Senseed: A Multisensory Learning Environment
For Urban Pre-Schoolers in China to Learn About Plant Seeds

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A consequence of rapid urbanisation is the ever-limited availability of green space in cities, limiting children’s access to nature and associated learning opportunities. To address this issue, the present paper describes the design of a learning environment called Senseed. The proposed project will introduce urban children aged 3-6 years to sensory games designed to increase their interaction with China’s natural environment, thus enhancing their interest in and understanding of nature. The study combines interviews, a questionnaire, and case studies to identify environmental education issues for pre-school learners, employing exhibition settings as a healthy and engaging multidisciplinary approach to pre-schoolers’ needs. Based on the theme of seed propagation, Senseed encourages pre-schoolers to play visual, auditory, tactile, and olfactory games, which are respectively assigned to four separate rooms. Unlike traditional displays, Senseed’s four rooms introduce natural elements of seed propagation—such as wind and sunlight—into these games. Children are encouraged to collect seeds and nurture and observe them at home to cultivate understanding and build emotional connections.

Keywords: environmental education; interactive experience; multi-sensory environment; pre-school education

Introduction
Nature deficit disorder (Louv, 2008) is a social phenomenon in which children become disconnected from nature because of fewer opportunities for outdoor activities or exposure to wildlife. According to the Research Report on Chinese Children’s Intimacy with Nature in Cities in 2013, 12.4% of a sample of over 1,300 children showed a tendency to be nature-deficient. This disorder has the following negative effects:

- little respect for nature (indifference, aversion, lack of empathy for plants and animals);
- ignorance of nature (lack of knowledge about food sources, no recognition of local plants);
- limited sensory development;
- reduced creativity and imagination;
- shorter attention span;
- poor physical condition (myopia, obesity); and
- psychological problems (depression, autism).

Numerous studies have confirmed this disconnect and associated problems (e.g., Kuh et al., 2013; Dyment & Bell, 2006; Fjartoft, 2004; Pellegrini, 2005; Taylor et al., 2001; Wells, 2000). A survey conducted by the author in three kindergartens in Beijing in 2014—including New Beginnings and Creative Bird—confirmed that students lacked general knowledge of natural environments. Of 12 common plants and insects, only ladybugs, dragonflies, and weeping willows were correctly identified by all 130 children. The reasons for Nature Deficit


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Disorder can be summarised as follows:

- little access to natural landscapes;
- overexposure to electronic devices;
- neglect of environmental education because other lessons are prioritised in early kindergarten.\[2\]

According to the 2020 Report on The State of Greening in China, China’s 14.8 square metres of green space per capita\[3\] is worse than the lowest number of 19.69 square metres worldwide as specified in the Annual Report on Remote Sensing Monitoring of Global Eco-environment 2020.\[4\] The use of electronic devices both in school and on weekends is in the top three most time-consuming activities.\[5\] The Research Report on Chinese Children’s Intimacy with Nature in Cities shows that 48.5% of Chinese children spend less than three hours a week outdoors, and it recommends that a primary school child should spend more than seven hours a week outdoors for extended periods of time. An over-emphasis on skills training has contributed to the neglect of other aspects of children’s overall development. According to the Report of Chinese Children’s Development (2019) - Situation of Children’s Life Outside School, most of the children’s time outside school is spent on homework, with an average of 87.85 minutes.\[6\]

The tangible benefits of exposure to natural environments for children’s comprehensive development have been extensively validated in relation to physical activities (Bell et al., 2008; Fjortoft, 2004; Lovell, 2009), mental and emotional health (Fabér et al., 2001; Roe, 2009), motor development (Fjortoft, 2004; Scholz & Krombholz, 2007), and creativity (Lester, 2007; Nicholson, 1971; Lou, 2008). Additionally, children can develop their environmental knowledge through contact with natural settings (Milton et al., 1995; Pilgrim et al., 2007), as well as an affective connection to nature (Bixler et al., 2002; Thompson et al., 2008). In terms of environmental education across age groups, younger children (up to 11 years old) tend to exhibit a stronger connection to nature, with more substantial positive short-term impacts than among older children (see Liefänder et al., 2013; Wells & Lekies, 2006). Wilson (1996) and Tilbury (1994) assert even more explicitly that environmental education should begin at the pre-school level or earlier. In light of children’s limited access to the natural environment in urban China and the fact that environmental education for children is somewhat neglected in practice, existing evidence of the wide-ranging benefits of environmental education for pre-schoolers should therefore be given greater emphasis.

