gender

In regard to differences in perceiving nature, the results show the older children were, they increasingly explored more various natural classifications. Particularly, within the TGA_K school where three groups explored, the oldest group heads the amounts of natural elements and diversity within indoor environments, even though their classroom involves fewer advantages of direct experiences of nature than rooms of younger groups as well within within same playground (as shown in Figure 3). In relation to gender, girls explored plants with flowers more than boys (f_{female} = 23, f_{male} = 11), and it could be explained by their greater intensively atractions toward various types of colourful flower-plants within classrooms and playgrounds for decoration purposes.

Regarding feelings toward perceived nature, there were no differences between aged groups. However, female pupils showed higher preferences to express perceptions and attitudes toward nature in the given tasks; their responses were double that of boys. They also reported more positive feelings (e.g., senses of excitement, fun, satisfaction and appreciation, relaxing, and calmness) than male pupils who described high arousal levels and unpleasant feelings toward their recognised natural objects, for example, through expressions of surprise, boredom, disgust, and fear.

What stands out in children's spatial preferences is both age and gender differences regarding favoured features of playground settings. In particular, with 58.5% responses, pupils aged 11-12 showed higher preferences to indoor spaces than children aged 7-9 (only 20.7%) who mostly select outdoor spaces as their favourite places at schools. About gender difference, 31.4% female pupils favour adventurous and energetic activities with the grassed surface in Kelvinbridge school, or even nature-based challenges of the wilderness area in the Milngavie school, while only 12.5% male pupils selected this option.

FINDINGS

This study examined the issues influencing child-nature multi-sensorial connections within primary schools. With respect to the main research question, the obtained results reveal how differently children experience nature through visual and non-visual senses within various spatial-natural features in primary school environments, from indoor to outdoor and from low to high naturalness spaces. Our findings contribute impacts of architectural features and landscape settings on pupils' natural explorations and environmental preferences.

School site location: Urban configuration and Child-Nature-Distance ranges

Firstly, this study reveals the significant influences of the nearby urban configurations on the quantitative and qualitative degrees of children's natural exploration through visual and non-visual sensorial modalities, for example the wilderness area of Milngavie and profound urban nature of Kelvinbridge that compose greenery and water landscapes. Responding to the restraints within urban planning would require a prioritising of decisions pertinent to the selection of sites for new schools based on proximity distance and regular daily access to natural areas, especially limited conditions of urban school sites with small sizes, hard surfaced playgrounds or poor performance landscape design. This has been seen in a study by Fischer *et al.* (2019) that the neighbouring vacant wild sites were planned, managed, and occupied to enhance students' gardening, recreational activities, and food experiences at the Caspar David Friedrich secondary school. Proper pathways to connect nearby natural areas outside a school could be improved in the re-accommodation of functional layout, and by increase in built envelopes' permeabilities to maximize naturalness values.

School playground characteristics: Nature-based design and Nature diversity for sensorial experiences

At school playgrounds, the more wilderness children are exposed to, the greater numbers of natural objects and types they can explore. A significant difference between natural land typologies and hard-surfaced playgrounds relates to diversity of nature. For example, the earthy ground of Milngavie site offers diversity of underground flora, fauna, and mineral elements that could not found at hard-surface grounds. Although fewer natural elements were reported in wilderness area than other places, the research saw Milngavie pupils spend more time to discover and observe natural objects (such as they overturned a log to find snails or woodlice), and discuss with friends during survey time instead of entirely focused on current tasks. Through discovery of new things, various pleasant and unpleasant arousal levels were reported toward living and non-living natural elements. Likewise, water landscapes provide rich sources for children's discovery of aquatic ecosystems, abiotic components, and offer more diverse soundscapes. Among natural classifications, this study found that flora species are widely experienced and favoured features at school sites. Colourful flower-plants are the most appealing feature that attract children's

attention and engagements with multiple senses, especially female pupils. Simultaneously, seasonal changes and weather conditions generate a variety of natural stimuli from incorporation of different elements. With variations in the colours and smells of vegetation, sounds of birds, movement of rivers, and the rustling of leaves in the wind, the intensity of stimuli perceived varies, and children are able to experience more natural diversity through a comprehensive sensorial experience, even when in classrooms. Within the natural world, a child of primary-school age has an opportunity for unlimited to discovery, to know, to feel, and then to place in memory the diversified and complex attributes of natural experience (Herrington and Lesmeister, 2006; Wilson, 1984). And green schools, if considered a potential part of the biophilic urban realm, can contribute to human health and wellbeing goals; the natural ground project “Urban Jungle” of Merrylee Primary School in central Glasgow offers an example.

Another important finding is the significance of nature-based playgrounds to the social dimension of children’s favoured places. The playground is considered an important social setting (e.g. gender, class, race, and identity) in educational contexts, and it’s common that boys are dominant playground users while girls are often excluded from much of the area of a playground (Blatchford et al., 2003; Paechter and Clark, 2007). This might be explained by the design of typical playgrounds which are mostly concrete or asphalt-covered surfaces supporting games and activities, historically for boys and older groups. To provide an equitable and healthy playground for all pupils, greening is now considered as an appropriate approach (Dyment and Bell, 2008; Lucas and Dyment, 2010). The results of our study support this approach, in particular by identifying female pupils’ inclination for outdoor activities within grassed surface, or earthy ground areas. We have found that younger girls favour adventurous energetic activities, suggesting there are advantages in designing playgrounds with a nature-based surfaced cover and playing facilities, in order to balance the distribution of gender and age ranges.

