Public Horticulture

Education Programs in Public Children's Gardens in the United States

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SUMMARY. This study examines the current status, implementation, and foci of children's education programs as a subset of general audience-targeted public education programs offered by public children's gardens in the United States. Children were a major target audience of the examined public gardens, followed by adults, families, and youth. Public children's gardens tended to offer more programs overall compared with public gardens without children's gardens. In addition, there was a greater diversity of children's education programs offered (classified into 10 topics and 11 activities) in public children's gardens. The most frequently offered topics were plants (39.1%), animals (22.0%), and art (11.3%). Observation was the most frequently offered activity (17.1%), followed by visual art (14.4%). However, the proportions of offered programs significantly differed across individual public children's gardens. The subjects (i.e., topics and activities) offered by children's education programs were more often directed toward younger children. Education coordinators and horticulture directors were asked about desired improvements to children's education programs. A large number of respondents (50) indicated a need to develop programs with greater topical variety, revealing a desire to diversify programs. In conclusion, the results of this study indicate that it is important to diversify the natural environmental experiences of education programs for children through developing children's gardens and age-specific education at public children's gardens in the United States.

Childhood is a pivotal period during which the brain actively and rapidly develops. According to developmental psychologists and educators such as Malaguzzi (1998), Piaget (1973), Piaget and Inhelder (1969), and Vygotsky (1978), children are highly sensitive to outdoor environments. The experience of obtaining new information from such environments affects their thoughts.

Children are heavily influenced by their environments and are easily captivated by their immediate physical environment, which stimulates the five senses (Krantz, 1994). Friedrich

Froebel, an early 19th-century German educator and the creator of the first kindergarten in 1837, insisted on the importance of this immediate environmental experience. Froebel claimed that immediate contact with nature influences children's mental and moral development (Beatty, 1995; Herrington, 2001).

Several studies have noted the importance of forming an environmentally friendly perspective through contact with nature during childhood. This perspective becomes a key element in determining one's awareness of and attitude toward nature

in adulthood (Groening, 1995; Kahn, 2002; Louv, 2005; Wake 2007; White and Stoecklin, 1998). Many studies have argued that such contact increases an individual's abilities regarding communication of knowledge, relaying of emotion, originality, sociability, confidence, creativity, imagination, power of observation, and personal relationships. Preschoolers exposed to nature are able to obtain a wider range of information and have better experiences when they enter school (Miller, 2007; Park and Huh, 2010). In addition, elementary school children show more positive awareness of the natural environment and an increased interest in and satisfaction with academic subjects, such as science and mathematics, when they are presented in environmental experience-based learning in gardens compared with in the conventional school setting (Catsambis, 1995; Farenga and Joyce, 1998; Simpson and Oliver, 1990; Yager and McCormack, 1989; Yager and Yager, 1985).

Europe recognized the importance of environmental experience-based learning relatively early. European educators began to create school gardens in the mid-1800s. These gardens later spurred the United States to follow this movement in the 1900s (Bachert, 1976). In addition, the nature-study movement, which began in the early 20th century, emphasized the importance of education through children's contact with nature and motivated the creation of children's gardens in schools (Shair, 1999). Thus, the children's garden concept evolved from the nature-study movement. In 1911, Ellen Eddy Shaw created one of the first children's gardens at the Brooklyn Botanical Garden. Concurrently, awareness of the importance of environmental education increased, and public institutions began providing more spaces for children to experience the natural environment (Eberbach, 1988; Halverson et al., 2008).

Against this backdrop, natural and environmental experience-based learning programs that were offered by public gardens for exhibition, conservation, and education were believed to be the perfect laboratories for children to nurture a sense of scientific curiosity and understand the value of life. Furthermore, it was believed that such lessons cannot be attained from a textbook-oriented

school system (Mohrmann, 1999; Steil and Lyons, 2009). A comparative study of an activity-based curriculum provided by public gardens and a traditional textbook-based curriculum in school showed that students experienced superior learning outcomes with an activity-based curriculum (Bredderman, 1982). With activity-based education, students learn in a self-directed manner by focusing on their own interests. Thus, compared with education in which such activities are optional, activity-based education increases the influence of learning on students (Wilson, 1996).

Therefore, the concept of a children's garden, which is designed as a place for children to experience the natural environment, has evolved over the last 15 years. A children's garden is considered an optimal place to motivate one's curiosity, research, and learning through contact with nature in playful and enjoyable ways (DiMare, 2012; Halverson, 2005; Sobaski, 2006). Consistent with these findings, the number of children's gardens within public gardens (hereafter referred to as "public children's gardens") has been steadily increasing in the United States (Finch, 1995; Kwon et al., 2015).

The interest in and importance of children's nature experience-based learning have increased. Studies have been conducted to examine the influence that environmental education programs provided by school gardens have on children's environmental awareness and attitudes (Miller, 2007; Skelly and Zajicek, 1998; Smith, 2003; Waliczek et al., 2001). Additional studies have sought to identify the benefits of the mental and social influences that nature

experience programs have on children (Alexander et al., 1995; Konoshima, 1995; Maller, 2009; Maller and Townsend, 2006) and to evaluate adolescent education programs in public horticultural institutions (Purcell et al., 2010). However, there is a lack of published studies that quantitatively examine children's education programs provided by public children's gardens in the United States.

Therefore, this study examines the current status of children's education programs offered by U.S. public children's gardens (as an experiential natural environment learning space) and analyzes their implementation and their subjects (i.e., topics and activities) to provide recommendations for their improvement.

Materials and methods

STUDY DESIGN. To examine the curricula and foci of children's education programs offered by public children's gardens (i.e., public gardens with children's gardens) in the United States, this study examined the existing research data (Kwon et al., 2015) on 163 public gardens (out of 776 initially aggregated gardens) and studied the composition of the education programs offered by the public children's gardens. The studied public gardens included 90 public children's gardens, five children's gardens under construction, and 38 children's gardens that were planned, but not yet built.

This research classifies public gardens into two types: those with children's gardens (90) and those without children's gardens (73), the latter of which included those with children's gardens that were planned or under construction. In the present study, the websites of these 163 public gardens were visited from Aug. to Dec. 2014. The research target was limited to public gardens that listed public education programs on their website.