According to Gu et al. (2020), environmental education for children can be facilitated both by increasing their exposure to natural elements in their physical environment and by adding nature-based lessons or activities to school curricula. Most of the existing international literature focuses on outdoor activities and nature-based curricula, while discussions of introducing natural elements tend to focus on schools and indoor activities in nature conservation institutions (Gu et al., 2020; Hu & Xu, 2006; Ballantyne & Packer, 2002; Fjortoft, 2001; Bailie, 2012). Notably, nature-related museums and exhibitions remain relatively scarce (Ardoin & Bowers, 2020). Informal learning spaces for environmental education tend to be monotonous and dominated by traditional parks, zoos, botanical gardens, and related exhibitions (such as nature-specific museums), which have not been widely researched in relation to the needs of pre-school children (Bates, 2018; Piscitelli & Anderson, 2000; Dunn, 2012; Kirk, 2013).

Otto and Pensini (2017) argued that direct contact through natural environmental education can improve environmental knowledge and connection to nature. Similarly, Gill (2014) highlighted the importance of more open, self-initiated, and playful experiences in this regard. In short, it seems important to investigate how nature-themed museums and exhibitions can be optimised to make them more interesting for preschool children and contribute more to their health and well-being. That is the focus of the present research.

The paper describes Senseed, an indoor educational and entertainment environment emphasising multi-

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sensory play with real plant seeds, along with subsequent plant cultivation and development. Senseed’s displays incorporate natural elements such as wind and sunlight and encourage interaction with real natural flora rather than depending unduly on digital media. Senseed’s design includes four distinct spaces, along with tools, play experiences, and a visual identity that links families, schools, and communities through environmental education. It is hoped that the Senseed concept can help optimise the future development of environmental education products, spaces, and services for pre-school children.

The rest of the paper is organised as follows. Building on Piaget’s theory of children’s cognitive development and the concept of cognitive-emotional parallelism, the next section conceptualises environmental education for pre-schoolers in terms of the affective, cognitive, and behavioural requirements for designing more effective learning settings. The paper goes on to analyse relevant display methods, game activities, and exhibitions, and then discusses contemporary environmental education issues in relation to pre-schoolers. Building on the conceptual framework and associated analysis, the section after details the design of Senseed, and the final one discusses its prospective application and areas for future development.

Cognitive, Affective and Behavioural Traits of Preschool Children in the Context of Environmental Education

In China, the term “pre-school” refers to children aged inclusively between three and six years who have not yet entered primary school. Lieffländer et al. (2013) criticised the neglect of environmental education for children and the failure to improve their sense of connectedness to nature. Rather than merely teaching environmental knowledge, Nisbet et al. (2009) argued that this connection to nature should encompass cognitive, affective, and behavioural or experiential aspects. Accordingly, the present study analyses the characteristics of environmental education for pre-school children from those three perspectives and concludes on the six dimensions that are important to a targeted and beneficial environmental education for pre-school children.

Cognitive Traits
Naturalist intelligence is the eighth intelligence in Howard Gardner’s (1995) theory of multiple intelligences (MI), and its existence is supported by neurological evidence (Checkley, 1997). It is clear that the ability to categorise objects objectively, including objects in the natural world, is an important skill for human development. Both Meyer (1997) and Nolen (2003) have noted that attachment to nature can be developed through education designed specifically to shape naturalist intelligence.

The cognitive characteristics of pre-schoolers are predominantly grounded in their perceptual-motor experiences (Piaget, 1970), and subsequent research confirms that environmental education with adequate sensory supports can help children learn better (Boss, 1999; Bredekamp & Copple, 1997; Kahn, 1997; Kahn & Kellert, 2002; White & Stoecklin, 2008). An example is using, reducing, and rebuilding new stores of sticks or shells in creative play and observing nature while collecting materials from one’s natural surroundings (Beery & Jørgensen, 2016). Direct sensory exploration of real natural elements—through sight, sound, touch, smell, taste, and bodily movement—can render experiences more meaningful for children (James & Bixler, 2008), thus creating an affective bond with nature and cultivating their interest in ecological behaviours (Monroe, 2012).

