Effect of Biophilic-Horticultural Education on Children's Multisensory Enhancement

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ABSTRACT

This study aimed to develop a program that can be linked to gardening education activities in elementary students' curriculums and creative experience learning courses, and to apply the developed program to 6th graders in an elementary school located in Seoul. Research was conducted in a large category called biophilia, which named the instinct of human nature and nature throughout the research. The curriculum revised in 2015 was selected for the purpose of the garden education program based on the objectives and contents of the unit, and for the purpose of the class. In the process of developing and implementing the program, experience properties and elements were divided into direct and indirect experience of nature, including shapes and forms found in nature, air, water, plants, weather, animals, and natural materials. The results showed that the biophilic horticultural education program was effective in promoting students' multi senses. In the case of the experimental group, all the multi-sensory areas showed statistically significant differences, especially in the area of environmental literacy, environmental effect and emotional balance including plant cultivation knowledge. There was a relatively smaller difference in the dietary effect area than other areas because of no directional dietary program was included in the developed program. As a result, first, it is expected that the data can be utilized on site as a program or place of activity for students in upper grades. Second, it will be necessary to develop a more diverse program using other biophilic elements that were not covered in this study in order to maximize the effects of biophilic education.

Keywords: environmentally friendly attitude, human nature, multi-sensitive angles, space-based experience

Introduction

Biophilia was first coined by Edward Osborne Wilson in 1979, and the term is the combination of “bio (life)” and “-philia (brotherly love),” meaning “love of life” (Wilson, 1994). The biophilia hypothesis has been widely used as a fundamental theory under which humans have an innate tendency to “love life” and restore a balance by seeking connections with nature in the process of urbanization. In particular, he suggested in his recent studies that communion with indoor gardens and green spaces that view nature as an important concept can bring about positive emotions and have positive effects not only directly on natural elements but also works of art that depict nature such as paintings, sculptures, and various activities involving natures, contributing to the reduction of depression and stress (Wilson, 1994). Kellert et al.

This study was supported by the “Research Between the Fields of Elementary Education” of the Subject Matter Education Joint Research of Seoul National University of Education in 2018.

Received: November 19, 2018, **Revised:** November 28, 2018, **Accepted:** December 6, 2018

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(2008) also reported that indirect natural elements that remind people of nature such as paintings and images as well as direct natural elements are effective in reducing stress. In line with that, many education facilities and community centers around the world have actively employed biophilic design, and have maintained green spaces, landscape gardens and other facilities in school environments to ensure students can experience natural elements and participate in programs involving nature and gardening activities using these environments, having various educational effects (Yoon and Lee, 2016). In particular, biophilic design introduces a variety of ecological activities that utilize physical environments, and can be utilized as an environment for healing that positively affect humans' multisensory elements, that is, wellbeing, sensory and psychological stability, resilience and health (Yoon, 2013). However, today's classrooms in elementary schools in urban areas and urban environments do not provide the utility of biophilic design, and they are rather staying in an environment that can produce students who do not care about nature and are ecologically illiterate (Jee, 2015). For this reason, biophilic programs have been considered as an alternative to a conventional one-time horticultural program in order to obtain various educational effects by actively utilizing biophilic elements and school environments that students can explore and experience in person (Yoon, 2013). Against this backdrop, this study aimed to analyze biophilic experience elements and designs that can be commonly found within schools, to develop biophilic horticultural programs by connecting them to the curriculum revised in 2015 and to measure the expected educational effects of the programs applied to children.

Research Methods

Subjects and Procedure

In this study, two 6-grade classes (24 students per class) in S elementary school located in an apartment area in Seoul were selected, and one 6-grade class that was homogeneous with the selected students above in terms of their residential type and prior educational experience was selected as a control group. The procedure shown in Table 1 was adopted to identify the effects of biophilic horticultural education activities and experiences on the multisensory enhancement of children. The research procedure in this study was composed of stages of planning and preparation, implementation and arrangement, and each stage was composed of sub-items including developing research questions, selecting analysis tools, implementing on site, pre and post-experiment questionnaire surveys, analyzing surveyed data and setting follow-up research directions (Table 1).

Experimental Design

The experiment used in this study was designed as shown in Table 2.

