Improving Children's Emotional Health through Installing Biowalls in Classrooms

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ABSTRACT

Background and objective: The physical environment where children spend most of their time is closely associated with their emotional development. To improve the emotional health of children, the introduction of natural elements in the indoor space has been suggested, the benefits of which have been shown in preliminary studies. This study aims to examine the effects that a biowall – a wall installation – in a classroom has on the emotional health of children in kindergarten.

Methods: A total of four biowalls were separately installed in four kindergarten classrooms at a school in Seoul, South Korea, and the 60 children in these classrooms participated in the study. We assessed the children's emotional intelligence (via an Emotional Intelligence Rating Scale), resilience (via the Devereux Early Childhood Assessment), and eco-friendly attitudes (via the Children's Attitudes Toward Scale) before the installation of the biowalls and then again 3 months later.

Results: The children's emotional intelligence, resilience, and eco-friendly attitudes had been significantly improved after the installation of the biowalls ($p = .01$). The sub-categories of the children's emotional intelligence and resilience were also significantly improved ($p < .001$).

Conclusion: This study demonstrates the potential of biowalls—as an indoor environmental factor—in promoting the healthy emotional development of children. By bringing natural elements into indoor classroom settings, biowalls appear to increase children's direct/indirect contact with nature. To extrapolate the results of the study to the general population, future studies should be conducted with broader age groups.

Keywords: Biophilic design, classroom environment, emotional intelligence, nature exposure, wall-greening

Introduction

Children's emotional development is closely associated with the physical environment in which they spend most of their time (Ferguson et al., 2013). Studies have shown that children prefer spending time in natural green spaces, such as grassy fields or parks (Korpela, 2002; Moore, 1986). When one feels connected to nature, they may experience a reduction in stress and express positive social and

eco-friendly behaviors, among many other benefits, which contribute to enhancing an individual's quality of life (Collado and Staats, 2016; Howell et al., 2013). Since children are sensitive and receptive to nature's benefits, providing a connection to nature during their preschool years is exceptionally critical (Kahn and Kellert, 2002; Phenice and Griffore, 2003; Zhang et al., 2014).

Children living in the urban environments of modernized cities barely have sufficient opportunities to experience and

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play in nature (Bailie, 2010; Hofferth, 2009). In today's society, children spend most of their time indoors during school hours, interacting with artificial objects, textbooks, and toys (Bailie, 2010; Phenice and Griffore, 2003). In South Korea, for example, preschool children spend approximately 22.7 hours indoors during the weekdays and only experience the outdoors for an average of 34 minutes each day (Yoon et al., 2020). Meanwhile, 12% of children in the UK (1.3 million) have not even visited a natural environment (e.g., park, forest, or grassland) within the last year (Natural England, 2016). Making matters worse, this trend of children spending huge amounts of time indoors has been increasing from 1975 to 2015 (Mullan, 2019). This highlights the importance of ensuring a high-quality classroom environment for children that lack nature-oriented indoor spaces (van den Berg et al., 2017). Studies illustrate that children experience different states of development and well-being according to the design of their learning environment, or classroom, where they spend so many hours of their daily routine (Evans, 2006; Leung and Fung, 2005).

Placing plants in a learning environment to combine nature with indoor spaces, for example, can help achieve this goal, and has gained popularity in recent years. It is also known as biophilic design (Gillis and Gatersleben, 2015), which relies on the assumption that plants positively contribute to the quality of an indoor environment (e.g., through air-purification and climate control) due to the emotional responses that result from their presence (Deng and Deng, 2018). Direct/indirect exposure to nature via indoor plants may not only benefit one's living environment but also benefit an individual's health in physical, cognitive, social, and emotional respects (Pegas et al., 2012).

Choi et al., (2016) reported that installing a minimum number of plants in an indoor space could lead to emotional stability and recovery, as their subjects showed improvements that were evident in their brain waves and heart rates. For children and students, studies have found that installing plants in a classroom improves physical health, motivation for academic achievement and concentration, while reducing problematic behaviors (Daly et al., 2010; Doxey et al., 2009; Park et al., 2008). For example, adding indoor gardens to urban elementary school classrooms creates opportunities for children (who previously lacked access to

nature in their classrooms) to interact with and experience nature, which increases their attention spans and emotional intelligence (H.H. Kim et al., 2020; van den Berg et al., 2017). Similarly, a study investigated the effects of placing plants in classrooms by utilizing biowalls. The study included 170 children (7-10 years old) from four classes, and the researchers discovered that the installation of biowalls increased the children's attention span and encouraged them to positively evaluate the classroom environment after four months (van den Berg et al., 2017).