However, current design regulations for school buildings provide constraints, due to safety concerns, that result in schools that are often over-designed, over-structured, and over-artificially equipped in order to control and monitor children’s activities (Malone and Tranter, 2003). The gap between children and nature has been increasing as a result, and opportunities for children’s non-visual experiences with nature have been diminishing. Our findings support a nature-based playground settings in which natural diversity must be yielded as an approach to nurturing children’s habits and interests in nature, in a broader sense, that can help narrow the widening gap between humans and nature (Grierson, 2009).

Classroom characteristics: Spatial layout, features of building envelopes, and indoor natural settings

Firstly, the influences of architectural features and spatial layout within buildings and school sites were illustrated through children's reports. For instance, their exploration of nature is enhanced within classrooms with windows facing outdoor nature. This can be seen in the cases of N_I,

K_3_I, and K_4_I classrooms where varieties of plants and animal species were highly noted. In contrast, a more adverse location of M_I revealed an insufficient connection between pupils and outdoor nature. Furthermore, this study explored additional conditions of openings' features (i.e. scale, orientational position, height, and operational status) on the degrees of nature pupils perceived through five senses. within spatial conditions with adequate openings to outside, vision is the strongest and the most efficient connection between children and nature from indoor places compared to non-visual sensorial experiences. Thus, the inclusion of permeable features in building envelopes and the spatial layout can efficiently establish pathways for children's multi-sensorial natural experiences within indoor environments. Responding to this, adaptable and flexible features in learning arrangements (Schabmann *et al.*, 2016) and building elements (i.e. flexible canopy (Kwon *et al.*, 2019) or moveable shading elements (Kükrer and Eskin, 2021)) can further be applied to alter the visual and non-visual permeabilities in specific situations, especially adverse weather conditions or unfavourable temporary factors in surrounding environments. Advanced technology innovations in architectural design allows for these accessible pathways to be implemented, with improved environmental performance.

Additionally, one of the most important findings is related to children's attention to indoor natural elements. Experiential, and regular, learning related to nature evokes their awareness through five senses, particularly through touching and smelling. The results of pupils' emotional reactions, especially female groups, showed greater biophilic feelings toward species which are often considered as 'disgusting', for instance, caterpillars, worms, and tadpoles (Almeida et al., 2014; Matchett and Davey, 1991). This positive alteration of children's perception could be explained by an increased familiarity within the studying environments. Results suggest that there are advantages in reconsidering indoor natural settings to upgrade pupils' direct experiences and nurture their biophilic feelings toward a wide range of natural elements.

Taken together, the findings of this study support the benefits of nature-based settings, including indoor and outdoor environments, to children's multi-sensorial experiences, knowledge, and biophilic feelings toward nature. The work is presented in the belief that nature can become an intrinsic driver of children's educational activities. Correspondingly, natural elements and stimuli can be physical and aesthetic components in the social and environmental evolution. When biophilic design approaches are applied to entire school environments, children's negative feelings toward unfamiliar and uncommon natural species can alter, our younger generations' environmental attitudes and behaviours towards the natural world can change, and we might be better placed to bridge gender differences. This study therefore attempts to contribute to the growing body of research that informs these approaches.

FUTURE RESEARCH

This research has identified and described key issues influencing children's multi-sensorial natural explorations, and their environmental preferences at primary schools. The findings

suggest that applications of the biophilic design, natural diversity, accessible and flexible pathways are potential approaches to connect the child with nature within their studying and playing environments. However, a limitation is that the data was gathered in the spring season only; thus, there is a need for further investigation on children's perception and preferences based on seasonal variations. Future research should also explore sub-sets of different educational-socio-cultural and economic factors to examine how these influence the child-nature connection, and inform educational architecture. These directions would broaden the present study for the decision-making process and identifying design parameters for sustainable architecture (Grierson and Moultrie, 2011; Grierson and Salama, 2016). Today's architect is challenged by new concepts on educational methods and the impacts of new emerging technologies, by complex, disordered, and uncertain situations. Requirements of spatial and functional settings for children's health and wellbeing at school environments following the COVID-19 pandemic are likely to result in sweeping changes in the relationship between children and nature (Rios *et al.*, 2021). In this sense, urban and architectural designers in general, are challenged and compelled to offer adaptable approaches, as Forsyth (2020) argues:

> "… The current pandemic brings the question of designing for infectious diseases back to the forefront and raises important questions for future research and practice."

For this reason, the need for further multidisciplinary research on how we can maintain and enhance our children's connection with nature through informed, well designed, changes in the built environment, is both vital and urgent.