Measuring Tools and Methods

Measuring tools used in this study were selected based on various earlier studies in connection with the content of horticultural education and educational goals as shown in Table 3 and 4. They were, in turn, divided into sub-items for the purpose of this study, and a total of 25 questions were developed. Each question was answered on a 5-point Likert scale as follows: 'strongly agree (1 point)', 'agree (2 points)', 'neutral (3 points)', 'disagree (4 points)' and 'strongly disagree (5 points)' (Table 4). The lower the combined score of the entire questions, the higher the biophilic score of the cognitive, emotional and psychomotor domains related to horticulture. The Cronbach's alpha of each sub-item ranged between .69 and .76, showing high reliability. Using the developed questionnaire, pre and post-experiment questionnaire surveys were conducted, and the collected data were analyzed using i-STATistics 2.0.

Table 1. Research process

Step	Procedure	Contents	Period
Planning and preparation	Theory & background exploration	Resource accumulation and categorizing through reference research	2016.11~ 2017.2
	Selecting research problems	Establishment of research planning based on horticultural programs	
	Selecting research tools	Collecting and selecting questionnaire with horticultural activities	
Implementation	Reorganization of educational process	Recomposition of horticultural programs through analysis of 6 grader's contexts and creative experience activity	2017.3~ 2017.12
	Implementation of pre-questionnaire	Implementation of pre-questionnaire and its results	
	Analyzing program elements	Analyzing of concept of biophilia	
		Analyzing of biophilic design elements	
		Analyzing of horticultural education activity	
	Analyzing of pre-research of horticultural program	Discussion of horticultural education activity based reference	
	Field implementation of horticultural programs	Composition and implementation of horticultural program	
	Implementation of post questionnaire	Implementation of post-questionnaire and selection of its results	
Arrangement	Supplementaion of horticultural program	Implementation of program and additional selective questionnaire	2018.2~ 2018.5
	Analyzing of results of questionnaire	Analyzing statistics of questionnaire results	
	Make up of results	Arrangement of research result and writing report	

Table 2. Preliminary analysis of variance in interpersonal relationship tendencies among three groups

	Pre		Post
Treatment group	O ₁	X ₁	O ₂
Control group	O ₃		O ₄

X₁: Application of the biophilic horticultural program

O₁, O₂: Pre-post data analysis of Treatment group(Paired t-test)

O₁, O₃: Pre homogeneity test of Treatment and Control group(Independent t-test)

O₂, O₄: Post homogeneity test of Treatment and Control group(Independent t-test)

O₃, O₄: Pre-post data analysis of Control group(Paired t-test)

Table 3. Division of educational goal

Domain	Division	Contents
Cognitive	Intelligent ability and function development	Plant cultivating skills, plant division, horticulture literacy
Emotional	Attitude, belief, value development	Emotion, humanity, stress
Psych-motor	Health development and diet	Diet, environment purification

Table 4. List of multisensory categories in a 5-point Likert scale questionnaire

Domain	Category	Code	Contents	Cronbach's α
Cognitive domain	Growth environment	1	Understanding of plant watering	.709
		2	Understanding of light intensity	
		3	Understanding of water requirement	
	Plant division	4	Understanding of outdoor plant	.691
		5	Understanding of indoor plant	
	Increase of integrative thinking	6	Interest of plant refinement	.764
		7	Interest of plant art refinement	
		8	Interest of plant science refinement	
		9	Interest of people-plant relationship	
Emotional domain	Emotional stability	10	Understanding of plant's healing effect	.722
		11	Refinement of plant cultivation interest	
		12	Worship of living	
	Stress	13	Relationship of leisure and plant cultivation	.707
		14	Correlation between mind stabilization and plant	
	Humanity cultivation	15	Correlation between sense of responsibility and plant	.710
		16	Interest of plant reservation	
		17	Interest of animal welfare	
		18	Interest of green life	
		19	Consideration of plant	
Psycho-motor domain	Environmental effect	20	Transpiration and plant	.734
		21	Forest shower and plant	
		22	Air purification and plant	
	Dietary effect	23	Interest of vegetables and fruits	.718
		24	Change of eating habit	
		25	Understanding of vegetable and fruit's nutrition	

