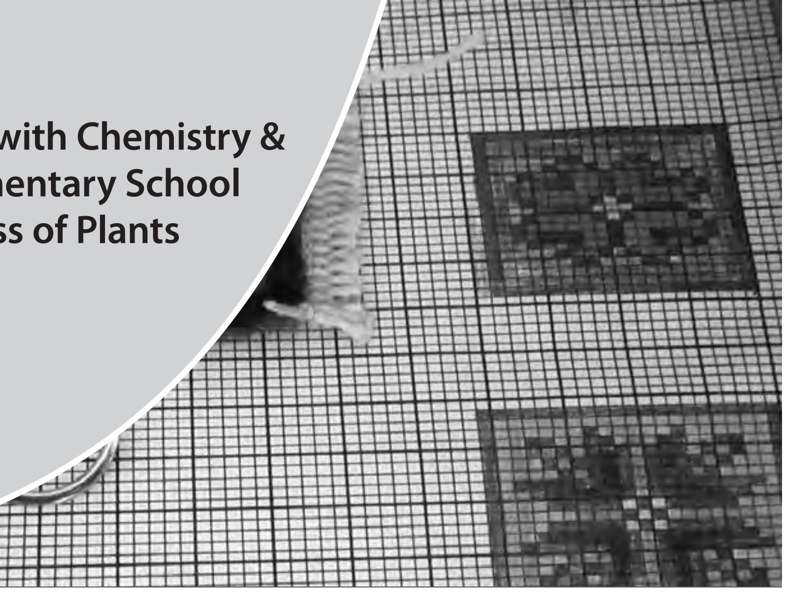
RESEARCH ON LEARNING

Integrating Botany with Chemistry & Art to Improve Elementary School Children's Awareness of Plants



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Abstract

Students need to be aware of plants in order to learn about, appreciate, care for, and protect them. However, research has found that many children are not aware of the plants in their environment. A way to address this issue might be integration of plants with various disciplines. I investigated the effectiveness of an instructional approach based on integration of botany with chemistry and art for increasing students' awareness of plants. The study was carried out in a science summer school for 10- to 12-year-old students (n = 25). A plant awareness questionnaire and a plant blindness test were used as pretests and posttests to assess the effects of the instruction on the students' plant awareness. Semi-structured interviews were also conducted with the students after instruction. The results indicated that integrating plants with various disciplines might overcome the learning problem of students associated with their "plant blindness." Moreover, this instructional approach can provide students opportunities to learn the names of plants and some concepts in the botanical discipline, as well as help them understand the relationship between plants and other disciplines.

Key Words: *Plant blindness; integration; botany; chemistry; art.*

Science education documents (e.g., National Research Council, 1996; NGSS Lead States, 2013) recommend teaching plants at each level of basic education. However, it may not be easy to teach plants because students' interest in plants is low (Wandersee et al., 2006). The term "plant blindness," introduced in 1998, refers to an inability of human beings to notice the plants in their environment although they encounter them frequently (Wandersee & Schussler, 2001).

As reported in the literature, many children and adults are not aware of the plants in their environment (e.g., Gatt et al., 2007; Yorek et al., 2009; Patrick & Tunnicliffe, 2011). There are various reasons for students having less interest in plants – a main one being how teachers present the subject (Schussler & Olzak, 2008). A good approach to teaching about plants should give students opportunities to touch plants and soil with their hands (Tunnicliffe, 2001; Jewell, 2002; Kirby, 2008; Blair, 2009; Patrick & Tunnicliffe, 2011) and help them see the plants from different perspectives (Strgar, 2007). Plants are interrelated with various disciplines such as ecology, chemistry, art, pharmacology, and economy. The integration of plants with various disciplines might be a good way to overcome students' plant blindness problems. According to Stoddart et al. (2002), the integration of disciplines has been described in three main ways: interdisciplinary, integrated, and thematic. In the interdisciplinary approach, the instructional content of secondary disciplines is used to support the primary discipline – for example, statistical literacy skills can be applied in science teaching. In the integrated approach, there is no dominant discipline – all have equal emphasis, and the teaching of science and of language, for example, is viewed as a synergistic process. In the present study, I used the thematic approach, which is characterized by the use of an overarching theme to create relationships between disciplines. As my students learned about plants, I introduced the relationships between botany, chemistry, and art.

Plants are interrelated with various disciplines such as ecology, chemistry, art, pharmacology, and economy.

Instructional integration of various disciplines has been used in science teaching (e.g., Furlan et al., 2007; Clay et al., 2008; Morrison, 2012), but little research has been conducted on the integration of disciplines in teaching about plants. Therefore, my main concern in the present study was to explore whether students' awareness of plants could be improved through an instructional approach based on integration of botany with chemistry and art.