To study the topics and activities of each subject provided by children's education programs at public children's gardens and their proportions, only annual programs offered in 2014 that listed either an informative title or a title and a description of the content of the program on their website were examined. In this study, "children" refers to individuals who are in grade six or lower, as follows: toddlers (<3 years of age), pre-kindergarteners (3–4 years), kindergarteners (5–6 years), first

graders, (7 years), second graders (8 years), third graders (9 years), fourth graders (10 years), fifth graders (11 years), and sixth graders (12 years). The total number of children's education programs was determined. The programs were analyzed according to the keywords in the title and content, which were then categorized into topics and activities. Programs could be categorized into multiple topics and/or activities (Tables 1 and 2).

The method employed to categorize topics and activities was as follows. The topics were classified as natural sciences or arts and nonnatural sciences. The topic of natural sciences (Kindersley, 2000) was further divided into biology, nonbiology, and complex. The arts and nonnatural sciences topic was divided into culture and general, according to previously described criteria (DeMarco et al., 1999; Miller, 2005). In addition, based on previous categorizations (Braus and Wood, 1993; Chawla, 1994; Disinger, 1998; Subramaniam, 2003), these topics were further categorized as follows. Biology included contents on plants, animals, and microorganisms (fungus and mold). Nonbiology included climate (temperature, precipitation, and wind) and soil (dirt and fertilizer). Complex included ecology (the natural environmental ecology of earth organisms) and the environment (the general environment, such as earth and waste). Culture included art (design and color) and literature, and general included other educational topics, such as history and mathematics. In total, 10 topics were identified. The activities of the programs were also categorized. Horticulture included gardening (indoor and outdoor gardening activities). Exploration included observation (garden walks and outdoor exploration) and guided tours (self-led and group tours). Art included visual arts (crafts, painting, and photography) and music (vocal and instrumental). Language arts included storytelling (listening to stories) and writing (creative writing or poetry). Practice included playing (games and physical activity) and hands-on activities (cooking and experiments), and event included exhibitions (museum or gallery tours) and performances (parties and musicals). The total number of activity categories was 11.

To examine the percentages of the target audience of public

We appreciate the people who we interviewed and who kindly answered our questions, especially those we interviewed at the following gardens: Garfield Park Conservatory in IL, ABQ Biopark Aquarium & Botanic Garden in NW, Denver Botanic Gardens in CO, Longwood Gardens in PA, Winterthur Museum, Garden and Library in DE, River Farm/American Horticultural Society in VA, Meadowlark Botanical Gardens in VA and The Morton Arboretum in IL.

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Table 1. The proportions of topics in children's education programs provided by public children's gardens in the United States.

Category	Natural sciences							Arts and nonnatural sciences		
	Biology			Nonbiology		Complex		Culture		General
	Plant	Animal	Microorganism	Climate	Soil	Ecology	Environment	Art	Literature	Other
Total (no.)	496	280	11	23	28	109	73	144	54	53
Total (%) ^z	39.1	22.0	0.9	1.8	2.2	8.6	5.7	11.3	4.3	4.2
Avg (%) ^y	42.7	24.1	1.0	1.5	2.3	7.8	4.8	12.9	6.1	4.4

^zThe percentage of programs offered on the specific topic relative to the total number (n = 1270) of children's education programs.

^yThe percentage of the programs offered on the topic by each public children's garden was calculated relative to the total number of programs that the garden offered. The average of this percentage across all gardens is presented.

Table 2. The proportions of activities in children's education programs provided by public children's gardens in the United States.

Division	Horticulture	Exploration		Art		Language art			Practice		Event
	Gardening	Observation	Guided	Visual	Music	Storytelling	Writing	Playing	Hands-on activities	Exhibition	Performance
			tour	art							
Total (no.)	75	217	59	183	43	81	13	75	66	7	16
Total (%) ^z	5.9	17.1	4.6	14.4	3.4	6.4	1.0	5.9	5.2	0.6	1.3
Avg (%) ^y	8.6	20.3	6.7	18.7	4.9	8.1	0.8	7.7	5.8	0.8	1.5

^zThe percentage of programs offered on the specific activity relative to the total number (n = 1270) of children's education programs.

^yThe percentage of the programs offered on the specific activity by each public children's garden was calculated relative to the total number of programs that the garden offered. The average of this percentage across all gardens is presented.

Fig. 1. The percentage of each of the four target audiences of education programs of public gardens with and without children's gardens in the United States. Data were collected from the websites of 76 public children's gardens and 43 public gardens without children's gardens that offered education programs.

education programs provided by the selected public children's gardens (90) compared with public gardens without children's gardens (73), the intended audiences were categorized into adults, youth, children, and families, based on information listed on the garden websites. Then, data from public education programs offered in 2014 were collected (Fig. 1). To examine the diversity of the programs, the geographical distribution and the topics and activities of the

education programs of public children's gardens (90) and public gardens without children's gardens (73) were compared (Fig. 2). In addition, a survey on the objectives (Fig. 3) and the types (Fig. 4) (Kwon et al., 2015) of children's education programs in children's gardens was also conducted. From July 2011 to Jan. 2012, the education coordinators and horticulture directors of the 776 public gardens initially aggregated by Kwon et al. (2015) were invited to

participate in an online survey conducted via the SurveyMonkey website (SurveyMonkey, 2011). In addition, a telephone survey was conducted twice (in July and Aug. 2014) to obtain supplemental information when the answers to the online survey were insufficient. The design and analysis of the results of the survey were based on discussions with 17 colleagues across the academic (professor), public (garden director and director of institution), and private (landscape designer and environmental educator) sectors (Kwon et al., 2015) as well as based on previous studies (Lekies et al., 2006; Purcell et al., 2010). Respondents from 163 public gardens in 43 states participated in the surveys. The proportion of children's education programs in each of the categories in each public children's garden was examined (Fig. 5). In addition, the frequency distribution of each subject offered by the education programs for each age group was examined (Fig. 6). Moreover, similar to research that has examined how garden activity programs generate a difference in environmental awareness at various age levels (Bradley et al., 1997; Skelly and Zajicek, 1998), the ages were divided into three main groups [preschool (toddler to kindergarten), lower-level elementary school (grades 1–3), and

Fig. 2. The geographical distribution of the number of program subjects provided by public children's gardens (A) and public gardens without children's gardens (B) as well as the differences in the number of program subjects offered relative to the presence of children's gardens (C). Programs subjects were classified into 10 topics and 11 activities, as described in the Materials and methods.

upper-level elementary school (grades 4–6)] to identify significant differences among the groups (Tables 3 and 4).

In addition, the programs pertaining to plants and animals, which constituted the highest percentage, were again categorized according to the content listed on the website. Plant programs were divided based on the following topics: plant structure, plant physiology, plant uses, and plant characteristics. The animal programs were divided based on the following topics: arthropods, birds, reptiles, amphibians, fish, annelid, mollusks, and mammals (Fig. 7).