Results and Discussion

Analysis of Biophilic Elements

To select biophilic elements utilized as a program frame in this study, recent earlier studies on the characteristics and elements of biophilic experience (Lee and Lee, 2016) and the elements and properties of biophilic design (Yoon and Lee, 2016) were analyzed. Considering the characteristics of this study, eco-friendly design elements for elementary schools (Sim, 2008) were also included. Based on the results of analysis, biophilic elements were divided into “biophilic design classification,” “biophilic experience elements,” “biophilic design elements” and “biophilic planning elements” (Figure 1). “Biophilic experience elements” were divided into “direct experience of nature,” “indirect experience of nature” and “experience of spaces and places” (Sim, 2008). Elements under the category of “direct experience of nature” included natural light, air, water, plants, animals, perceived weather, natural landscapes and views and lighting, and elements under the category of “indirect experience of nature” included images of nature, natural materials, natural colors, natural light, imitated air conditions, shapes and forms found in nature, forms reminiscent of nature, abundant information, variability of nature, geometric shapes found in nature and biomimetics. Elements under the category of “experience of spaces and

places” include views and hiding places, complexity, integration of the part and the whole, changing spaces, mobility and navigation (Hwang and Lee, 2015). “Eco-friendly elements” among “biophilic design elements” included color, water, air, sunlight, animals, views and landscapes, greenwalls and ecosystems, and “shapes and forms found in nature” included animal and plant motives, tree shapes, arch shape and biomimetics. “Patterns and processes found in nature” included fractal structure, supplementation and contrast, integration of the part and the whole, spaces for conversion and changes over time. “Eco-friendly relationships between humans and nature” included elements such as views and hiding places, order and complexity, changes and transformation, safety and protection, information and perception, etc. Lastly, “eco-friendly design elements for elementary schools” included “energy efficiency,” “sustainability” and “creation of green environments,” and “energy efficiency” included design elements such as light (natural lighting, artificial lighting), air (natural ventilation, eco-friendly materials), thermal environments (reduction of cooling and heating loads) and renewable energy (solar energy). “Sustainability” included design elements such as materials (utilization of recycled materials), waste (waste treatment) and water resources (water conservation and reuse), and “creation of green environments” included design elements such as landscaping (green buildings, green spaces, biotop, spaces for education) (Sim, 2008). The items above are briefly summarized in Figure 1.

Based on Figure 1, biophilic elements for horticultural activities in schools were re-organized as shown in Table 5. Biophilic experience elements were used as a general frame for embracing all the topics above, and they were, in turn, divided into elements, topics and educational elements (Table 5). In particular, Table 5 shows the overall biophilic elements that can be connected with school environments. This study focused on identifying various biophilic elements within schools considering the unique characteristics of the place of schools and horticultural activities, while general studies focused on the concept of biophilia and its design aspects. In particular, it was difficult to connect place and space-based experiences with many elements considering practical circumstances, but elements like “ecological attachment to

Figure 1. Analysis of biophilic elements.

Table 5. School environment and biophilic element connected with school environment and horticultural activity