An example of biophilic design, biowalls are a creative alternative to containerized plants in a classroom environment (Manso and Castro-Gomes, 2015), and there are numerous advantages of utilizing them in an indoor space. Often referred to as vertical planting systems, biowalls need less maintenance than conventional containerized plants/gardens due to their self-supportive drip irrigation systems. Also, the vertical presentation of the plants on biowalls demands less space than plants displayed in containers. A biowall has a large green side across its surface, which contains space for dense plant placement. This facilitates the unique sensation and experience of nature, creating a substantial psychological impact on viewers. Another characteristic of biowalls is their ability to purify the air, while moderating the temperature and humidity in the space's micro-environment. Furthermore, biowalls can offer an opportunity for environmental education, aesthetic value, a resting space, and emotional/psychological stability to observers (van den Bogerd et al., 2020).

Thus far, there has been a lack of studies investigating the effects that indoor plants have on children's emotional development. Therefore, this study examines the effects of biowalls on the emotional health of children in kindergarten, as they spend most of their time in a classroom environment.

Research Methods

Participants and Experimental Design

To recruit participants for the study, the researchers visited D kindergarten, which is located in Geumcheon-gu, Seoul, South Korea. Before installing the biowalls, the re-

searchers explained the study's purpose, schedule, and the precautions involved to both the young children and their teachers at the kindergarten. Of the children, 60 agreed to participate in the study, and for those who were willing, their parents completed a form, indicating their child's agreement to participate.

The researchers surveyed the demographic information (e.g., gender, age, etc.) that had been provided by the children's parents, which showed that the average age of the children was 4.0 ± 0.8 years. Twenty children per each age group of 3, 4, and 5 years old were selected to form the experimental group. Overall, the male to female ratio was 0.88; 46.7% ($n = 28$) of the participants were boys, while 53.3% ($n = 32$) were girls. The study used a one-group pre-test/post-test design, with no control group.

The Installation of the Biowalls

The plants used in the biowalls were native to South Korea, and included the broad flat rock tree (*Maesa japonica* [Thunb.] Moritzi & Zoll) and the marlberry (*Ardisia japonica*). Plants with evergreen growth characteristics in the shade were selected for this study, to enable easier maintenance and management of the biowall. In addition, these plants are known for providing the effects of removing fine dust and purifying air (National Institute of

Biological Resources, 2018). The installation was completed on the walls of four kindergarten classrooms (Fig. 1). One biowall was installed per classroom, so four biowalls were installed in total (Biowall, Garden4u, Ansan, Korea). The areas of the biowalls were 222 cm x 110 cm, 150 cm x 120 cm, 150 cm x 123 cm, and 148 cm x 121 cm, as they were modified to fit the sizes of the individual classroom walls (Fig. 1). The biowalls were equipped with an air ventilation system, which circulated and propelled the fresh air that was released from the plants on the biowalls into the ambient air. Also, an automatic irrigation system was installed, which controlled the water, supplying an adequate amount to the plants. The children were at the kindergarten, where they were exposed to the biowalls, for an average of seven hours daily.

Assessments

To assess improvements in the children's psychological health, we measured their emotional intelligence, resilience, and eco-friendly attitude. The evaluation was conducted twice by the children as well as their teachers. The first evaluation occurred before the biowalls' installation and the second was conducted 3 months later. The children's emotional intelligence and resilience were evaluated by the teacher based on observations of their daily life, while

Fig. 1. This is an example of an installed biowall (148 cm x 121 cm) and the plants that were utilized, which include broad flat rock trees and marlberry.

the researchers asked the children questions regarding their eco-friendly attitude (i.e., a self-evaluation). The average time required for the assessment of each child was 20 min.