Finally, the respondents to the survey were asked about improvements

that should be made to children's gardens (Table 5). The survey was conducted using the same methods as those used for Figs. 3 and 4.

DATA ANALYSIS. A multiple analysis method was employed to examine the percentage of educational targets relative to the existence of a children's garden (Fig. 1), to determine the objectives of operating children's education programs (Fig. 3), to delineate types of children's education programs (Fig. 4), and to identify areas for improvement in children's education programs in public children's gardens (Table 5).

The frequency analysis method was used to analyze the frequency of topics and activities in children's education programs (Tables 1 and 2), to

analyze the diversity of children's education programs relative to the existence of a children's garden (Fig. 2C), to examine the program content in detail, and to determine the proportions of plant- and animal-related programs (Fig. 7).

The SigmaPlot program (version 13; Systat Software, San Jose, CA) was employed to plot quartiles to study the proportions of topics and activities in the children's education programs provided by each public children's garden (Fig. 5). A cross-tabulation analysis was conducted using the chi square test to examine the relative differences in the topics and activities of education programs offered to different age groups

(preschool, lower-level, and upper-level elementary school) (Tables 3 and 4). All statistical analyses were conducted using SPSS (version 20.0 for Windows; IBM, Armonk, NY). The level plot function in R (version 3.1.2; R Foundation, Vienna, Austria) was used to examine the frequency distribution of topics and activities for each age group. A heat map was created and analyzed to visualize the data (Fig. 6).

A spatial analysis technique based on geographic information system (GIS) data was employed to analyze the geographical distribution of the diversity of children's education programs in the United States (Fig. 2A and B). The location data of public gardens was projected using Albers equal-area conic projections after identifying the

gardens' longitudes and latitudes from their addresses. All GIS analyses were conducted using ArcGIS (version 10.0; ESRI, Redlands, CA).

Results and discussion

EDUCATION PROGRAMS IN PUBLIC GARDENS. Of the public children's gardens (90), 76 offer public education programs. A major target audience of these programs is children at 93.4% (71) of the public gardens with education programs, followed by adults at 89.5% (68), families at 46.1% (35), and youth at 35.5% (27). Among the 73 public gardens that do not have children's gardens, 42 offer public education programs. The rank order of the target groups of these programs is

Fig. 3. The purpose of operating children's education programs in public children's garden in the United States. Multiple responses were collected from 67 public gardens through online or phone surveys.

Fig. 4. The types of children's education programs provided by public children's gardens in the United States. Multiple responses were collected from 67 public gardens through online or phone surveys.

children at 85.7% (36), adults at 81.0% (34), families at 26.2% (11), and youth at 16.7% (7) (Fig. 1). The results demonstrate that a major target of public education programs is children. However, in public children's gardens, the proportions of each target audience are at least 8.0% to 19.0% points higher than in public gardens without children's garden. The results from Purcell's study (Purcell et al., 2010), which examined education personnel at public horticultural institutions and their education programs, showed that the target audiences were adults (35.4%), children (35.2%), families (14.9%), and adolescents (8.9%). These figures are similar to the results from the present study. However, the present study further shows that the public education programs offered by public children's gardens provide more activities than those offered by public gardens without children's gardens.

The subject (21 total subjects: classified into 10 topics and 11 activities) diversity of children's education programs provided by public children's gardens and public gardens without children's gardens was compared, as described in the materials and methods. For public children's gardens that operate children's programs on an annual basis (67), the average number of programs was (mean $\pm$ SD) 10 ± 3.3 , with a maximum of 18 programs and a minimum of four programs. Thirty-five (52.2%) public children's gardens had greater than or equal to the average number of programs. These gardens were evenly distributed across the United States (Fig. 2A). However, for public gardens without children's gardens that offer children's education programs annually (34), the average number of the combined subjects was (mean $\pm$ SD) 5.6 ± 2.4 , with a maximum of 12 and a minimum of 2 programs. Seventeen gardens had the average number of subjects or more, and 17 gardens had fewer than the average number of subjects. Those with an above average number of subjects were distributed mainly in the East (Fig. 2B). The present study performed a similar study to that of Kwon et al. (2015) regarding the demographic and socioeconomic factors that affect the development of public children's gardens. In addition, as an expansion of the previous

Fig. 5. The distribution of children's education program subjects [(A) 10 topics and (B) 11 activities] provided by each public children's garden in the United States.

study, the size and opening year of both the public gardens and their children's garden were examined. However, no relationship between the demographic or socioeconomic factors, size or opening year, and the composition of programs was observed. Thus, the diversity of children's education programs might be dependent on educators' willingness to offer a diverse array of programs. This idea requires further examination. Furthermore, an analysis of the total numbers of the 10 topics and 11 activities in each program showed that there was greater subject diversity in children's education programs in public children's gardens than in public gardens without children's gardens with respect to topics [an average of ($\pm$ SD) 5.0 ± 2.0 subjects vs. 2.8 ± 1.6 subjects, respectively, and 5.0 ± 1.8 vs. 3.0 ± 1.6 activities, respectively]. This result shows that diverse programs are more commonly implemented in public children's gardens than in public gardens without children's gardens (Fig. 2C). The results also show that children's education programs provided by public children's gardens offer a greater variety of subjects.

Of the 71 public children's gardens that offered children's education, 67 responded. The respondents answered a question regarding the purpose of operating children's

education programs. Their responses were evaluated using multiple answer analysis. The answers were as follows, in descending order: connecting to nature (37 times), fostering an awareness of the environment (35 times), learning about plants (28 times), and learning various subjects (22 times). This result shows that the most significant purpose of such education programs is to offer experience-based learning through contact with nature (Fig. 3). Similarly, Maller and Townsend (2006), who researched children's mental health and well-being through nature experience activities (nature-based programs provided by schools), found that 50.8% of participants stated that the purpose of the programs was for children to connect with nature. Thus, both the providers and beneficiaries of such programs expect to pursue the same purpose.