Division	Elements	Subjects	Educational elements
Direct Experience of Nature	Natural light	Window (side window, open-shut window) Skylight window Atrium	· Natural light, reflected light, scattering light and shadow, light and shadow, solar energy
	Artificial light	Light control system Sensor lighting facilities	· Role of light and air as plant cultivation environment
	Water	Fountain	· Aquatic ecosystem, water sound, water saving and recycle · Role of light and air as plant environment
		Fishbowl	
		Pond	
	Views and vistas	Waterway	· Nature-human relationship · Circulation of ecosystem, various land-based relationship (natural views, geographic, ecological and cultural relationships)
		Falling water	
		Sky	
		Swamp	
		Forest	
Indirect Experience of Nature	Landscape	Grass	· Nature-people relations, principles and circulation of ecosystem, plant growth and development · Various plant cultivation, craft programs and its educational effect · Cultivation and its educational effect of various small animals and insects
		Hill	
		Mountain	
	Plant	Greening works of architecture	· Nature-people relations, principles and circulation of ecosystem, plant growth and development · Various plant cultivation, craft programs and its educational effect · Cultivation and its educational effect of various small animals and insects
		Creating green belt (flower bed, slope green belt)	
		Biotop	
		Educational space (school garden, greenhouse, vegetable garden, indoor/classroom garden, etc)	
		Indoor plant (foliage plant, succulent plant, fern, etc)	
	Animal	Water plant	· Nature-people relationships, development of five human sensory, etc · Development of various design educational program and craft
		Small animal	
		Insect	
Experience of Space and Place	Images of nature	Sunlight	· Affinity for nature, nature reservation, coexistence of human and nature · Artistic inspiration of nature-based design
		Water	
		Plant	
		Animal	
		Scenery	
	Natural materials	Fire	· Various experience of nature, affinity nature, nature reservation, coexistence between nature and human · Planting techniques based on nature · Landscaping and gardening
		Plant motive	
		Animal motive	
	Natural colors	Natural motive (shell, cloud, wind, etc)	· Recycling of ecosystem, nature reservation, etc · Importance of water resources · Recycling, waste sorting and resource saving
		Wood	
		Stone	
Experience of Space and Place	Naturalistic shapes and forms	Soil	· Recycling of ecosystem, nature reservation, etc · Importance of water resources · Recycling, waste sorting and resource saving
		Cotton	
		Leather	
	Prospect and refuge	Brown	· Recycling of ecosystem, nature reservation, etc · Importance of water resources · Recycling, waste sorting and resource saving
		Gray	
		Green	
	Mobility and wayfinding	Natural pattern (fractal, hierarchy structure, etc)	· Recycling of ecosystem, nature reservation, etc · Importance of water resources · Recycling, waste sorting and resource saving
		Curve, obtuse angle, etc	
		Circle, oval, tube form, etc	
	Ecological attachment to place	Rooftop garden, vegetable garden	· Recycling of ecosystem, nature reservation, etc · Importance of water resources · Recycling, waste sorting and resource saving
		School garden	
		School forest	

place” that was obtained in an earlier study (Sim, 2008) including the utilization of recycled materials, waste treatment, water conservation and reuse were considered as a practical and characteristic element in providing biophilic education that considers the sustainability of ecosystems (Table 5).

Composition of the Biophilic Horticultural Activity Program

Based on the biophilic elements analyzed in Table 5, related subjects and units were analyzed to provide biophilic horticultural activities within the subjects (Table 6). The results of analyzing the subjects for 4th, 5th and 6th graders showed that biophilic elements can be relatively more connected to the subjects for 6th graders such as science, art, social studies, Korean and practical arts. In particular, “direct experience of nature” was mostly related to units about science due to the characteristics of the element, and units about agriculture and horticulture in practical arts, and observation-based

Table 6. Textbook and unit connected with biophilic horticultural contents

Attribute	Element	Connected text/semester/unit/subject		
		4th Grade	5th Grade	6th Grade
Direct experience of nature	Window : side window, open-shut window) : light control system	Science/2(3)/shadows & mirror	Science/1(1)/temperature and heat Art/1(1)/temperature and heat, world of light	Science/1(3)/use of lens Practical arts/1(4)/life & electronics Art/1(4)/world of color and light
	Synthetic light : sensor light, facilities, fountain, fishbowl, pond	Science/2(5)/travel of water	Practical art/1(2)/plant & animal in life	Science/2(2)/use of electronics
	Water : waterway, falling water, sky, swamp	Social science/1(1)/characteristics and position of map/1(4)/dissolution and solution	Science/1(2)/sunsystem and star/1(4)/solution and solvent/2(1)/solar system and star/2(4)/dissolution and solution	Science/1(1)/movement of earth and moon Science/2(3)/change of season
	Nature scenery and landscape : forest, grass, hill, mountain	Art/2(2)/travel of water/2(4)/various feeling of color	2(1)/weather and our life	
	Landscape : architecture greenery, wall greenery, rooftop gardening, indoor gardening, provisions for green space(flower bed, slope gardening), Biotop(ecological pond, swamp, fountain, etc) educational space(school garden, greenhouse, vegetable garden, indoor garden)	National language 1(1)/sharing thought and feeling/1(7)/dictionary is my friend/1(8)/how about this suggestions Social science/2(1)/village and urban lifestyle science/1(3)/lifespan of plant/nature reserve activity	National language/1(10) /process of writing social science/1(1)/ our land good to live/1(2)/land harmonized with environment Mathematics/1(6)/width of polygon/2(3)/plant function and anatomy/ 2(5)/various unit Practical arts education/2(1)/plant and animal in life/2(5)/balanced dietary life of i	National language/1(2)/validatable opinion Science/1(2)organism and environment/2(1)/organism and our life Practical art education/1(2)animals in life/1(3)/living goods for environment and sharing/1(5)/practice of healthy dietary life
	Plant : shrub, tree, shrub, flower, fruit, indoor plant(foliage plant, succulent plant, ferns, etc)			Art/1(1)/hello, our school/1(10)/various earth village
	Animal : small animal, insects			Creative experience activity/nature reservation