Emotional Intelligence

Under the umbrella of social intelligence, emotional intelligence indicates an individual's mental capacity for realizing and describing various emotions, including their own as well as those of others (Lee, 2005; Salovey and Mayer, 1990). To evaluate the children's emotional intelligence, we used the Emotional Intelligence Rating Scale for Preschool Children proposed by Lee (2005) and developed under an emotional intelligence model (Salovey and Mayer, 1990). This scale is composed of 31 questions with four subcategories: Perceive Emotions (7 questions), Manage Emotions (8 questions), Facilitate Thought (9 questions), and Understand Emotions (7 questions). The total possible score of the scale ranges from 31 to 155; a higher score within this range indicates that the respondent has a higher degree of emotional intelligence. The Cronbach's coefficient for the emotional intelligence survey was measured at 0.90 (Lee, 2005).

Resilience

Resilience refers to an individual's mental capacity for handling and successfully adapting to adverse events during their lifetime (e.g., risk, stress, or trauma). To evaluate the children's resilience, we used the Korean version of the Devereux Early Childhood Assessment (Egeland et al., 1993; LeBuffe and Naglieri, 1999; Lee, 2002). The survey included 37 questions with four subcategories: Attachment (8 questions), Initiative (12 questions), Self-Control (7 questions), and Behavioral Problems (10 questions). The total possible score ranges from 37 to 185; a higher score indicates a higher degree of resilience. The Cronbach's coefficient for the resilience survey was measured at 0.85 (Lee, 2002).

Eco-Friendly Attitude

To evaluate the children's eco-friendly attitude, we utilized Children's Attitudes Toward Scale-Preschool version (CATC-PV) (Hur, 2001; Musser and Diamond, 1999). This scale is composed of 18 questions, with two subcategories:

Nature-Friendly Attitude (11 questions) and Environment Conservation Attitude (7 questions). The total possible score ranges from 18 to 72; a higher score indicates a more positive eco-friendly attitude. The researchers individually interviewed the children and ensured that the pictures used in the study were clearly understood. The Cronbach's coefficient for the emotional intelligence survey was measured at 0.75 (Hur, 2001).

Satisfaction Survey

We revised and tailored a satisfaction survey for the classroom environment (Park et al., 2016). The children, parents, and teachers participated in this modified satisfaction survey 3 months after the biowalls were installed. The survey consisted of two questions that related to their satisfaction after the biowalls were installed: (1) How satisfied are you with the environment? (5-point Likert scale), (2) Have the children experienced any positive changes (multiple responses)?

Data Analysis

To compare the children's measurements before and after the biowalls' installation, the paired samples t-test was conducted utilizing SPSS software (Version 25 for Windows; IBM corp., Armonk, NY, USA). For a reliability analysis, Cronbach's α coefficient was calculated to measure the reliability of this study's evaluation tools. Values of $p < .05$ were considered statistically significant. Finally, the children's demographic information and satisfaction with their classroom environment (after the biowalls' installation) was analyzed by utilizing Excel software (Office 2016; Microsoft Corp., Redmond, WA, USA).

Results and Discussion

The Effects of the Biowalls on Children's Emotional Intelligence, Resilience, and Eco-Friendly Attitude

After the installation of a biowall in their classroom, the children showed significantly improved resilience, emotional intelligence, and eco-friendly attitudes (Table 1, 2,

and 3). Before the installation, the children's emotional intelligence score was 106.12 ± 9.96 , but after 3 months with the biowalls their score was increased to 115.44 ± 9.01 ($p < .001$). Comparing the children's four subdivided scores before and after the installation, they significantly improved after 3 months.

Similarly, a significant increase in the children's resilience score was observed after the installation ($p < .001$, Table 2). The children also showed improvement in the four subcategories for the resilience score: Initiative, Self-Control, Attachment, and Behavioral Problems were

at a highly significant level of $p < .001$.

Also, compared to the scores before the installation, the children's eco-friendly attitude scores were high 3 months after the installation. The children's overall eco-friendly attitude score was increased from 55.32 ± 6.98 to 58.40 ± 6.71 (Table 3). Under the two subcategories for the eco-friendly score, the Nature Friendly Attitude improved, while Environmental Conservation Attitude did not significantly improve over the course of the study.