Volpe and Gori (2019) underlined the need for primary education to target the right senses; for example, touch is more useful than vision for perceiving texture. In general, as appropriate sensory signals can help children learn specific concepts, a flexible multisensory approach beyond the current visual hegemony in education facilitates personalised learning. Therefore, the use and selection of digital media needs to take into account sensory learning of specific concepts, and this approach is central to the Senseed project.

Because of young children’s short attention span and the rhythm of natural cycles, some self-exploratory activities need more time to reveal the joy of natural environments as compared to the more immediate appeal of digital games and media. For that reason, direct and varied feedback is important when designing nature-based educational spaces and experiences. In science museums, for example, there is evidence that diverse sensory modalities enhance young children’s science learning (Anderson & Lucas, 1997).

Affective Traits
Developing a positive attitude to nature is crucial for pre-schoolers’ overall sense of connection with their environment, and that positivity can be promoted by cultivating their environmental knowledge. According to Piaget, children’s cognition works in parallel with their emotions. That is, their emotional response to something emerges and evolves during contact through continuous education. When introducing young
children to the world of nature, Milbrath (1994, p. 278) and Liefländer et al. (2013) suggested integrating cognitive and affective responses. Indeed, according to Wilson (1996) and Carson (1956), feelings are more important than facts. Wilson (1993) believed that humans are born with an inherent emotional bond with life and lifelike forms—a phenomenon known as biophilia (Barbiero & Berto, 2018). This is distinct from natural intelligence, manifesting instead as an ability to process environmental information and output environmental knowledge (Checkley, 1997). However, the intrinsic human inclination towards biophilia can be seen as the ultimate starting point for developing a child’s naturalist intelligence (Barbiero & Berto, 2018). Gardner (1999) also acknowledged that a certain degree of natural intelligence capacity is developed when biophilic preferences are expressed. Zhang et al. (2013) found empirical support for these theoretical findings when they surveyed 1,119 children aged 9–10 years in 15 urban schools in China. Specifically, they found a significant positive correlation between children’s exposure to nature and their biophilic traits. It follows that creating positive emotional experiences when designing informal spaces for environmental education can encourage children to explore nature in great depth. By learning more about nature, pre-schoolers can in turn cultivate their value judgments of the natural world and develop a positive attitude towards it.

Behavioural Traits

Children’s daily routines characteristically include play (Watts et al., 2014; Canadian Association of Occupational Therapists, 1996; Couch et al., 1998; Rodger, 2010), which serves both as a means of developing positive emotions and as a learning process (Piaget, 1951). For that reason, the design of environmental education and nature-based educational spaces must incorporate the fundamentals of play behaviours. The various types of play behaviour can be assigned to four distinct categories: constructive, representational, social, and active play (Johnson et al., 1987). Different types of play can help develop different abilities. For example, Dansky and Silverman (1975) found that children think more creatively in experiments where the rules of the game are not provided, and the tools supplied can be played with freely in the given scenario. In that experiment, children who were allowed to play freely with common objects were better able to think of different uses for the same object after ten minutes than those who could only imitate how the objects were used by adults and those who could only colour with crayons. Nicholson’s (1972) theory of loose parts holds that, in any given environment, inventiveness, creativity, and the possibility of discovery are directly proportional to the number and range of variables in that environment. Manipulative or constructive play with objects is very similar to the type of free play referred to above, as children can explore infinite possibilities for playing with objects in their own preferred ways, and this discovery-based activity tends to be highly creative. According to Singer and Singer (1985), pretend play can help develop children’s adaptability and flexibility. In addition, the psychological need to interact with their peers becomes stronger as children get older. Children as young as two years show some willingness to play with their peers, and between the ages of three and five, they are already learning to share and understand the social principle of fair play (He & Jin, 2006). Piaget (1962) confirmed that social play, especially cooperative play, allows children to overcome their self-centredness, satisfying their need to interact with others while also learning to think from the other’s perspective and to understand the idea of roles, laying the foundations for positive interpersonal relationships (Brewer, 1998).

Finally, as well as promoting the growth and development of bones and muscles (Huang, 1989), it has been further theorised that physical play promotes prosocial behaviour in children, making them more compassionate, willing to help others, and to share, cooperate, and donate in the future (Quan, 2012). Given previous theories on the cognitive, affective and behavioural characteristics of preschool children, the author summarised the following six dimensions that can be targeted further to provide interesting, effective, and beneficial environmental education for preschool children:

- the use of all five senses in children’s learning and exploration;
- direct contact with real natural objects;
- varied ways of exploration;
- collaboration with peers;
- information and entertainment;
- immediate feedback.
Figure 1. Six dimensions of environmental education for pre-schoolers in exhibition settings.