The study was carried out in a science summer school program in Turkey called "A Journey to the Botanic World," designed for the 10- to 12-year-old students who spent their time in the summer school on a voluntary basis. The program, run by Muğla Sıtkı Koçman University, lasted for 8 days in June. Instruction started at 9:00 a.m. and finished at 6:00 p.m. The director of the summer school was a science educator. There were also 13 academicians who taught plants to the children: four botanists (one professor and three Ph.D. students), four chemists (an associate professor, a Ph.D. student, and two M.A. students), two art education lecturers, two science educators (an assistant professor

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and an M.A. student), and an undergraduate student who helped the students with technological problems (e.g., the use of any mobile devices, phones, or tablets with Internet access).

The participating students were exposed to a wide range of activities for recognizing plants, especially those in their own environment. Moreover, they had to discover the link of the plants with chemistry and art. The participants worked in groups of five in the activities.

○ Learning Outcomes

The participating students discovered the Plant Kingdom through activities that integrated botany, chemistry, and art to help them

- recognize the plant species in their own environment and some other plant species;
- appreciate plant diversity;
- know the basic characteristics of plants in their own environment and some other plants;
- recognize the links between plants, chemistry, and art;
- apprehend the importance of plants for human life;
- understand some concepts in botany; and
- gain better appreciation of the work of botanists, chemists, and artists.

○ Five Botany-Based Activities

Preparing Herbarium Specimens

The participating students made their own herbarium specimens in this activity. The activity started with a visit to Muğla Sıtkı Koçman University Herbarium to learn what a herbarium is, how herbarium specimens are prepared, and why a herbarium is important. Then the study groups collected plant specimens in a Calabrian pine forest, using the proper techniques for preparing herbarium specimens. During the collection of plant specimens in the field, the participants learned the names of the plants and their characteristics. For example, they discovered why the Calabrian pine is called *Pinus brutia* by examining the cracks on its trunk. They observed some different thyme species (*Thymus* spp.) in the field, picking up and smelling some flower and leaf specimens, and then they stated that thyme is an aromatic plant.

Flora Catalogue

The participants prepared a flora catalogue of the campus in this activity. Each study group was given a camera, and the participants were taught how to take pictures of plants. The participants worked as if they were plant photographers and took pictures of the plants during a walk in the forest on the campus. Each group was also given a mobile device, phone, or tablet with Internet access to which their photos were then uploaded. Next, the groups searched for the plants' scientific and common names on the Internet to find out one interesting feature of each of the plants. A flora catalogue was finally created with the students' photographs and information gathered online by the groups.

A Trip to a Botanic Garden

In this activity, the participants visited a botanic garden where they could observe many species of plants (e.g., 41 species of palm family, hundreds of natural and exotic subtropical plants, 300 species and subspecies of cacti, succulents, etc.). On the way to the botanic garden, they stopped for a 30-minute break in a natural forest of Turkish sweetgum (*Liquidambar orientalis*), an endemic plant. They smelled resin to understand that it is an aromatic and medicinal plant. After the visit to the botanic garden, they stopped over on the way home in another forest, where they observed another endemic plant species (*Teucrium sandrasicum*) and some other, nonendemic plant species. They collected specimens of some nonendemic plants and were asked to classify them according to one feature that they chose, such as flower, trunk, or leaf. The groups completed the activity with the preparation of a systematics poster and a talk on plant systematics.

Three-Dimensional Views of Plants

In this activity, the educators were expecting the students to explore the many things in the plants that are impossible see with the naked eye and to know that plants are composed of a great number of cells. First, they observed plants specimens with their eyes alone. Then they observed the same specimens under the stereoscopic microscope and examined the cilia and veins of leaves and their shapes. Also, they observed carpels, stamens, pollens, and petals of flowers. While the participants were examining the plants under a stereoscopic microscope, they also observed some insects on the flowers and were asked by the educators how and why these insects were on the flowers. They continued to use the light microscope to observe plant cells in their prepared microscopic slides from sections of leaves and flowers and to differentiate between leaf and flower cells of the same plant.

Planting a Young Tree

In this activity, the participants planted young trees in a 500-m^2 empty field. Each study group planted 10 species of trees. They first measured the empty field for planting the young trees and then decided the appropriate tree types and planting locations by considering their number, their growth rate, and their aesthetic characteristics. The groups completed the activity with the preparation of identification cards for each tree with the common and scientific names of the plant, the planting date, and the name of the person who planted it. The identification cards were finally attached to the young trees.

○ Three Chemistry-Based Activities

Making Olive Oil Soap

The aim of this activity was to help the participants explore the utilization of vegetable oils and aromatic plants. They made their own olive oil soap in this activity by mixing 100 mL olive oil and 160 mL ethyl alcohol in a round-bottom flask fitted with a distillation column. They heated the solution in the heating mantle for 5 minutes, added 20 g of potassium hydroxide to the mixture, and boiled the mixture to 100°C for 1 hour. They checked whether the reaction was complete by dropping water into the mixture. If the solution in the round-bottom flask became homogeneous when the water was dropped into it, the reaction was complete. They continued the distillation process for about 15–20 minutes at 75°C to remove the ethanol from the round-bottom flask and obtained a high-viscosity soap. They added distilled water to dilute the soap. The groups added different plant aromas such as laurel and thyme to the soap to give it fragrance. They finished the activity by washing their hands with the soap they had made.