Table 6. (continued)

Attribute	Element	Connected text/semester/unit/subject		
		4th Grade	5th Grade	6th Grade
Indirect Experience of Nature	Nature image : sunlight, water, plant, animal, scenery, fire, plant, animal, nature motive(shell, cloud, wind)	Science/1(5)/separation of mixtures/2(1)/earthquake and volcano	National language /1(4)/thoughts of works/2(4)/show the knowledge and appreciation	Mathematics/1(2)/building blocks Science/2(4)/combustion and fire extinguish
	Nature materials : wood, stone, soil, cotton	Art/1(1)/secrets of beauty, sculpture elements/1(2)/ various feelings of color/1(3)/to the world of observation	Practical arts education/1(1)/plant and life Art/1(5)/nature with five sensory	Art/1(2)/into the scenery/1(4)design for all/1(5)/hearing and watching nature
	Natural color : brown, gray, green	Art/1(4)/to the world/1(7)/joyful art in the life	Mathematics/2(2)/congruence and symmetry	Mathematics/1(4)/rate and ratio/2(3)/cylinder, cone, ball
	Natural form and shape : nature pattern(fractal, hierarchical structure, shell, curve, obtuse angle, oval, tube form, etc)		Art/2(2)/exploration classroom with knowledge/2(3)/joyful imagination garden	
Experience of space and place	View and hiding place : rooftop garden, vegetable garden, school garden, school forest	Science/1(1)/lifespan of plant/1(3)/life of plant creative activity/plant reservation activity	Science/1(3)/plant anatomy and function Mathematics/2(5)various units Practical art education/1(1)/ plant and animal in life/1(2)/plant growing	Art/1(5)/hearing and watching nature Practical arts education/1(2)/plant in life
		Science/2(1)/life of plant/2(2)journey of water	Social science/1(2)/land harmonized with environment/1(1)/ Hello, our school/1(12)/world of color and light	Science/2(1)/organism and our life
		Art/2(1)/various plant of color	Practical art education/1(1)/ plant and animal in life/1(2)/plant growing	
		National language/1(3)/talking with feelings	Science/2(1)/weather and our life/2(5)/nature with five sensory/2(2)/animal and plants in life	Art/1(2)/into the scenery Practical art education/1(2)/animal in life
		Mobility and wayfinding : stoneway, labyrinth	Art/2(1)/beauty of sculpture elements	Art/1(5)/hearing and watching nature
		Art/1(7)/interesting art in life	Art/2(5)/nature with five sensory	Science/2(2)/change of season
	Ecological attachment to place) : Use of recycling materials (separating facility of recycling materials), Reuse of water resources (water waste preventing toilet, water use monitoring, water recycling system, rain reserve system, etc)	National language/1(3)/public facilities and citizen involvement 1(8)/how about this suggestions?	Social science /1(2)/land harmonized with environment Science/1(4)/dissolution and solution	Art/1(4)/design for all
		Science/1(5)/separation of mixtures/2(2)/journey of water		

units about art were connected to the program. In particular, “indirect experience of nature” was connected with subjects including art, mathematics and Korean and related units, and “experience of places and spaces” was connected with units related to science and art (Table 6).