**Types of Display and Activities in Contemporary Children’s Environmental Education Spaces**

In shaping urban children’s attachment to nature, educational spaces such as natural history museums, nature-related science museums, and art exhibitions targeting families, kindergarteners, and the general public are important audience-specific platforms. According to the 2012 Blue Book on Outdoor Activities for Urban Children in China, parents exert the strongest positive influence (46%) on their children’s outdoor activities. In contrast, teachers’ positive influence was surprisingly low (3.3%). Most children were found to have little access to nature: 71% reported that walking and strolling in open spaces in their neighbourhoods accounted for most of their daily outdoor activity, and 14.8% were primarily exposed to nature indirectly through structured weekend visits to zoos, botanical gardens, forest parks, and museums.\(^7\)

This section examines the display and game methods in children’s environmental education spaces in relation to the six dimensions mentioned in the previous section. The cases are mainly selected from natural science museums and natural history museums in Shanghai, China and the surrounding cities with developed educational resources, but also include exhibits from other types of institutions related to environmental education, such as art museums and children’s museums (Andre et al., 2017). In order to analyse more comprehensively the current trends and issues in environmental education spaces for children, some Chinese cases have obvious limitations, and in these instances, representative advanced cases from overseas are selected.

**Display Approaches**

- **Static Objects or Artifact Models.** Specimens and objects that afford little interaction have been identified as a major problem in science museums’ efforts to disseminate scientific knowledge to the general public in China (Dong et al., 2010). For example, both the Natural History Museum and the National Wetland Museum in Zhejiang place relatively large collections of specimens on static display in reconstructed scenes of wildlife (Figures 2 and 3). While the American Museum of Natural History’s addition of sounds and smells to simulate the life of prehistoric plants and animals (Figure 4) is

\[^7\] http://www.ci123.com/article.php/43691
considered a breakthrough beyond traditional exhibition practice, displays remain passive, with limited interactive value.

Figure 4. American Museum of Natural History, New York, USA. ©C. Chesek

Figure 5. Manchester Museum, UK. ©Elaine Bates

The Manchester Museum has transformed the specimen display in the Nature Discovery gallery into a familiar scene for children by creating a storybook made of cut-out papers (Figure 5) outside the specimen stand. This encourages parents to guide their children and read with them, using the exhibit to trigger interaction (Bates, 2018).

- **Multimedia Exhibitions.** Increasingly, multimedia installations facilitate child-exhibit interactions in a playful way by using mobile computing, wireless technologies, sensors, sound, and visual tracking (Xu, 2005). In the Funky Forest of the Art Garden exhibition at Singapore Art Museum, for example, children can move physical logs to redirect waterfall flows to provide water to plants that are projected on the wall, which attracts more creatures to inhabit the forest. This interactive hands-on approach and sophisticated visual effects embody the play-related characteristics that children so enjoy and meet the cognitive, behavioural, and other psychological needs of childhood development (Figure 6).

Figure 6. Funky Forests, Singapore Art Museum, Singapore. ©Design IO LLC
Although exhibitions of this kind are designed to supplement the limited interactivity of static displays, the ultimate purpose of getting close to nature is not well-served by an over-reliance on technology. Although allowing them to enter a room with immersive video games is an effective way of getting children to put down their iPads, the version of nature that these children encounter is still a product of virtual technology and cannot ultimately heal the nature deficit.

Game Types

- *Sports Equipment.* Large-scale sports equipment inside or outside the natural displays typically uses exaggerated plant and animal forms to attract children. In Figure 6, for example, vines and mushrooms are transformed into climbing playgrounds to capture children’s playful behaviour, using physical activities to encourage them to run and chase.

Although these exhibits eliminate the use of technological supports to engender intense sensory stimulation, the children are again exposed to artificially processed natural elements rather than to natural objects per se. This again differs somewhat from children's activities in real natural environments and does not help them understand real wildlife.

- *Role Play.* This is one of the favourite activities of pre-school children. For example, children disguised as bees and ladybirds can burrow into flowers to learn about their structure and the process of pollination.