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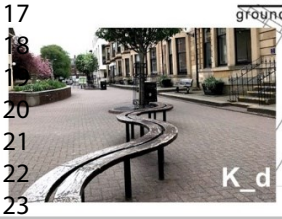
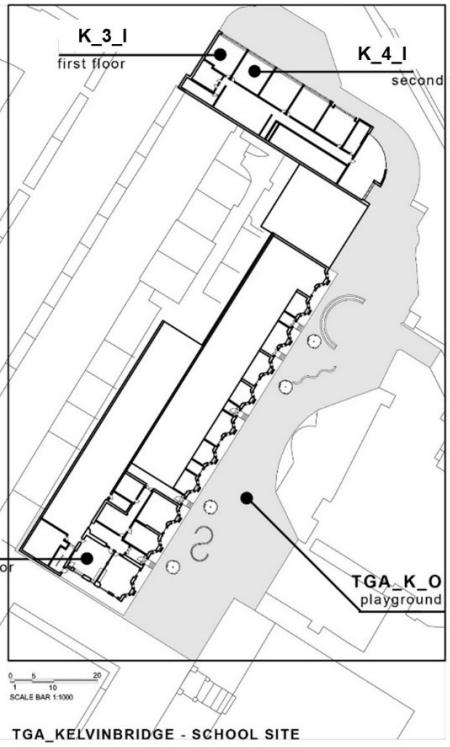
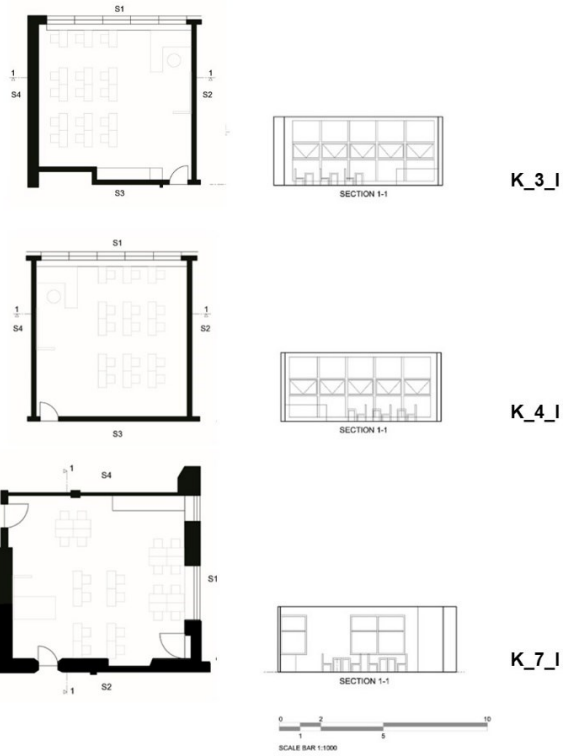
K_a

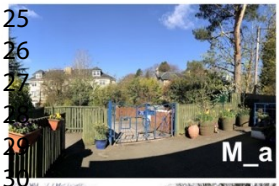

K_b


K_c

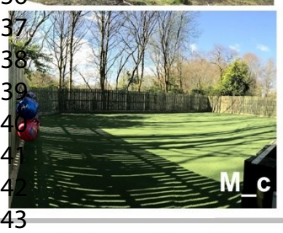

K_d

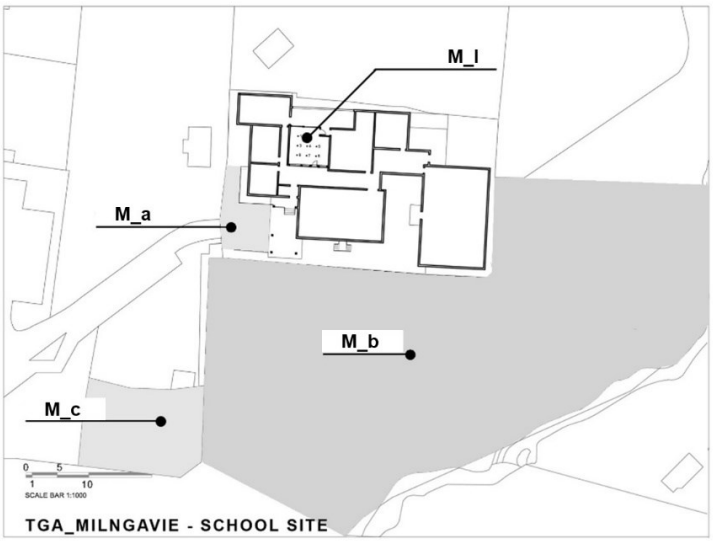

K_3_I
first floor
K_4_I
second floor
K_7_I
ground floor
TGA_K_O
playground
SCALE BAR 1:1000
TGA_KELVINBRIDGE - SCHOOL SITE