Development and Application of the Biophilic Horticultural Program

Restructured Program for On-site Application

Several elements were extracted from the curriculum-connected programs suggested in Table 6 to develop a curriculum-based program composed of a total of 12 sessions for on-site application. “Indirect experience of nature” and “direct experience of nature” were selected as a property for the program, but “experience of places and spaces” was not selected due to limitations in school environments. “Indirect experience of nature” was mainly composed of handicraft activities (writing a life note, making plant curtains, making a cushion with fallen leaves, making an air freshener with herbs, etc.), and “direct experience of nature” was composed of activities of directly cultivating plants (water culture, understanding biotop, making an ecosphere, etc.). Taking advantage of the characteristics of biophilia, participants were able to experience all four seasons through the activities. Unlike conventional horticultural activities, biophilic horticultural activities were designed to utilize biophilic environments and design. For instance, the indirect experience activity of “making a natural sound bell” used natural sounds as a class bell to experience natural images, and activities such as “making plant curtains” and “making a cushion with fallen leaves” used a variety of plants as a motive to make classroom curtains and cushions. In addition, the activity of “upcycling gardening” was differentiated by recycling containers and soil used when planting herbs and using food waste compost to ensure participants experience eco-friendly elements. The program for the direct experience of nature was also composed of various ecological experience activities such as “making an ecosphere,” “exploring school gardens and vegetable gardens” and “understanding biotop” instead of an one-time activity of planting (Table 7). By doing so, biophilia horticultural activities were designed to be more suitable to provide education on ecology and natural environments than general horticultural activity programs (Table 7). Overseas cases such as exploring places for and placing bird houses, observing the growth of seeds and making a nature class web also seem to be committed to biophilic elements (Texas A&M Univ, 2010).

Results After Applying the Developed Program

(1) Homogeneity Test Between the Experimental Group and the Control Group

A preliminary test was conducted on the experimental group and the control group prior to applying the program, and the results were analyzed by sub-item. The two groups were found to be homogeneous in terms of growth environments, plant classification, promotion of integrative thinking ability, emotional stability, stress, cultivation of character, environmental effects and dietary effects. This result can be attributed to the fact that the preliminary test was carried out in the beginning of the first semester among students who were the same age and had relatively homogeneous experiences of educational environments (Table 8).

(2) The Results of Pre and Post-experiment Surveys of the Control Group

Pre and post-experiment surveys were performed to examine changes in the level of horticultural knowledge, familiarity with nature and psychological stability after implementing the developed program. To examine significant differences between the experimental and control groups, t-test was performed. The control group who did not participate in the program did not show any significant difference between the results of the pre-experiment survey and those of the post-experiment survey performed after 10 months except integrative thinking ability and emotional stability (Table 9).

Table 7. Biophilic horticultural activity connected with school class

Division	Year	Session	Program	Connected subject	Biophilia element
Indirect experience of nature	Year round	1	Life note writing	National language/Science/art	Natural shape and form
		2	Making natural signal	Class management	Air/water
		3	Making a curtain with plants	Science/practical art education	Plant/weather
		4	Drawing a big tree	Art	Plant
		5	Water recycling and I	Science	Water
		6	Making plant collages with pant pictures	Art/science/practical art education	Natural materials
		7	Making a plant pot with recycling paper	Art/practical art education	Natural materials
		8	Understanding medicinal plants	Science/practical art education	Plant
Indirect experience of nature	Spring	9	Upcycling garden	Ethics/art/creative experience	Plant
		Making new cloth to pots			
Indirect experience of nature		10	Making ecosphere	Practical art education/science	Water/plant
		11	Making rainbow garden	Art/practical art education	Landscape
		12	Decorating a wicking pot with airpurifying plants	Practical art education/science	Plant
Direct experience of nature	Summer	13	Making herb drink and canape	Practical art education	Plant
		14	Doing water culture	Practical art education/science	Water/plant
		15	Understanding biotop	Science	Light/water/plant
		16	Managing indoor garden	Practical art education/science	Light/water/plant
Indirect experience of nature	Fall-winter	17	Making fallen leaves cushion	Practical art education	Natural materials
18		Collecting wasted tissues for mulching	Art		
Indirect experience of nature		19	Making natural diffuser with herb	Practical art education	Natural materials
		20	Collecting various shaped seeds	Practical art education	Natural materials

Table 8. Result of homogeneity test between treatment and control group (n=24)