- *Construction Play.* At present, most venues and educational spaces outside China utilise hands-on exhibits such as “measuring the size of a butterfly’s wings” or “feeling how many bones are in an elephant’s trunk.” However, this highly task-oriented form of learning leaves little scope to freely explore construction play, which is not often seen in natural museums.

The National Building Museum in Washington, D.C. offers children a more engaging combination of construction play and sensory experience. This is an effective way of encouraging active and creative thinking, and deepens children’s understanding of educational objects through fine hand movements and tactile and visual perception. As shown in Figure 8, children can build their own skyscrapers from different building parts. Through manipulation, they can use their imagination while learning about building structures.
Issues with Children's Contemporary Environmental Education in China

Among young children, hands-on manipulation, sensory engagement, and self-initiated exploration are crucial for learning (Wilson, 1996). However, the author found few exhibits or activities targeting pre-schoolers at the China Wetland Museum and Zhejiang Natural History Museum. Such museums typically exhibit specimens or, at the other extreme, rely heavily on digital media to simulate nature, using interactive images to entertain children. While this kind of indirect and vicarious contact may compensate for children’s lack of opportunities to engage with and explore natural landscapes (Kellert, 2005; Bates, 2018), such experiences cannot adequately convey the reality of those landscapes or the opportunities they afford for spontaneous— as opposed to pre-designed— exploration (Sobel, 2008).

After focusing on the public exhibition environment in former section, this one will look at the common approaches to environmental education at home and school (Table 2), and include their disadvantages and advantages in an attempt to understand the panorama of contemporary environmental education for children in China.

According to the six dimensions that characterise the environmental education of pre-school children in the second section, there are several approaches in each category—public spaces, kindergartens and homes—that seem to contribute to the development of pre-school children’s learning about the natural world, as they form a relatively complete hexagon (Table 1 and 2). Respectively, outdoor activities represented by camps and so on meet children’s social needs and engage them in a sensory process; raising and cultivation activities like domestic pets, plants and kindergarten nature corners promote direct contact and emotional bonds with the natural world; and construction games of exhibitions allow a varied exploration that enables immediate feedback. When these radar diagrams are overlapped, as in Figure 9, the shortcomings of these methods are still obvious, but these could be alleviated by incorporating the others’ positives. Therefore, this elucidates crucial perspectives for designing a targeted environment of environmental education for children aged 3-6 years.
<table>
<thead>
<tr>
<th>Locations</th>
<th>Activities</th>
<th>Objects</th>
<th>Games</th>
<th>Pros and cons</th>
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</thead>
<tbody>
<tr>
<td>Public spaces</td>
<td>Parks and green spaces</td>
<td>Natural elements</td>
<td>Multisensory/social/constructive</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
</tr>
<tr>
<td>Zoos and aquariums</td>
<td>Natural elements</td>
<td>Vision-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camps/nature schools</td>
<td>Natural elements</td>
<td>Multisensory/representational/active and physical/social/constructive</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
<td></td>
</tr>
<tr>
<td>Exhibitions - constructions play</td>
<td>Natural elements/cartoonish images or objects</td>
<td>Multisensory/representational/social/constructive</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
<td></td>
</tr>
<tr>
<td>Exhibitions – multimedia</td>
<td>Images/videos/cartoonish images or objects</td>
<td>Vision/tactile/active and physical/constructive</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
<td></td>
</tr>
<tr>
<td>Exhibitions - static objects or artefact models</td>
<td>Natural elements</td>
<td>Vision-based</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
<td></td>
</tr>
<tr>
<td>Exhibitions - sports equipment</td>
<td>Cartoonish images or objects</td>
<td>Vision/tactile/active and physical</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
<td></td>
</tr>
<tr>
<td>Exhibitions - role play</td>
<td>Cartoonish images or objects</td>
<td>Representational/social</td>
<td>Immediate Feedback, Direct Contact, Varied Exploration, Information and Entertainment, Collaboration</td>
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</tr>
</tbody>
</table>

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Table 2. Advantages and disadvantages of environmental education in China (kindergartens and homes)