OBJECTIVE AND TYPE OF CHILDREN'S EDUCATION PROGRAMS IN PUBLIC CHILDREN'S GARDENS. In the survey section regarding the types of children's education programs, the group types and children's ages were recorded based on the respondents' self-reported answers and information found on the websites of the sampled public gardens. The most frequently reported group type was school groups (29%), followed by preschool groups (including kindergarteners and

preschoolers aged 1–6 years) (20%) and camp and scout groups (6%) (Fig. 4). Although camps and summer camps may be quite varied, the common factor is that all of the education programming reported by the gardens as "camp" occurred in the public gardens sampled. In addition, for the "scout" type, all of these types of education programs have Boy and Girl Scout audiences. Our results are similar to those reported for the youth-oriented program types provided by public horticultural institutions (Purcell et al., 2010). In these institutions, school group programs (71.2%) represented the most active type of program in operation. The other child-centric programs were camp groups (23.2%) and afterschool groups (12.0%).

ANALYSIS OF CHILDREN'S EDUCATION PROGRAMS IN PUBLIC CHILDREN'S GARDENS. Among public children's gardens that offer children's education programs (71), 67 public children's gardens held an annual schedule of programs during 2014. These gardens offered a total of 1270 children's education programs (Tables 1 and 2). The average number of programs was (mean $\pm$ SD) 19 ± 18 (maximum = 91, minimum = 3), with most gardens offering less than 10 programs. The average number of programs related to the 10 topics and 11 activities was calculated relative to

Fig. 6. The frequency distribution of (A) 10 topics and (B) 11 activities of the children's education programs provided by public children's gardens according to target age group.

the total number of programs. The average number of programs offering each topic was 19 ± 18 , with a maximum of 102 and a minimum of 1. The average number of programs offering each activity was 12 ± 9 (maximum = 44, minimum = 2).

The total number of programs offered by the 67 public children's education programs was categorized by topic: plants (39.1%), animals (22.0%), art (11.3%), ecology (8.6%), environment (5.7%), literature (4.3%), other categories (4.2%), such as mathematics and history, soil (2.2%), climate (1.8%), and microorganisms (0.9%) (Table 1).

Plants were the most common topic, with an average representation of 42.7% (Table 1), but the proportion of plant programs varied widely across public children's gardens. Some public children's gardens focused 100% of their programs on plants, whereas plant programs in

gardens in the bottom quartile represented less than 32% of the total number of programs. Furthermore, the public garden with the lowest percentage of plant-related programs (9%, representing one program) had a higher percentage of art programs (36%, representing four programs) (Fig. 5A). Public children's gardens with children's education programs all offered some type of plant-related program. Animal-related programs ranked second (24.1%) (Table 1) after plant-related programs. In one public garden, 86% of the topics were animals, whereas animal-related programs in public children's gardens in the bottom quartile constituted less than 12% of the total programs. Some gardens had no animal-related programs (Fig. 5A). Only nine of the 67 public children's gardens offered microorganism-related subjects, and these nine gardens only offered one or two of these programs. Thus,

microorganism was the least common subject among all the programs (Fig. 5A). Ecology programs followed animal-related programs in prominence. Although one public garden devoted 67% of its education programs to ecology, other gardens did not have any ecology programs (Fig. 5A; Table 1). Climate, soil, and environment programs, which fall under the non-biology and complex topics, represented as much as 33% of the programs in some public children's gardens. However, more than half of the public children's gardens did not offer these subjects (Fig. 5A). This result indicates that these subjects are not typically included as part of general education programs in public children's gardens. Thus, the environmental aspects of public children's gardens allow them to provide more programs related to biological subjects, such as plants and animals. However, public children's gardens also offer subjects relating to other natural sciences and to arts and non-natural sciences, such as art, literature, and other categories (e.g., mathematics and history). In the existing scholarship on environmental education programs provided by children's gardens (Braus and Wood, 1993; Miller, 2005), environmental education mainly focuses on scientific education. However, a full education scope should encompass not only science but also mathematics, languages, art, culture, and politics (i.e., virtually all subjects) in a comprehensive way. This conclusion is also reflected in the current research.

Arts and nonnatural sciences programs, including art, literature, and other categories, represented more than 55% of the programs in some public children's gardens. Art constituted an average of 12.9% of the programs (Table 1), and one public garden devoted 67% of its programs to art. In addition, half of the public children's gardens had 11% of their programs devoted to art. Furthermore, more than half of the public children's gardens did not include either literature or other programs (Fig. 5A). The results also demonstrated that art-related education programs are among the top three programs offered by public children's gardens, indicating that such programs enable children to

Table 3. Differences in the topics of children's education programs offered to target age groups by public children's gardens (preschool, lower-level, and upper-level elementary school) based on cross-tabulation analysis.

Category	Subject ^z offered (Yes/No)	Age group			Total [no. (% of total)]	Chi square (<i>P</i>)
		Preschool ^y [no. (%)]	Lower-level elementary ^x [no. (%)]	Upper-level elementary ^w [no. (%)]		
Plant	Yes	111 (55.2)	168 (83.6)	128 (63.7)	407 (67.5)	38.838
	No	90 (44.8)	33 (16.4)	73 (36.3)	196 (32.5)	(0.000***)
Animal	Yes	90 (44.8)	145 (72.1)	104 (51.7)	339 (56.2)	33.028
	No	111 (55.2)	56 (27.9)	97 (48.3)	264 (43.8)	(0.000***)
Microorganism	Yes	2 (1.0)	15 (7.5)	18 (9.0)	35 (5.8)	13.164
	No	199 (99.0)	186 (92.5)	183 (91.0)	586 (94.2)	(0.001**)
Climate	Yes	4 (2.0)	19 (9.5)	18 (9.0)	41 (6.8)	11.044
	No	197 (98.0)	182 (90.5)	183 (91.0)	562 (93.3)	(0.004**)
Soil	Yes	16 (8.0)	28 (13.9)	31 (15.4)	75 (12.4)	5.756
	No	185 (92.0)	173 (86.1)	170 (84.6)	528 (87.6)	(0.056)
Ecology	Yes	7 (3.5)	55 (27.4)	82 (40.8)	144 (23.9)	89.988
	No	194 (96.5)	146 (72.6)	119 (59.2)	459 (76.1)	(0.000***)
Environment	Yes	8 (4.0)	42 (20.9)	50 (24.9)	100 (16.6)	35.772
	No	193 (96.0)	159 (79.1)	151 (75.1)	503 (83.4)	(0.000***)
Art	Yes	57 (28.4)	97 (48.3)	87 (43.3)	241 (40.0)	17.791
	No	144 (71.6)	104 (51.7)	114 (56.7)	362 (60.0)	(0.000***)
Literature	Yes	48 (23.9)	24 (11.9)	8 (4.0)	80 (13.3)	35.050
	No	153 (76.1)	177 (88.1)	193 (96.0)	523 (86.7)	(0.000***)
Other	Yes	18 (9.0)	57 (28.4)	52 (25.9)	127 (21.1)	26.952
	No	183 (91.0)	144 (71.6)	149 (74.1)	476 (78.9)	(0.000***)

^zIndicates the group of programs offering (Yes) or not offering (No) that activity.