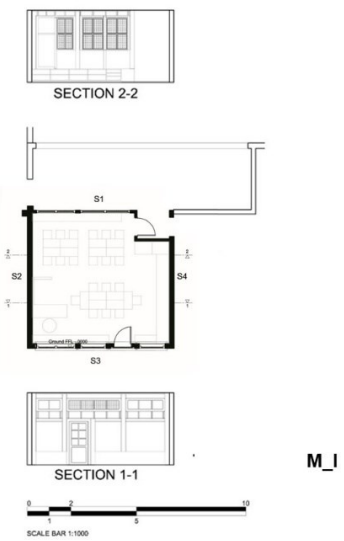

S1
S2
S3
S4
SECTION 1-1
K_3_I
K_4_I
K_7_I
SCALE BAR 1:1000


M_a


M_b


M_c

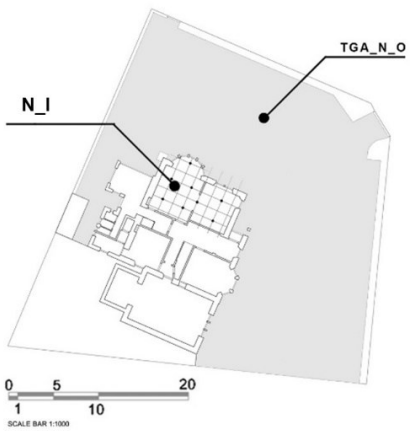

M_I
M_a
M_b
M_c
SCALE BAR 1:1000
TGA_MILNGAVIE - SCHOOL SITE

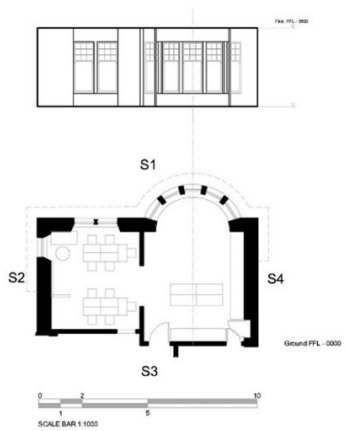

SECTION 2-2
S1
S2
S3
S4
SECTION 1-1
M_I
SCALE BAR 1:1000

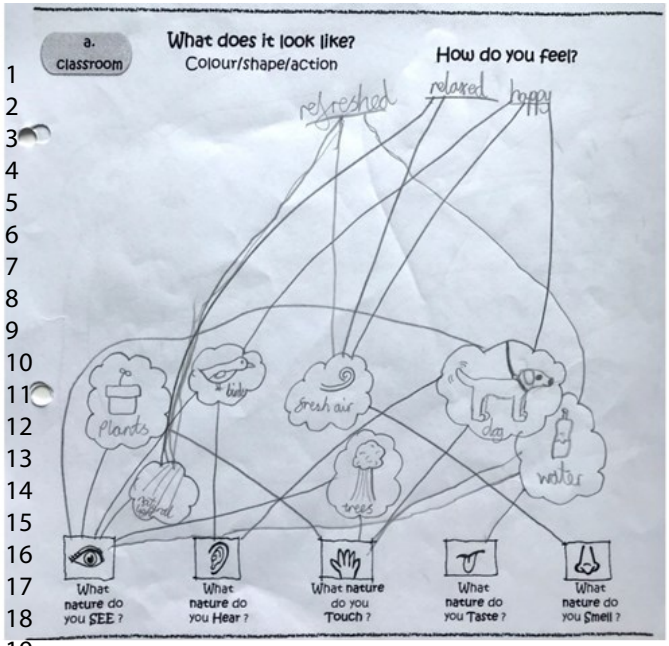

N_a

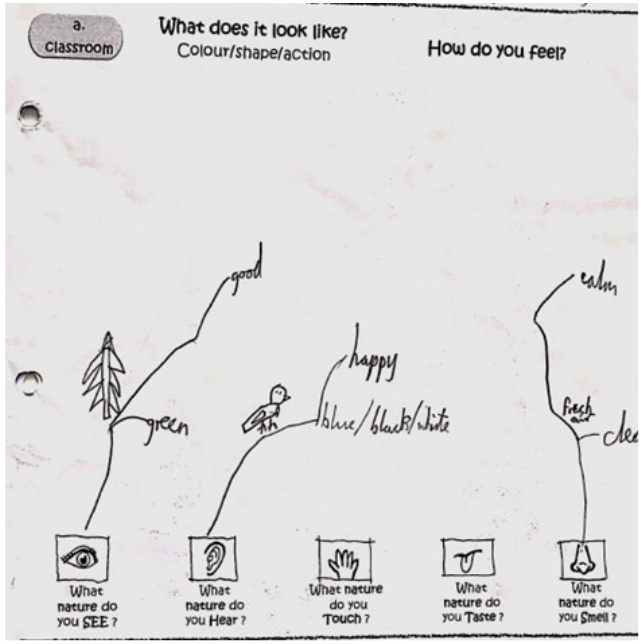

N_b