<table>
<thead>
<tr>
<th>Locations</th>
<th>Activities</th>
<th>Objects</th>
<th>Games</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
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<td>Kindergartens</td>
<td>Outdoor activities</td>
<td>Natural elements</td>
<td>Multisensory/representational/active and physical/social/constructive</td>
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<tr>
<td>Educational cards and physical books</td>
<td>Images</td>
<td>Vison-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observational corners</td>
<td>Natural elements</td>
<td>Multisensory/representational/social/constructive</td>
<td><img src="image2.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>Homes</td>
<td>Toys</td>
<td>Cartoonish images</td>
<td>Multisensory/representational/social/constructive</td>
<td><img src="image3.png" alt="Image" /></td>
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<td></td>
<td>Television programmes</td>
<td>Cartoonish images/videos</td>
<td>Vison-based</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>Plants and pets</td>
<td>Natural elements</td>
<td>Multisensory/representational/active and physical/social/constructive</td>
<td><img src="image5.png" alt="Image" /></td>
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</tbody>
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The Design of Senseed

As a conceptual and experimental concept of environmental education for pre-schools, **Senseed** is designed to supplement a natural, fun, and educative space when the wildlife outside has a long life cycle and slow feedback for pre-school learners. Compared with animals or other natural objects, plants are common, safe and easy for children to start with. This section describes the project’s design in greater detail, focusing on features taken from the six dimensions listed above.

Direct Contact with Natural Elements

**Senseed** utilises real seeds as the medium for a nature-based experience, encouraging children to learn about seed dispersal by playing visual, auditory, tactile, and olfactory games in each of the four rooms. The visual and auditory rooms, respectively, introduce wind and sunlight. In addition, light sensors, high speed cameras, projections displayed on the ground, infrared sensors, and odour generators are employed to support the necessary science objectives. Utilising natural dynamics, **Senseed** intends to recreate and stress how plants reproduce and alleviate the problem of environmental education spaces in China through the targeted use of digital technology.
Senseed’s branding and visual identity system (Figure 14) also foregrounds seeds. The real grass planted on the logo and other signage throughout the museum means that these change with the seasons. Children can observe and touch them, evoking the changing of the seasons and how this affects the natural environment.

**Multisensory Play**
Unlike traditional natural displays, Senseed is based primarily on multisensory play that is complemented by multimedia technology but not contingent upon it. Figures 15, 16, 17 and 18 show how children are encouraged to interact in the visual, auditory, tactile, and olfactory rooms.

**Figure 15. Visual room interactions**

**Figure 16. Auditory room interactions**
Figure 17. Tactile room interactions

Figure 18. Olfactory room interactions

Drawing on established research on children’s play behaviours, Senseed combines the five senses with games that are suitable for pre-school children, mainly involving manipulative/object play, physical activities, and social games. While some guidance is provided, the distinct absence of fixed rules encourages children to freely explore possibilities for displaying props, seeds, and spaces, thus empowering them to acquire information in their preferred way. By combining different types of play, this format encourages the development of observation, exploration, teamwork, and sensory and physical capabilities.

Varied Ways to Explore

- **Variable Forms of Spatial Organisation.** Blowing dandelions is one of the great joys of childhood play, and incorporating familiar activities into the experience helps children become more involved in new activities (Allen, 2004; Kellert, 2005). Accordingly, the common dandelion was chosen as the main interactive seed in the visual room, along with the willow, maple, and star fruit vines, which also reproduce through wind transmission. As shown in Figure 19, each has a different flight pattern by virtue of their differing construction.

Figure 19. Dandelion seeds, Poplar seeds, Tristellateria Australasiae, and Maple seeds

When the transparent hose is connected to the ground interface, the ventilation system is activated and randomly generates air currents to simulate different wind directions and speeds. These expel the seeds in different ways from the corresponding coloured interface, creating a familiar musical fountain-like effect for children. The children can adjust the wind trajectory from the tubes by connecting different interfaces and creating new flight paths to see the seeds fly in different states and create new forms of spatial organisation and display effects (Figure 20).

Figure 20. Different seed flight paths configured by the children

- **Diversity and Openness of Play Behaviour.** In a traditional exhibition, visitors must usually follow specified operational requirements for interaction. By dispensing with such restrictions, Senseed
greatly increases the children’s level of participation and self-generated initiative.

The auditory room chooses pod plants (yellow beans, black beans, red beans, peas, and others) using ballistic transmission as content for the experience. These pod plants exploit sunlight to crack their tightened skins and eject their seeds into the distance to grow. The cracking can be induced by light and heat and usually makes a clearly audible sound when it occurs.

As children are familiar with reflection games using mirrors, they are encouraged to reflect the sunlight from the roof to illuminate the pods on the walls, heating them up to eject the seeds. During this process, the amplitude and speed of the arms and body can be varied to create different percussions, resulting in different rhythms of blasting and different trajectories of sunlight reflection (see Figure 21).