^yAges 1–6 years (toddler, prekindergarten, kindergarten).

^xAges 7–9 years (grades 1–3).

^wAges 10–12 years (grades 4–6).

, *Significant at $P < 0.01$ and 0.001 , respectively.

connect with nature through art. The reason why art was ranked third after plants and animals is explained by studies arguing that art is an important subject that relates to other subjects within a comprehensive education. Children's education programs that include art significantly increase children's creativity (Miller, 2007). This principle also applies to children's education programs offered by public children's gardens.

The results of the topic analysis indicate that every public children's garden offered at least one plant-related program among the 10 topics, whereas the other nine topics were not necessarily offered. Because of the characteristics of public children's gardens, natural science programs were offered more frequently than arts and nonnatural sciences programs. In some public children's gardens, this trend was reversed, indicating that the composition of education programs varies across public children's gardens (Fig. 5A; Table 1).

When the total number of programs offered by the 67 public

children's education programs was categorized by activity, the activities were ranked as follows: observation (17.1%), visual art (14.4%), storytelling (6.4%), gardening (5.9%), playing (5.9%), hands-on activities (5.2%), guided tours (4.6%), music (3.4%), performance (1.3%), writing (1.0%), and exhibition (0.6%) (Table 2). When the proportion of each activity provided by children's education programs in each public children's garden was analyzed, observation constituted an average of 20.3% (Table 2). Some public children's gardens had programs entirely composed of observation activities, whereas those in the bottom quartile had observation activities that represented less than 9% or even none of the programs (Fig. 5B). Observation activities are discovery activities in public children's gardens that serve as a strong motivation for children to voluntarily research and conduct self-directed learning through their connection with nature (Wake, 2007). These activities represent the greatest environmental advantages that public children's gardens can offer to children. Following

observation, visual art ranked the highest, with an average of 18.7%. However, while the maximum percentage was 83% in some public children's gardens, less than 4% of the programs in the bottom quartile included visual art, and some gardens had no such programs (Fig. 5B; Table 2). Exposure and interaction with art during childhood is important as a learning experience that not only offers pleasure but also increases one's physical development through motion (drawing and painting) and other motor activities (Fox and Berry, 2008; Froebel, 1974). Public children's gardens' ability to offer various natural materials for use in such activities explains the relatively high proportion of these activities found in the present study. In addition, the average percentages of these activities were as follows: gardening (8.6%), storytelling (8.1%), playing (7.7%), guided tours (6.7%), hands-on activities (5.8%), music (4.9%), performance (1.5%), writing (0.8%), and exhibition (0.8%) (Table 2). These activities have been described by previous research on

Table 4. Differences in the activities of children's education programs offered to target age groups by public children's gardens (preschool, lower-level, and upper-level elementary school) based on cross-tabulation analysis.

Category	Subject offered ^z (Yes/No)	Age group			Total [no. (% of total)]	Chi square (<i>P</i>)
		Preschool ^y N (%)	Lower-level elementary ^x N (%)	Upper-level elementary ^w N (%)		
Gardening	Yes	55 (27.4)	82 (40.8)	60 (29.9)	197 (32.7)	9.334
	No	146 (72.6)	119 (59.2)	141 (70.1)	406 (67.3)	(0.009**)
Observation	Yes	81 (40.3)	114 (56.7)	87 (43.3)	282 (46.8)	12.350
	No	120 (59.7)	87 (43.3)	114 (56.7)	321 (53.2)	(0.002**)
Guided tour	Yes	35 (17.4)	71 (35.3)	61 (30.3)	167 (27.7)	17.159
	No	166 (82.6)	130 (64.7)	140 (69.7)	436 (72.3)	(0.000***)
Visual art	Yes	73 (36.3)	113 (56.2)	90 (44.8)	276 (45.8)	16.155
	No	128 (63.7)	88 (43.8)	111 (55.2)	327 (54.2)	(0.001**)
Music	Yes	40 (19.9)	31 (15.4)	13 (6.5)	84 (13.9)	15.685
	No	161 (80.1)	170 (84.6)	188 (93.5)	519 (86.1)	(0.000***)
Storytelling	Yes	67 (33.3)	32 (15.9)	5 (2.5)	104 (17.2)	67.369
	No	134 (66.7)	169 (84.1)	196 (97.5)	499 (82.8)	(0.000***)
Writing	Yes	2 (1.0)	9 (4.5)	9 (4.5)	20 (3.3)	5.068
	No	199 (99.0)	192 (95.5)	192 (95.5)	583 (96.7)	(0.079)
Playing	Yes	52 (25.9)	61 (30.3)	40 (19.9)	153 (25.4)	5.833
	No	149 (74.1)	140 (69.7)	161 (80.1)	450 (74.6)	(0.054)
Hands-on activities	Yes	23 (11.4)	38 (18.9)	40 (19.9)	101 (16.7)	6.161
	No	178 (88.6)	163 (81.1)	161 (80.1)	502 (83.3)	(0.046*)
Exhibition	Yes	11 (5.5)	11 (5.5)	11 (5.4)	33 (5.5)	0.000
	No	190 (94.5)	190 (94.5)	190 (94.5)	570 (94.5)	(1.000)
Performance	Yes	19 (9.5)	24 (11.9)	13 (6.5)	56 (9.3)	3.583
	No	182 (90.5)	177 (88.1)	188 (93.5)	547 (90.7)	(0.167)

^zIndicates the group of programs offering (Yes) or not offering (No) that activity.

^yAges 1–6 years (toddler, prekindergarten, kindergarten).

^xAges 7–9 years (grades 1–3).

^wAges 10–12 years (grades 4–6).

*, **, ***Significant at $P < 0.05$, 0.01, and 0.001, respectively.

interdisciplinary environmental education (Braus and Wood, 1993). However, in this study, gardening activities, which one would expect to be predominantly offered at public gardens based on their environmental aspects, were not the primary programs offered as part of the education programs at public children's gardens. Our results are consistent with previous studies showed that school gardening conveys many positive benefits to children. Hence, interest in gardening as part of an education curriculum in school has been increasing (DeMarco et al., 1999; Miller, 2007). Therefore, gardening-related activities can be provided to children by schools to support their education.