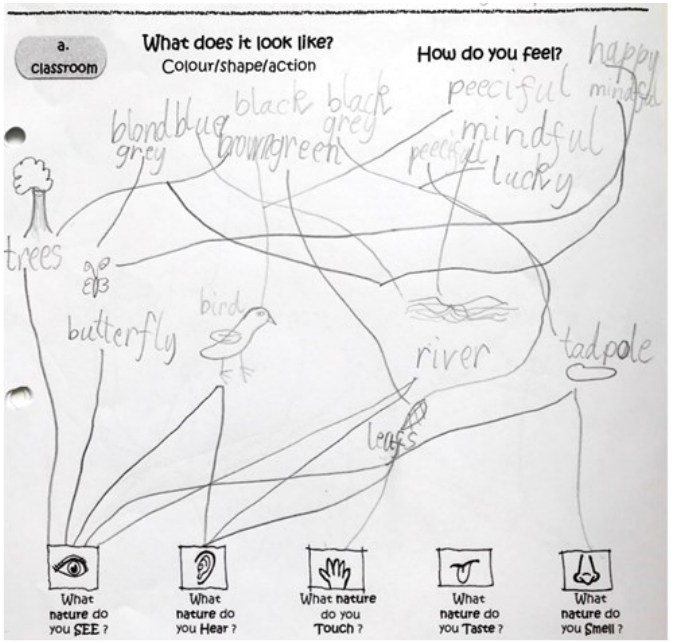

N_c

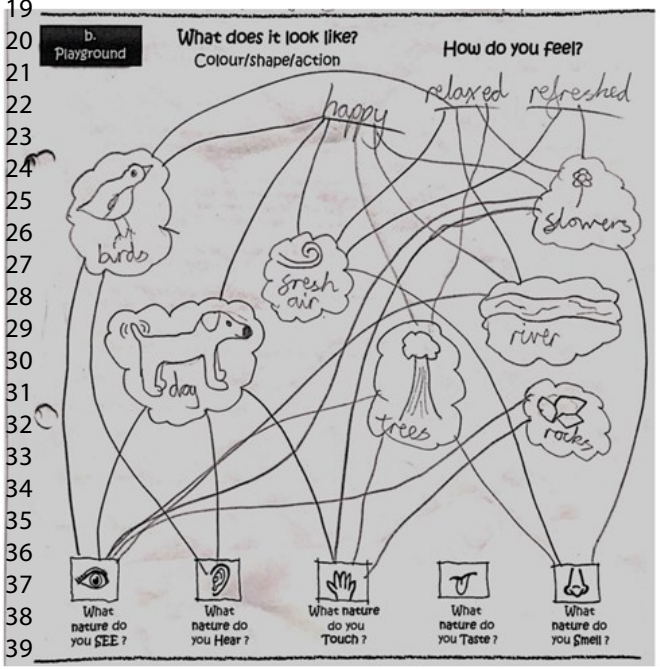

TGA_N_O
N_I
SCALE BAR 1:1000
TGA_NEWLANDS - SCHOOL SITE

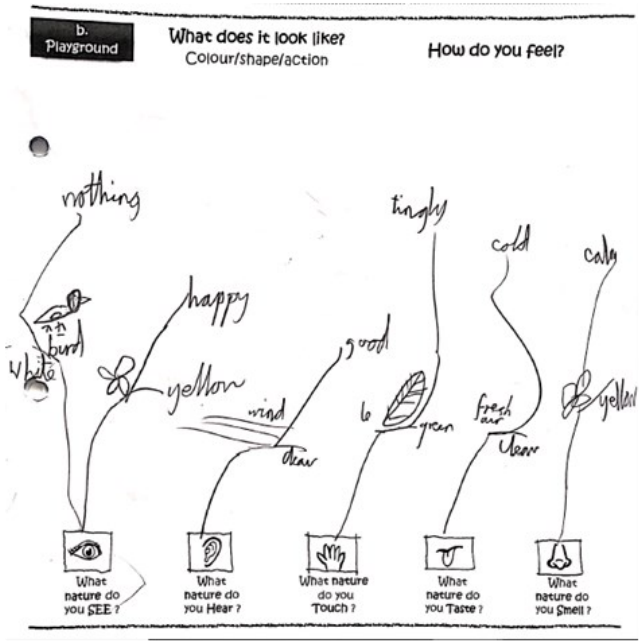

S1
S2
S3
S4
N_I
SCALE BAR 1:1000

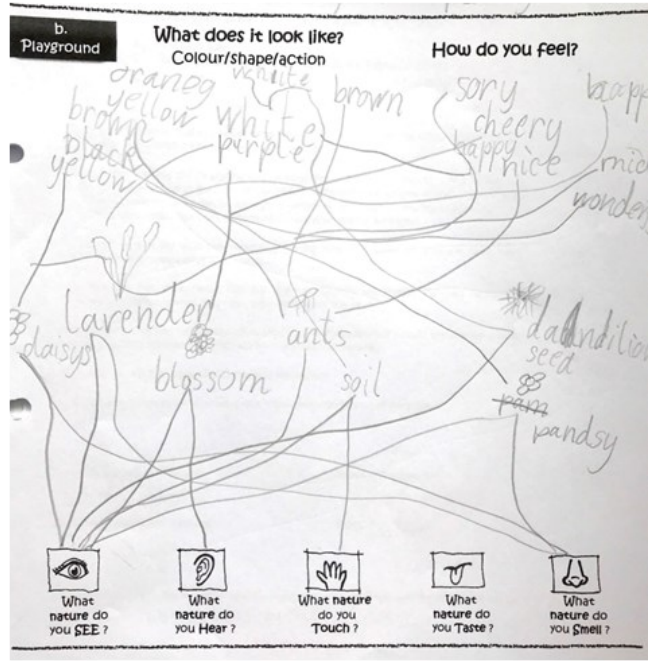

a. classroom
What does it look like? Colour/shape/action
How do you feel?
refreshed
relaxed
happy
plants
bird
fresh air
dog
water
trees
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?