Subordinate variable	Group	M	SE	t	p
Growth environment	Control	6.875	1.777	-1.634	.109
	Treatment	6.042	1.756		
Plant division	Control	6.875	2.092	-0.316	.753
	Treatment	6.708	1.517		
Integrative thinking increasement	Control	7.292	2.236	0.626	.535
	Treatment	7.667	1.903		
Emotional balance	Control	6.958	3.420	1.240	.221
	Treatment	8.167	3.332		
Environmental literacy	Control	6.208	1.834	-1.822	.075
	Treatment	5.333	1.474		
Humanity increasement	Control	11.458	4.331	1.751	.087
	Treatment	13.333	2.963		
Environmental effect	Control	7.042	2.331	1.532	.132
	Treatment	8.250	3.082		
Dietary effect	Control	5.792	2.782	1.252	.217
	Treatment	6.792	2.750		

Table 9. Result of paired samples t-test of control group (n=24)

Questionnaire	Variable	M	SE	t	p
Pre	Growth environment	6.875	1.777	1.446	.162
Post		6.625	1.439		
Pre	Plant division	6.875	2.092	0.848	.405
Post		6.708	1.829		
Pre	Integrative thinking increasement	7.292	2.236	2.696	.013*
Post		6.833	1.993		
Pre	Emotional balance	6.958	3.420	-2.563	.017*
Post		8.625	2.516		
Pre	Environmental literacy	6.208	1.474	1.639	.115
Post		5.542	1.532		
Pre	Humanity increasement	11.458	2.963	-2.050	.052
Post		13.292	3.250		
Pre	Humanity increasement	7.042	2.331	-1.584	.127
Post		7.833	2.792		
Pre	Dietary effect	5.792	2.782	-1.149	.262
Post		6.583	2.858		

* $p < .05$

(3) The Results of Pre and Post-experiment Surveys of the Experimental Group

The results of the experimental group showed a statistically significant decrease in the average value of 8 areas (Table 10), and the “curriculum-based programs” seemed to play a very important role. Apart from general knowledge about plants, stress-related areas including “cultivation of character” and “emotional balance,” and areas of environmental effects including “environmental literacy” and “integrative thinking ability” showed relatively higher effects than other areas, which indicated that biophilic elements were well expressed and verified the educational effects of the program. In particular, the results of the environment-related areas can be attributed to the fact that various biophilic experience activities including indirect experience of nature (writing a life note, making plant curtains, etc.), activities utilizing images of nature (making a natural sound bell, making a cushion with fallen leaves, etc.) and upcycling natural materials were considered in the program. The results of the stress-related areas can be attributed to the fact that classrooms in schools that had been considered as a learning environment were utilized to perform the program, which reduced participants’ psychological burdens of learning. They can be also attributed to the fact that the program was composed to integrate biophilic experience elements into conventional planting-focused horticultural activities, which increased the continuity of the program. On the contrary, there was a relatively smaller difference in the average value of the dietary effect area than other areas. The reason seemed to be that vegetable plants were used, but, unlike general horticultural activities, indirect experience activities based on the biophilic thinking were included only, not direct activities related to dietary life. It also seemed to be difficult to correct the behaviors of 6th graders whose dietary habits were already formed only by applying the horticultural program. Therefore, it will be necessary to consider the necessity for the dietary program in order to improve these effects (Table 10).

(4) The Results of the Post-experiment Survey of the Experimental and Control Groups

The independent sample t-test was performed to compare the results of the post-experiment survey of the experimental and control groups. All areas except the areas of integrative thinking ability showed a statistically significant decrease in

Table 10. Result of paired samples t-test of treatment group (n=24)

Questionnaire	Variable	M	SE	t	p
Pre	Growth environment	6.042	1.756	4.371	.000***
Post		5.458	1.532		
Pre	Plant division	6.708	1.517	5.376	.000***
Post		5.833	1.129		
Pre	Integrative thinking increasement	7.667	1.903	0.440	.664 ^{NS}
Post		7.625	1.789		
Pre	Emotional balance	8.167	3.332	3.400	.002**
Post		6.750	1.847		
Pre	Environmental literacy	5.333	1.834	4.891	.000***
Post		3.958	1.301		
Pre	Humanity increasement	13.333	4.331	3.651	.001**
Post		11.125	2.473		
Pre	Humanity increasement	8.250	3.082	4.046	.001***
Post		6.417	2.302		
Pre	Dietary effect	6.792	2.750	2.687	.013*
Post		5.750	1.800		