The results show that among the 11 activities, no activity was offered at every public children's garden. However, public children's gardens experiment with various combinations of programs that incorporate nature and other topics to

take advantage of the experience of nature that they can offer. Some studies have emphasized comprehensive education within gardens (Braus and Wood, 1993; Disinger, 1998; Eames-Sheavly, 1998) and have concluded that implementing various activities would not only heighten children's awareness of the natural environment but also heavily influence various aspects of their physical and mental development.

The frequency distribution of children's education program topics and activities for each age group was examined using heat map analysis (Fig. 6A). In addition, significant differences in the subjects offered to the target age groups were identified using cross-tabulation analysis (Tables 3 and 4). However, differences existed in each age group. Plant programs were more common in the lower-level elementary (grades 1–3) group (83.6%) than in the preschooler (toddlers, prekindergarten, and kindergarten) group (55.2%) or in the upper-level elementary (grades

4–6) group (63.7%). This result was statistically significant ($\chi^2 = 38.838$, $P < 0.001$) (Table 3). Compared with the other age groups, grades 1–3 (72.1%) were offered a higher frequency of animal programs. This difference was also statistically significant ($\chi^2 = 33.028$, $P < 0.001$) (Fig. 6A; Table 3). Art, which ranked below plants and animals, was primarily offered to preschool and upper-level elementary students but was also a frequent topic in programs offered to lower-level elementary school students (48.3%). Microorganismal, soil, ecological, and environment topics were more commonly offered to upper-level elementary school students. In addition, climate and other were more commonly offered to lower-level elementary (grades 1–3) school students (Fig. 6A; Table 3). A study that compared organism-centered science education curricula and textbooks for elementary schools in the United States found that third graders learned about the classification of plants and animals; fourth

graders learned about life cycles and growth; and fifth graders learned about organs and the environment, the structure of organisms, and environmental change. This result indicates that as one advances through elementary school, one learns more about the environment and about organismal structures. This finding is consistent with the findings of the present study showing that micro-organismal, soil, ecological, and environment programs were more often offered to upper-level elementary students (National Governors Association Center for Best Practices and Council of Chief State School Officers, 2010; Seo, 2013).

Observation and visual art, which ranked as the most common subjects in children’s education programs, were heavily and evenly distributed across children from preschool to elementary school age, except for toddlers and sixth graders. In addition, for both of these subjects, the frequency exceeded 55% at the

lower level and reached statistical significance (observation: $\chi^2 = 12.350$ $P < 0.01$; visual art: $\chi^2 = 16.155$, $P < 0.001$) (Fig. 6B; Table 4). Gardening was offered to children of preschool and especially kindergarten age, but it was more commonly offered to children in lower-level elementary school (40.8%). Activities such as storytelling and music, which do not require advanced levels of understanding but may be fun and interesting, were more common among children younger than lower-level elementary school students (Fig. 6B; Table 4). Activities in which participants performed a hands-on activity independently, such as cooking and experimentation, and writing were commonly found in programs targeted at upper-level elementary school students (Fig. 6B). This result is consistent with previous research by Waliczek et al. (2001), who examined the effect of grade on attitude toward school and interpersonal relationships related with green activities. Their

results showed that children who participated in green activities were older and thus able to work more independently compared with younger children, who work under more supervised conditions, such as in the storytelling or music activities found in the present study. However, in the present study, gardening programs were more frequently offered to young children. This result is consistent with previous research that showed that green activities offered to younger students produce greater improvements in environmental awareness in diverse environments (Jaus, 1984; Skelly and Zajicek, 1998).

Most of the topics and activities provided by public children’s gardens were oriented around kindergarteners and lower-level students (grades 1–3), and the frequency of programs steadily decreased beginning in grade 5. Preschoolers need their parents’ or instructors’ help because they lack cognitive and physical skills (Rimm-Kaufman et al., 2000). Thus, fewer programs catered to preschoolers, especially those under kindergarten age. In a study on the influence of gardening and environment-related education on one’s attitude toward such education, more positive cognition was observed in second grade than in fourth grade (Skelly and Zajicek, 1998). Many similar studies have shown that lower-level students display much more positive development as a result of environment-related subjects than do higher-level students (Bradley et al., 1997; Harvey, 1989a, 1989b; Jaus, 1984; Ramsey and Rickson, 1976). These results indicate that earlier education has a more positive impact, which explains why more of the programs in the present study concentrate on younger children.

The detailed contents of programs on plants and animals, which composed more than 20% of children’s education programs offered by public children’s gardens, were analyzed. Plant-related programs were categorized into four groups. “Plant structure,” which explains plant components, constituted 45% of the plant programs. “Plant characteristics,” which explains plants as categorized by their climate ecology (e.g., tropical and desert plants), constituted 24.7% of plant programs. “Plant uses,” which teaches how plants are

Fig. 7. The detailed contents of (A) plant and (B) animal programs provided by public children’s gardens in the United States. Programs were categorized according to the content listed on the website.

Table 5. Proposed measures to improve children’s education programs: responses by education coordinators and horticulture directors in public children’s gardens in the United States by online or telephone survey (multiple responses, n = 61).

Categories	Responses (no.)
More variety in program topic areas	50
Program evaluation to improve program	38
More staff/instructors	22
Programs for special needs	20
Other	3

used in everyday life, constituted 21.5% of plant programs. Finally, “plant physiology,” which covers plant photosynthesis, transpiration, and respiration, constituted 9.1% of plant programs (Fig. 7A). As in other research that addresses science education programs in elementary schools in the United States, lower-level elementary school students learned about the structure of plants, whereas upper-level elementary school students learned about plant characteristics, uses, and physiology. Thus, this difference between the education provided to different age levels is reflected both in the textbooks that are used at these levels and the programs offered in public children’s gardens (Kim, 2005; Seo, 2013). Among animal-related programs, arthropod programs ranked the highest (at 34.6%), followed by bird (15.4%), reptile (13.9%), and amphibian programs (10.6%) (Fig. 7B). When one study asked children about their favorite location in children’s gardens, the highest-ranked area was the place where they could observe their favorite animals, such as butterflies (which are arthropods) and birds. This result is reflected in children’s education programs and in attempts to organize programs according to children’s preferences (Midden and Chambers, 2000).