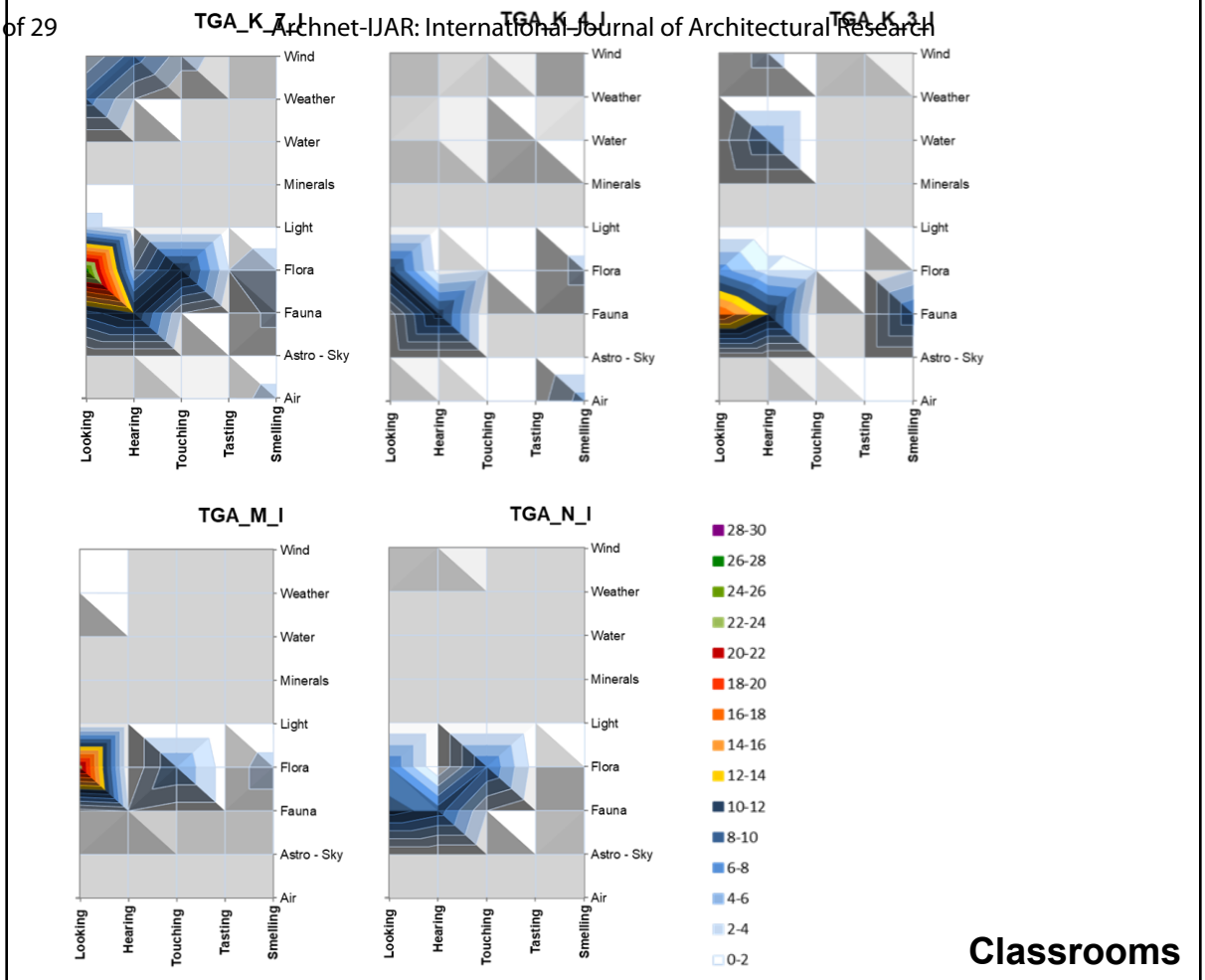

a. classroom
What does it look like? Colour/shape/action
How do you feel?
good
green
happy
blue/black/white
calm
fresh air
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?


a. classroom
What does it look like? Colour/shape/action
How do you feel?
happy
peaceful
mindful
lucky
black
grey
green
trees
butterfly
bird
river
tadpole
leaves
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?


b. Playground
What does it look like? Colour/shape/action
How do you feel?
happy
relaxed
refreshed
birds
flowers
fresh air
river
dog
trees
rocks
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?


b. Playground
What does it look like? Colour/shape/action
How do you feel?
nothing
tingly
happy
cold
calm
bird
white
yellow
wind
clear
good
green
fresh air
yellow
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?


b. Playground
What does it look like? Colour/shape/action
How do you feel?
orange
white
brown
yellow
purple
black
sory
cheery
happy
nice
lavender
daisys
ants
blossom
soil
dandilion
seed
pansy
What nature do you SEE ?
What nature do you Hear ?
What nature do you Touch ?
What nature do you Taste ?
What nature do you Smell ?