![Figure 21. Different movements of light on the wall reflected by mirror and sunlight from the ceiling](image)

Taking into account safety and hygienic issues, the sensations of smell and taste are designed as an integrated whole. The olfactory room offers opportunities to engage with sour, sweet, bitter, and salty tastes and smells, basing the content on foods with distinctive qualities such as lemon, apple, bitter gourd, chilli, and asparagus. When the author experimented with the prototype for the smell boxes, children were observed putting different boxes together to combine the smells (Figure 22). This self-motivated innovation is a positive validation of the approach, as mixing smells in this way represents a new form of olfactory interaction.

![Figure 22. Prototype of smell boxes](image)

Collaboration

Rather than a single interactive act, smelling boxes in the olfactory room become more like a cooperative game, which extends the fun. The tactile room also supports co-operative gameplay. Here, the seed types are the Spiny Cocklebur and the Bidens Pilosa, which rely on animal furs to travel great distances. Soft, spherical
booths encase these seeds, changing the width of the path in space as they move rhythmically between larger and smaller spherical booths. As the paths change in size, the child’s position changes in relation to the display. For example, if a pathway that two children can cross together becomes a pathway that only one person can pass through sideways, the child must change their interaction behaviour from an easy “run” to a hard “squeeze” (Figure 23) as the location and amount of seeds sticking to the child also change.

Figure 23. Paths change in size

The Bond of Emotion and Knowledge

In Senseed, the four rooms correspond to the four modes of dispersal, and children can collect their favourite seeds to take back to their school or home to cultivate. This encourages them to take proactive ownership of the cultivation process, facilitating engagement both during and after the visit. One of the tools used to extend the experience of the venue is the playbook, which contains information about the different modes of plant dispersal in each of the four rooms and features special tricks that allow children to relive the games they played at the venue. For example, in the chapter on the visual room, children can press the plastic bubble wrap on the pages to create air flows that keep the dandelion seeds flying. In the chapter on the auditory room, the collected pods can be stored until the child interacts with the mirrors to eject the seeds from their pods. Using the collected Spiny Cocklebur and Bidens Pilosa seeds, children can experiment with different textures of fabric to see which will capture the most seeds (see Figure 24).

Figure 24. Visual, auditory, tactile, and olfactory pages of the playbook

By following the steps in the interactive playbook, children learn to nurture and care for the plants and develop an understanding of the light, water, and soil needed for different plants to grow, along with a sense of pride and ownership that further deepens their connection and interaction with nature.

Conclusion

As mentioned at the outset, nature deficit disorder is threatening urban children’s connection with nature in China, risking degradation of the senses, mental illness, physical weakness, and ignorance and indifference regarding wildlife. Natural history and natural science museums and exhibitions are important venues for bringing pre-school children into indirect contact with the natural world, but these currently depend on high-tech replicas and monotonous displays, interaction, and games. The aim of the present study is to boost children’s knowledge and enjoyment of nature by introducing natural elements into exhibition spaces in various ways that will encourage age-appropriate multisensory activities. By enabling children to collect seeds to grow at home, it is hoped that Senseed will enrich the design of displays and interactive games in exhibition settings.

This paper still has some limitations. Firstly, research on the environmental education in contemporary China still relies mainly on desktop research and official reports, with limitations in terms of sample size and type of data obtained from primary interviews and field research, which to some extent affects the analysis of issue
from a more localized point of view. For further application of the conceptual design, these solutions also need more prototype work to test the possibility of meeting the characteristics of Chinese students in the future. Secondly, although Senseed questions the current dependency on technology to engage children with over-edit nature images as a potential problem for an objective understanding of nature, it does not completely dismiss the role of technology in nature-related display settings. The utilization of natural force to enhance preschoolers’ perceptions of how seeds spread in natural world provides a new approach to the use of technology in environmental education, but a systematic investigation on the invisibility of technology (Hill & Bannon, 2006), namely the balance between technological magic and the perception of wildlife to achieve certain educational function, could enrich the subject in the future. Finally, Senseed seems to extend the impact of urban environmental education through tools from the venue to homes and schools (such as the play book and plant seeds that can be taken away after a visit), which also pushes to a higher level of discussion on how public venues can strengthen the systemic links between the various platforms in environmental education like families and schools.

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