FUTURE IMPROVEMENTS FOR CHILDREN’S EDUCATION PROGRAMS IN PUBLIC CHILDREN’S GARDENS. Of the 61 public children’s gardens that responded to the survey on measures to improve children’s education programs, 50 stated that the variety of topics should be increased (Table 5). This result is similar to the results of a research project that asked adolescents about how a children’s garden can be improved. One of their ideas was to offer a wide variety of programs (Lekies et al., 2006). Another study on activating adolescent-centered education programs in public garden institutions concluded that “providing a range of engaging activities” could be an option (Purcell et al., 2010). These similar conclusions indicate that the aims of institutions with existing nature and experience programs and environmental education are similar. Another study stated that the evaluation of programs and an increase in the number of employees should be taken as measures of improvement (Lekies

et al., 2006; Steil and Lyons, 2009). The present study similarly showed that after offering a greater variety of topics, program evaluations to improve programs (38) and hiring more staff (22) could serve as improvement measures. Other answers included stronger volunteer-led instruction, the creation of subject sites, the presence of a full-time educator and more training for staff. As the conclusion of this study shows, the programs provided by public children’s gardens are diverse. However, when an individual public garden is considered, the distribution of programs is disproportionate, implying that additional measures to diversify programs should be taken.

Conclusions

To examine the current status of children’s education programs offered by public children’s gardens and to evaluate improvement plans, an analysis of the distribution and subject composition of children’s education programs was undertaken by using online research and survey tools. Public education programs offered more activities in public children’s gardens compared with public gardens without children’s gardens in the United States. A major target of public education programs in these public children’s gardens appeared to be children. Furthermore, children’s education programs in public children’s gardens had greater subject diversity. This result indicates the effort to offer a greater variety of children’s education programs by developing public children’s gardens.

In this study, biological topics and observation-based activities were the main constituents of the programs. This result is in accordance with the natural environment aspects of the public children’s gardens. However, the subject diversity in the children’s education programs offered by public children’s gardens reflect not only the importance of science-associated programs but also the emphasis that public children’s gardens place on a comprehensive education.

In addition, the results of this study demonstrate that the program subjects offered in public children’s gardens were related to school curricula. This can be beneficial for school teachers because these gardens can provide an educational space where

the children can learn a variety of subjects through direct experience. Furthermore, this study shows that many children’s education programs offer environmental education to young children, while these programs decrease as children advance to the upper grades. This phenomenon probably occurs because this is the age at which children are developing various abilities. However, the observed trends in the composition of program offerings are markedly different across public children’s gardens. The program composition in an individual garden is often disproportionate, which is one reason why education coordinators responded that an increased variety of subjects was necessary to improve children’s education programs. Therefore, to motivate children’s curiosity and interest using public children’s gardens, it is important to diversify the natural environmental experiences of education programs. The results of this study would be useful for educators, researchers, and teachers planning children’s education programs. Finally, public children’s gardens should be considered necessary and active places for natural environment education in the future.

Literature cited

- Alexander, J., M.W. North, and D. Hendren. 1995. Master gardener classroom garden projects: An evaluation of the benefits to children. *Children’s Environ.* 12:256–263.
- Bachert, R.E. 1976. History and analysis of the school garden movement in America, 1890–1910. Indiana Univ., Bloomington, Doctoral Diss. Abstr. 37-08A.
- Beatty, B. 1995. Preschool education in America: The culture of young children from the colonial era to the present. Yale Univ. Press, New Haven, CT.
- Bradley, J.C., T.M. Waliczek, and J.M. Zajicek. 1997. Relationship between demographic variables and environmental attitudes of high school students. *J. Nat. Resour. Life Sci. Educ.* 26:102–104.
- Braus, J. and D. Wood. 1993. Environmental education in the schools: Creating a program that works! North Amer. Assn. Environ. Educ., Washington, DC.
- Bredderman, T. 1982. Activity science: The evidence shows it matters. *Sci. Child.* 20:39–41.