TGA_K_7_I
TGA_K_4_I
TGA_K_3_I
TGA_M_I
TGA_N_I
Wind
Weather
Water
Minerals
Light
Flora
Fauna
Astro - Sky
Air
Looking
Hearing
Touching
Tasting
Smelling
28-30
26-28
24-26
22-24
20-22
18-20
16-18
14-16
12-14
10-12
8-10
6-8
4-6
2-4
0-2
Classrooms

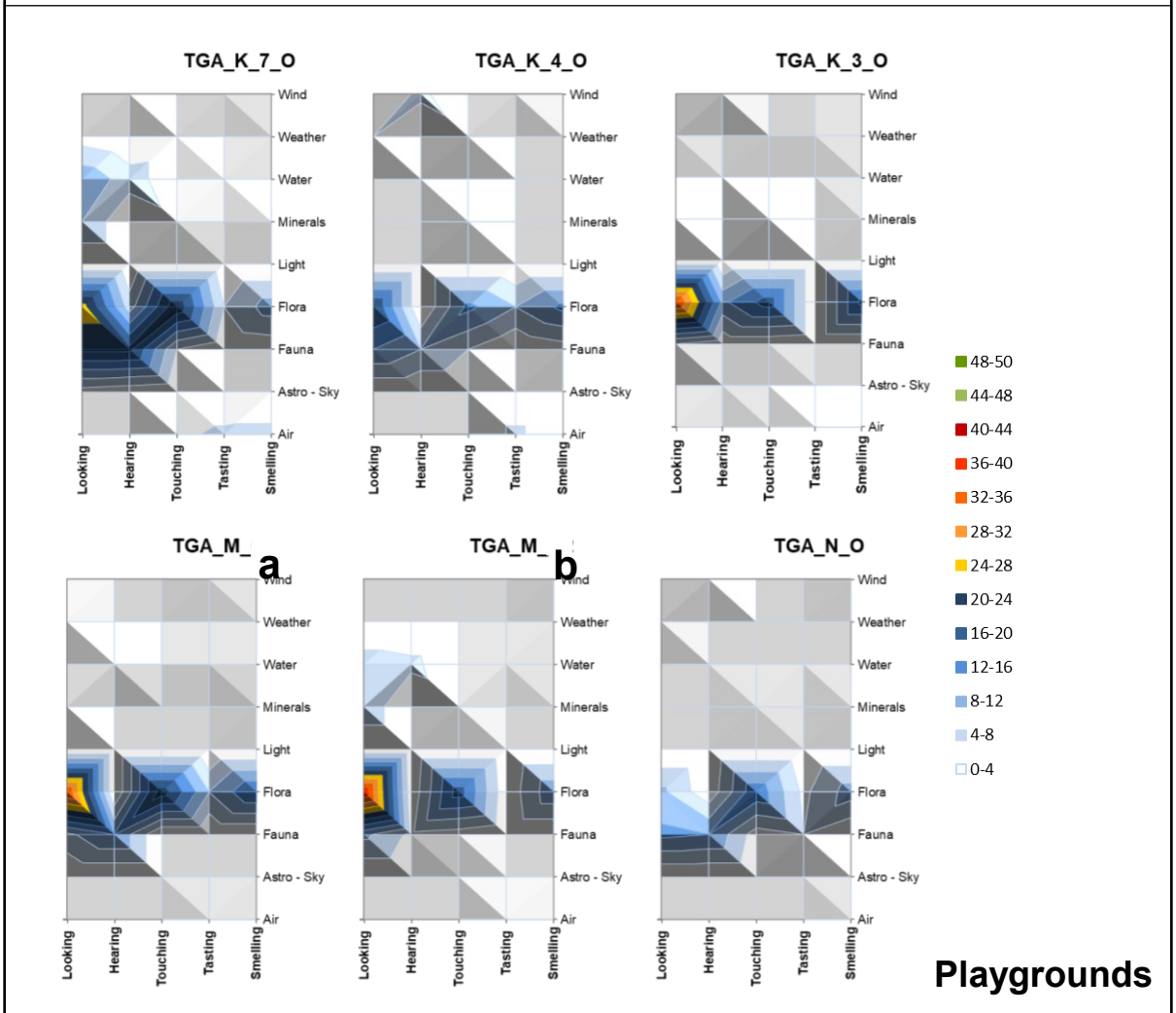

TGA_K_7_O
TGA_K_4_O
TGA_K_3_O
TGA_M_
a
TGA_M_
b
TGA_N_O
Wind
Weather
Water
Minerals
Light
Flora
Fauna
Astro - Sky
Air
Looking
Hearing
Touching
Tasting
Smelling
48-50
44-48
40-44
36-40
32-36
28-32
24-28
20-24
16-20
12-16
8-12
4-8
0-4
Playgrounds