Satisfaction Evaluation

Table 1. The paired samples t-test comparisons of the children's emotional intelligence scores are illustrated below, including before the installation of the biowalls in the classroom and 3 months after

Variable	Pre-test	Post-test	<i>p</i>
	Mean $\pm$ SD		
Emotional intelligence	106.12 ± 9.96	115.44 ± 9.01	$< .000^{***}$
Perceive emotions	25.09 ± 2.86	27.89 ± 2.76	$< .000^{***}$
Manage emotions	25.58 ± 4.01	27.21 ± 4.01	$.006^{***}$
Facilitate thought	24.05 ± 3.08	25.89 ± 2.82	$< .000^{***}$
Understand emotions	31.40 ± 3.36	34.44 ± 2.89	$< .000^{***}$

Note. $n = 60$

** $p < .01$, *** $p < .001$.

Table 2. The paired samples t-test comparisons of the children's resilience scores are illustrated below, including before the installation of the biowalls in the classroom and 3 months after

Variable	Pre-test	Post-test	<i>p</i>
	Mean $\pm$ SD		
Resilience	95.19 ± 11.49	126.02 ± 12.38	$< .000^{***}$
Initiative	32.52 ± 5.98	37.87 ± 6.25	$< .000^{***}$
Self-control	17.27 ± 4.39	21.00 ± 3.53	$< .000^{***}$
Attachment	23.42 ± 3.17	26.31 ± 3.85	$< .000^{***}$
Behavioral problems	21.98 ± 5.72	40.85 ± 4.86	$< .000^{***}$

Note. $n = 60$

*** $p < .001$.

Table 3. The paired samples t-test comparisons of the children's eco-friendly attitude scores are illustrated below, including before the installation of the biowalls in the classroom and 3 months after

Variable	Pre-test	Post-test	<i>p</i>
	Mean $\pm$ SD		
Eco-friendly attitude	55.32 ± 6.98	58.40 ± 6.71	$.008^{**}$
Nature friendly attitude	34.60 ± 5.05	36.72 ± 4.57	$.015^{*}$
Environmental conservation attitude	20.70 ± 3.51	21.68 ± 3.23	$.109^{NS}$

^{NS}Non-significant * $p < .05$, $p < .01$.

The satisfaction evaluation conducted after the biowalls' installation revealed that 67.8% of the children were either "Satisfied" or "Very satisfied" with the classroom environment in their responses to the first question (Table 4). Regarding the second question about positive changes in the classroom environment, the highest rating among the children was "Feeling better" ($n = 34$, 22.4%), followed by "Classroom was clean" ($n = 33$, 21.7%), and "Air was improved" ($n = 32$, 21.1%).

The teachers ($n = 3$) that responded to the satisfaction evaluation illustrated their satisfaction with the classroom environment (i.e., the addition of the biowalls) for the first question (Table 4). In the second question, the highest rating among the teachers was "Classroom was beautiful" ($n = 2$, 66.7%), followed by "Air was improved" ($n = 1$, 33.3%).

Similarly, most of the parents (96.5%) that responded indicated that they were either "Satisfied" or "Very satisfied" with the biowalls in the classroom environment (Table 4), and many ($n = 34$, 54.0%) said that the "Children became more interested in plants." Regarding the second question about positive changes in their children, the parents said that the "Children were emotionally stable" ($n=10$, 15.9%), "Environmental diseases were alleviated" ($n = 5$, 7.9%), "Children's expressiveness was improved" ($n = 3$, 4.9%), "Children's relationships with peers were improved" ($n = 2$, 3.2%), "Children became more knowledgeable about plants" ($n = 2$, 3.2%), and "Children's concentration improved" ($n=2$, 3.2%).

Comprehensive Discussion

Table 4. Satisfaction with installing the biowalls in the classroom

Environmental satisfaction		n (%)
Children ($n= 59$)	Very satisfied	26 (44.1)
	Satisfied	14 (23.7)
	Normal	17 (28.8)
	Not satisfied	2 (3.4)
Teacher ($n= 3$)	Very satisfied	1 (33.3)
	Satisfied	2 (66.7)
Parent ($n= 57$)	Very satisfied	24 (44.1)
	Satisfied	31 (23.7)
	Normal	2 (28.8)

Installing biowalls to serve as natural elements in a classroom environment significantly improved the children's emotional and behavioral development after 3 months. These encouraging effects, such as increased emotional intelligence, were likely due to children's direct/indirect contact with the natural elements. Direct contact (i.e., observing or touching the plants on the biowalls) included the children experiencing a variety of emotional exercises, which positively influenced the development of emotional intelligence (Coel et al., 2009). Also, these installations changed the physical environment, which encouraged children to interact with the environment, providing them an external stimulus. Notably, closely interacting with natural elements not only may improve social behaviors but also can enhance interactions between individuals, which may be a critical factor in the development of children's emotional intelligence (Mirrahimi et al., 2011). When considering the developmental process of children in preschool, imagery and sensation-based stimuli may serve as alternative tools for encouraging children to recognize and express a diversity of feelings (Brechet, 2017). Thus, having a biowall in a classroom may serve as a simple and naturally effective stimulus for the children that can help them express their emotions about nature or natural elements.