^{NS}Non-significant, * $p < .05$, ** $p < .01$, *** $p < .001$

Table 11. Result of post test between treatment and control group (n=24)

Subordinate variable	Group	M	SE	t	p
Growth environment	Treatment	5.458	1.532	-2.720	.009**
	Control	6.625	1.439		
Plant division	Treatment	5.833	1.090	-2.013	.050*
	Control	6.708	1.829		
Integrative thinking increasement	Treatment	7.625	1.789	1.448	.154 ^{NS}
	Control	6.833	1.993		
Emotional balance	Treatment	6.750	1.847	-2.943	.005**
	Control	8.625	2.516		
Environmental literacy	Treatment	3.958	1.301	-3.859	.000***
	Control	5.542	1.532		
Humanity increasement	Treatment	11.125	2.473	-2.599	.013*
	Control	13.292	3.250		
Environmental effect	Treatment	6.417	2.302	-1.918	.061
	Control	7.833	2.792		
Dietary effect	Treatment	5.750	1.800	-1.209	.233
	Control	6.583	2.858		

^{NS}Non-significant, * $p < .05$, ** $p < .01$, *** $p < .001$

the average value of the experimental group, and, in particular, the areas of emotional stability and environmental literacy showed a relatively big difference in their average value, which can be attributed to the elements of experiencing biophilic spaces that were continuously provided for the experimental group (Table 11). The reason seemed to be, first, that biophilic horticultural activities were routinely provided by teachers in class for students as a learning program developed after analyzing subjects and units in their curriculum, and, second, that the program was provided from a biophilic aspect for students not only to experience general horticultural activities such as planting, but also to routinely experience

environments and improve ecological literacy at school. Therefore, it will be very meaningful to provide elementary school students with programs by considering the characteristics of the school-based biophilic program suggested in this study (Table 11).

Conclusion

This study assumed that experiencing ecological environments and activities using plants for biophilic horticultural activities were effective in enhancing the multi senses of elementary school students. Based on the basic concept of various biophilic design elements and properties, a biophilic horticultural education program was developed by comprehensively analyzing biophilic experience properties and elements, biophilic design elements and properties, biophilic types and eco-friendly design elements in elementary schools that can be connected to ecological education. In addition, related subjects and units were analyzed to increase the on-site applicability of the program. The subjects for 4th, 5th, and 6th graders were analyzed, and biophilic elements were relatively more connected to the subjects for 6th graders such as science, art, social studies, Korean and practical arts. The developed program was composed of a total of 12 sessions, and was directly applied to classes in elementary schools. Among many biophilic experience elements, direct and indirect experiences of nature were selected, but experience of places and spaces was not selected due to limitations in school environments. Indirect experience of nature was mainly composed of handicraft activities (writing a life note, making plant curtains, making a cushion with fallen leaves, making an air freshener with herbs, etc.), and direct experience of nature was composed of activities of directly cultivating plants (water culture, understanding biotop, making an ecosphere, etc.). As a result, biophilic horticultural activities seem to allow people to experience various ecological elements and natural environments together with general horticultural activities, providing a broader range of educational effects than general horticultural activities. The developed program was applied on site, and the following results were obtained. First, the experimental group showed a statistically significant decrease in the average value of all the 8 multisensory areas. In particular, the program was found to be effective in increasing horticultural literacy and improving familiarity with nature and psychological stability. The effects of the program on areas related to stress and environmental effects were higher than other areas, which indicated the biophilic elements within the program were well expressed. On the contrary, there was a relatively smaller difference in the average value of the dietary effect area than other areas. The reason seemed to be that it was difficult to correct the behaviors of 6th graders whose dietary habits were already formed only by applying the horticultural program, and that specific dietary programs or cooking activities were not included in the program. It can be concluded as follows. First, biophilic horticultural activities were routinely provided by teachers in class for students as a learning program developed after analyzing subjects and units in their curriculum. Second, the program was provided from a biophilic aspect for students not only to experience general horticultural activities such as planting, but also to experience environments and ecological literacy at school. Therefore, it will be very meaningful to broadly provide this kind of programs for elementary school students.

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