Table 1. Themes of affective feelings related to perceived nature

Features of feelings		Coding Categories	Relevant words
Pleasant	High arousal	Surprise Excitement	*different, surprised, weird, strange, odd, exotic* *cool, excited, excited, exciting, welcome*
	Moderate – high arousal	Joy	*happy, very happy, joyful, delighted, funny*
	Moderate – low arousal	Satisfaction	*fresh, nice, fine, refreshed, lucky, good*
	Low arousal	Appreciation	*new, alive, mindful, make … positive, helpful, like, refreshing, fresh, cool, warm, colourful, cheery, wonderful, lovely, loving, cute, love, gentil: beautiful*
		Relaxed Calmness	*relaxed, relax* *calm, peaceful*
		Boredom	*normal, nothing, blank, tired*
Unpleasant	Moderate – low arousal	Sadness	*sad*
	Moderate – high arousal	Craving	*jealous, hungry*
	High arousal	Disgust Anxiety, Fear	*yucky, grumpy, not to good, dirty, disgusting, sick* *alarmed, a bit scarred*

Table 1. Ratios of TGA_children's affective feelings according to perceived natural types and senses

	Senses	Air	Fauna				Astro - Sky	Light	Minerals	Flora						Water	Weather	Wind
			Pets	Insects	Birds	Total				Tree, plant	Flowers	Leaves	Grass	Others	Total			
Pleasant – High arousal	L	-	.32	.60	.14	.26	1.0	-	-	.31	.44	.11	-	.14	.31	.14	.20	-
	H	-	.18	-	.36	.25	-	-	-	.13	-	-	-	-	.01	.09	-	.19
	To	.05	.09	-	-	.02	-	-	-	.12	.02	.11	-	-	.07	-	-	-
	Ta	-	-	-	-	-	-	-	-	-	.02	.07	-	-	.02	-	-	.06
	Sm	.14	-	.13	-	.02	-	-	-	.04	.12	.07	-	-	.07	-	.20	.06
Pleasant – Low arousal	L	-	.23	-	.10	.11	-	1.0	.44	.27	.12	.21	1.0	-	.19	.32	.40	-
	H	-	-	.07	.36	.22	-	-	-	.04	-	.04	-	-	.02	.27	-	.44
	To	.05	-	-	-	-	-	-	-	.10	.12	.11	-	-	.10	-	-	.06
	Ta	.27	-	-	-	-	-	-	-	-	-	.07	-	-	.01	.05	-	-
	Sm	.41	-	.07	-	.01	-	-	-	.06	.10	.04	-	.29	.08	-	-	.06
Unpleasant – Low arousal	L	-	-	-	-	-	-	-	-	.02		.04		.29	.03		.20	
	H	-	-	-	.02	.01	-	-	-	-	-	-	-	-	-	-	-	-
	To	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.09	-	.06
	Ta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sm	-	-	-	-	-	-	-	-	.00	.02	-	-	-	.01	-	-	-
Unpleasant – High arousal	L	-	-	.07		.01	-	-	.11	-	.02	-	-	.29	.02	.05	-	-
	H	-	.14		.02	.05	-	-	-	.02	-	-	-	-	.01	-	-	.06
	To	-	-	-	-	-	-	-	.22	-	-	.04	-	-	.01	-	-	-
	Ta	.09	-	-	-	-	-	-	.11	-	.02	.04	-	-	.01	-	-	-
	Sm	-	.05	.07	-	.02	-	-	.11	-	.02	.07	-	-	.02	-	-	-
		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Notes:
Pleasant – High arousal: Surprise; Excitement, Entrancement, Interest; Joy
Pleasant – Low arousal: Appreciation, Adoration, Admiration, Awe, Satisfaction; Relaxed, Calmness
Unpleasant – Low arousal: Boredom, Sadness
Unpleasant – High arousal: Disgust, Craving; Anxiety, Fear

Nature : plants, trees, etc. /animals /weather, climate, sky, cloud, etc. /water / soil, rock, etc. /fire, ice, etc.

☺ What is your favourite place at your school? .....

☺ Tell me why you like this place: .....

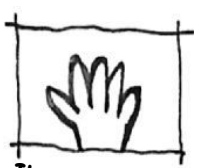
a. Classroom

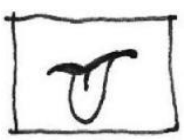
What does it look like?
Colour/shape/action

How do you feel?


What **nature** do you **SEE** ?


What **nature** do you **Hear** ?


What **nature** do you **Touch** ?


What **nature** do you **Taste** ?


What **nature** do you **Smell** ?

Initials: ..... Class: ..... Age: ..... Girl: ..... Boy:..... Date: ..... Time: ..... School..... Place: .....

Nature : plants, trees, etc. /animals /weather, climate, sky, cloud, etc. /water / soil, rock, etc. /fire, ice, etc.

☺ **What parts of nature** do you **like most** in the **school playground** and **garden?**

.....

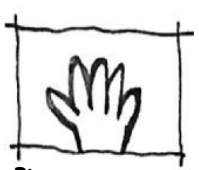
b. Playground

What does it look like?
Colour/shape/action

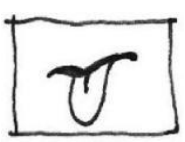
How do you feel?

What **nature** do you **SEE** ?

What **nature** do you **Hear** ?



What **nature** do you **Touch** ?



What **nature** do you **Taste** ?

What **nature** do you **Smell** ?

Initials: ..... Class: ..... Age: ..... Girl: ..... Boy:..... Date: ..... Time: ..... School..... Place: .....