Previous studies also reported that direct/indirect contact with natural elements positively affected children's emotional intelligence (Balseviciene et al., 2014; Lee et al., 2020; Park et al., 2016). For example, a previous study investigated the increased emotional intelligence of 336 children between the ages of five and seven who practiced direct contact with nature by growing plants. Balseviciene et al. (2014) investigated the emotions and behaviors that were affected by having opportunities to experience indirect contact with nature. By observing over 1,468 preschool children between the ages of four and six, they found that preschool children show superior peer relations and sociable behaviors—indicating that they are emotionally stable—if they live in a residential environment that exposes them to nature more frequently.

As the children went about their daily routine in a classroom that contained the new biowall, their enhanced resilience may have derived from them experiencing nature's buffering effects (Wells and Evans, 2003). Contributing to

their sense of resilience, this protective response results from the impact of experiencing close contact with nature, either directly or indirectly. Since the biowalls bring natural elements into the classroom environment, the children assumedly had more opportunities to experience close contact with nature. Thus, we could anticipate (to a certain extent) nature's buffering effects in a classroom setting that contained a biowall, a natural element that exposes children to nature. The buffer provided by the biowall eases the potential effects of stress and adversity on the children (Wells and Evans, 2003).

Previous studies also reported increased resilience and emotional stability after having contact with green plants and nature (Amoly et al., 2014; Flouri et al., 2014; S.O. Kim et al., 2020; Wells and Evans, 2003). For example, S.O. Kim et al. (2020) conducted a study through the lens of psycho-physiology, which demonstrates that the installation of green plants in a learning environment may lead to improved concentration and emotional stability. This conclusion was supported by increased theta-waves in the brain activity of nine-year-old children. Wells and Evans (2003) examined the relationship between resilience and the frequency of exposure to nature by utilizing 337 children as participants. The relationship was positive, which means that if children live in a residential environment that gives them more exposure to nature, they have a superior chance of demonstrating more resilience and self-esteem, a finding which is also comparable to those of the current study.

The improvements in children's eco-friendly attitude 3 months after the biowalls' installation may have been influenced by having nature near their living space, connecting them to it on a more intimate level. Since this study aimed to encourage this connection and instigate contact with nature by providing it in their living space for 3 months, the children may have generated a stronger relationship with nature (Mayer and Frantz, 2004). Therefore, biophilic design (e.g., the installation of biowalls in classrooms) may be a medium or tool for teaching children about environmental education (Cole et al., 2013; Cole, 2014; Tucker and Izadpanahi, 2017).

Previous studies also reported that individuals who live in green spaces or green buildings more easily connect to

nature and demonstrate an enhanced eco-friendly mindset/conduct (Azizi et al., 2015; Wu et al., 2013). For example, Wu et al. (2013) conducted a study on 61 college students and found that those who attended a 'green' school were more likely to recycle their waste, as compared to students who attended a conventional campus. Notably, Cheng and Monroe (2012) reported that having a connection to nature near one's home has a strong positive correlation with developing an interest in environmentally conscious practices, to the extent that it can even be utilized as a predictor. Thus, these studies also support our results and findings, as positive perceptions toward nature facilitate an eco-friendly attitude (Corraliza and Collado, 2019).

Conclusion

The present study demonstrates that installing biowalls in classroom environments at the kindergarten level positively affects children's emotional development and health over a period of 3 months. Biowalls bring natural elements into indoor classroom settings, which provides a physical environment that exposes children to increased direct/indirect contact with nature.

However, this study has limitations, as the design did not exclude the potential for children's maturation over the course of the experiment and the influence of other environmental factors. To differentiate the maturation effects of the fast-growing children, a complete experimental design with control groups should be adopted in future studies. Also, the subject group should be broader, and the space of the studies be directed toward larger audiences. These efforts will further elucidate the various beneficial effects of biowalls in indoor environments.

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