- Catsambis, S. 1995. Gender, race, ethnicity, and science education in the middle grades. *J. Res. Sci. Teach.* 32:243–257.
- Chawla, L. 1994. Gardening as an initiation into environmental action. *Amer. Horticulturist* 73(7):6–7.
- DeMarco, L.W., D. Relf, and A. McDaniel. 1999. Integrating gardening into the elementary school curriculum. *HortTechnology* 9:276–281.
- DiMare, J.N.A. 2012. An exploration of place-based design in northeastern children's gardens. MLA Thesis, Cornell Univ., Ithaca, NY.
- Disinger, J.F. 1998. Tensions in environmental education: Yesterday, today, and tomorrow, p. 1–12. In: H.R. Hungerford, W.J. Bluhm, T.L. Volk and J.M. Ramsey (eds.). *Essential readings in environmental education*. Stipes, Champaign, IL.
- Eames-Sheavly, M. 1998. Sowing the seeds of success: How to start and sustain a kids' gardening project in your community. Dept. Fruit Veg. Sci., Cornell Univ., Ithaca, NY.
- Eberbach, C. 1988. Garden design for children. MS Thesis, Univ. Delaware, Newark.
- Farenga, S.J. and B.A. Joyce. 1998. Science-related attitudes and science course selection: A study of high-ability boys and girls. *Roeper Rev.* 20:247–251.
- Finch, C.R. 1995. Green brigade: Horticultural learn-and-earn program for juvenile offenders. *HortTechnology* 5:118–120.
- Fox, J.E. and S. Berry. 2008. Art in early childhood: Curriculum connections. 10 May 2015. <<http://webshare.northseattle.edu/fam180/topics/art/Art%20in%20Early%20Childhood.htm>>.
- Froebel, F. 1974. The education of man (W.N. Hailman trans., original work published 1826). AM Kelley, Clifton, NJ.
- Groening, G. 1995. School garden and kleingarten: For education and enhancing life quality. *Acta Hort.* 391:53–64.
- Halverson, A.F. 2005. Field of dreams: A grass-roots approach to starting a children's garden. PhD Diss., Cornell Univ., Ithaca, NY.
- Halverson, A., N. Wells, D. Rakow, and S. Skelly. 2008. The growth of a children's gardens, p. 7–35. In: E. Goodenough (ed.). *A place for play: A companion volume to the Michigan television film "Where do the children play?"*. Natl. Inst. Play, Carmel Valley, CA.
- Harvey, M. 1989a. Children's experiences with vegetation. *Child. Environ. Qrtly* 8:36–43.
- Harvey, M. 1989b. The relationship between children's experiences with vegetation on school grounds and their environmental attitudes. *J. Environ. Educ.* 21(2):9–15.
- Herrington, S. 2001. Kindergarten: Garden pedagogy from romanticism to reform. *Landscape J.* 20:30–47.
- Jaus, H.H. 1984. The development and retention of environmental attitude in elementary school students. *J. Environ. Educ.* 15(3):33–36.
- Kahn, Jr. P.H., 2002. Children's affiliations with nature: Structure, development, and the problem of environmental generational amnesia, p. 93–116. In: P.H. Kahn, Jr. and S.R. Kellert (eds.). *Children and nature: Psychological, sociocultural, and evolutionary investigations*. MIT Press, Cambridge, MA.
- Kim, S.S. 2005. (The) comparative study on the primary textbooks in science between Korean and American in terms of contents of the curriculum graduate. School Educ., Yonsei Univ., Seoul., South Korea.
- Kindersley, D. 2000. The Dorling Kindersley science encyclopedia. DK Childrens Books, London, UK.
- Konoshima, H. 1995. Participation of school children in agricultural activities at school farms in Shiga Prefecture. *Acta Hort.* 391:217–222.
- Krantz, M. 1994. Child development: Risk and opportunity. Wadsworth, Belmont, CA.
- Kwon, M.H., C.W. Seo, J.Y. Kim, M.I. Kim, C. Pak, and W.K. Lee. 2015. A children's gardens within public gardens in the United States. *HortTechnology* 25:671–680.
- Lekies, K.S., M. Eames-Sheavly, K.J. Wong, and A. Ceccarini. 2006. A children's garden consultants: A new model of engaging youth to inform garden design and programming. *HortTechnology* 16:139–142.
- Louv, R. 2005. Last child in the woods: Saving our children from nature-deficit disorder. Algonquin, Chapel Hill, NC.
- Malaguzzi, L. 1998. History, ideas, and basic philosophy, p. 49–97. In: C.P. Edwards, L. Gandini, and G. Forman (eds.). *The hundred languages of children: The Reggio Emilia-advanced reflections*. Ablex, Norwood, NJ.
- Maller, C. 2009. Promoting children's mental, emotional and social health through contact with nature: A model. *Health Educ.* 109:522–543.
- Maller, C. and M. Townsend. 2006. Children's mental health and wellbeing and hands-on contact with nature. *Intl. J. Learning* 12:359–372.
- Midden, K.S. and J. Chambers. 2000. An evaluation of a children's garden in developing a greater sensitivity of the environment in preschool children. *HortTechnology* 10:385–390.
- Miller, D.L. 2007. The seeds of learning: Young children develop important skills through their gardening activities at a mid-western early education programs. *Appl. Environ. Educ. Commun.* 6:49–66.
- Miller, M.A. 2005. An exploration of a children's gardens: Reported benefits, recommended elements, and preferred visitor autonomy. PhD Diss., Ohio State Univ., Columbus, OH.
- Mohrmann, P. 1999. Planting the seeds of science: The school garden. A perfect laboratory for teaching science. *Instructor* 108(6):25–29.
- National Governors Association Center for Best Practices and Council of Chief State School Officers. 2010. Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects. Common Core State Standards Initiative, Washington, D.C. 20 Aug. 2015.
- Park, S.H. and M.R. Huh. 2010. Effects of a horticultural program on the preschool children's emotional intelligence and daily stress. *Korean J. Hort. Sci. Technol.* 28:144–149.
- Piaget, J. 1973. To understand is to invent: The future of education. Grossman, New York, NY.
- Piaget, J. and B. Inhelder. 1969. The psychology of the child. Basic Books, New York, NY.
- Purcell, K.B., R.E. Lyons, L.D. Dierking, and H. Fischel. 2010. Adolescent involvement at public horticulture institutions. *HortTechnology* 20:915–920.
- Ramsey, C.E. and R.E. Rickson. 1976. Environmental knowledge and attitudes. *J. Environ. Educ.* 8(1):10–18.
- Rimm-Kaufman, S.E., R.C. Pianta, and M.J. Cox. 2000. Teachers' judgments of problems in the transition to kindergarten. *Early Child. Res. Qrtly.* 15:147–166.
- Seo, H.J. 2013. A comparative analysis of the elementary school science curriculum and textbook between Korea and United States—Focus on life science-graduate program in science education. MS Thesis, Chonnam Nat'l. Univ., Educ. Gwangju, South Korea.

- Shair, G. 1999. A history of a children's gardens. *Public Garden* 14(3):9–11.
- Simpson, R.D. and J.S. Oliver. 1990. A summary of major influences on attitude toward and achievement in science among adolescent students. *Sci. Educ.* 74:1–18.
- Skelly, S.M. and J.M. Zajicek. 1998. The effect of an interdisciplinary garden program on the environmental attitudes of elementary school students. *HortTechnology* 8:579–583.
- Smith, L.L. 2003. The integration of a formal garden curriculum into Louisiana public elementary schools. PhD Diss., Stephen F. Austin State Univ., Nacogdoches, TX.
- Steil, A. and R.E. Lyons. 2009. Improving the evaluation of public garden educational programs. *HortTechnology* 19:601–608.
- Sobaski, C. 2006. An investigation of interactivity at the Michigan 4-H Children's Garden. MS Thesis, Univ. Delaware, Newark.
- Subramaniam, A. 2003. Garden-based learning: Considering assessment from a learner-centered approach. Univ. California 4-H Ctr. Youth Dev. Monogr., Dept. Human Community Dev., Univ. California, Davis, CA.
- Survey Monkey. 2011. Survey Monkey. 17 July 2011. <<http://www.surveymonkey.com>>.
- Vygotsky, L.S. 1978. *Mind in society: The development of higher psychological processes*. Harvard Univ. Press, Cambridge, MA.
- Wake, S.J. 2007. Designed for learning: Applying “learning-informed design” for a children's gardens. *Appl. Environ. Educ. Commun* 6:31–38.
- Waliczek, T.M., J.C. Bradley, and J.M. Zajicek. 2001. The effect of school gardens on children's interpersonal relationships and attitudes toward school. *HortTechnology* 11:466–468.
- White, R. and V. Stoecklin. 1998. Children's outdoor play & learning environments: Returning to nature. 20 Nov. 2015. <<https://www.whitehutchinson.com/children/articles/outdoor.shtml>>.
- Wilson, R.A. 1996. Starting early: Environmental education during the early childhood years. ERIC Dig. ED402147. ERIC Clearinghouse Sci. Mathematics Environ. Educ., Columbus, OH.
- Yager, R.E. and A.J. McCormack. 1989. Assessing teaching/learning successes in multiple domains of science and science education. *Sci. Educ.* 73:45–58.
- Yager, R.E. and S.O. Yager. 1985. Changes in perceptions of science for third, seventh, and eleventh grade students. *J. Res. Sci. Teach.* 22:347–358.