Testing Acids & Bases with Red Cabbage Extract

The aim of this activity was to help the participating students discover that some plants include natural pigments. Moreover, these natural pigments can be used for various purposes. A red cabbage was cut into pieces and then boiled in a beaker for 30 minutes. The colored water was filtered. The study groups were given materials such as vinegar, lemon, orange, apple, mineral water, liquid soap, baking powder, and toothpaste in test tubes to test their acidity and alkalinity. As the colored water was dripped into the test tubes, the participants observed and recorded the color changes. They observed that cabbage juice is naturally purplish and that when poured into an acid, such as vinegar, lemon, orange, apple, or mineral water, it turns reddish. When added to a base, such as soap, baking powder, or toothpaste, it turns blue or green.

My Egg Is Colorful

In this activity, the participants discovered that some plants could be used for making natural dyes because of their intensely colored pigments. First, white-shelled eggs were covered with walnut shell, red onion skin, onion skin, pomegranate skin, or pine bark. These plant skins were fastened with cotton ropes around the eggs. Then the eggs were boiled in a beaker. After the eggs were cooled, the plant skins around them were removed. The participants observed that the white eggs had become colorful. Then they peeled the shells of the boiled eggs. Finally, the shells colored with natural dyes were used to make mosaic art. In this way, the participants obtained natural dyes and created a piece of visual artwork.

○ Two Art-Based Activities

Endemic Plants

In this activity, the participants watched a documentary about Turkish sweetgum (Toprak, 2007), which pointed out that this endemic species was at risk of extinction and that efforts must be made by the public to preserve it. The participants were asked to envision themselves as a documentary director and to answer the question: "If you were to shoot the second part of this documentary, what would be the name of the documentary and its main theme?" The activity continued with the participants reading newspaper stories about thefts of endemic plants. Then each study group performed a creative drama about plant theft. The participants finally completed the activity with a poster design and presentation about endemic plants and their preservation.

Handmade Carpet

The main focus of this activity was on handmade carpets, one of the cultural values of Muğla. Naturally dyed fibers are used in weaving carpets. Therefore, handmade carpets are good tools for the participating students to learn about plants that contain pigments and to discover their important artistic and cultural values in their society. The activity started with the introduction of Turkish handmade carpets, their history, and a film showing these carpets in the paintings of European artists. They also discovered how and from which plants the colors they saw in handmade carpets were obtained. They finally designed their own carpet motifs and wove those motifs using naturally dyed fibers.

○ Assessment

A plant awareness questionnaire and a plant blindness test were used to assess the effects of instruction during the science summer school on the students' plant awareness. These two instruments were implemented as the pretests before instruction and also as the posttests after instruction.

The plant awareness questionnaire was developed by the author. This instrument included two open-ended questions. The first question was "Write down the name of 10 living things that come to your mind first." This question was adopted from the "conceptual understanding test of the living things and the life concept" developed by Yorek et al. (2009). This conceptual understanding test was developed for assessing how 9th-grade students construct their understanding of living things. When Yorek et al. (2009) analyzed one of the questions in their test, they noticed that the participants had possible symptoms of plant blindness. Because of this, with their permission, I used the question in the plant awareness questionnaire. First, I asked an expert group (including one biology educator, one language educator, one science teacher, and Yorek) whether this question was appropriate for 10- to 12-year-old children. All of them stated that young children can understand and answer this question. The second question asked the students to write down the source of their knowledge about each living thing they named.

The plant blindness test was adopted from Schussler and Olzak (2008), who developed it for testing college students' plant blindness. I asked these authors whether the instrument was appropriate for 10- to 12-year-olds. They replied affirmatively, and I obtained their permission to translate the instrument into Turkish and use it in this research. The Turkish version was examined by one biology educator, one language educator, and one science teacher, and I revised it on the basis of their comments (e.g., some images in the instrument were changed). The plant blindness test included 14 plant and 14 animal images, which were presented to the participants for 9 seconds each, using a presentation program that alternated between plant and animal images. After the presentation, the students were asked to write down the names of the presented plant and animal images on a recall sheet.

The two instruments were administered to a sample of 10- to 12-year-old students (n = 30) as the pilot test group. The pilot test results were used to determine which words/phrases/images students had difficulty in understanding. The instruments were then revised on the basis of the pilot test's results.

In both the pretest and the posttest, the participants responded first to the plant awareness questionnaire and then to the plant blindness test. Although 25 students joined the science summer school, only 23 of them satisfactorily completed these assessment instruments.

Moreover, after instruction, a semi-structured interview was carried out with 87% of the participants on a voluntary basis. Two questions were asked during the interviews: "What did you learn about plants in the science summer school?" "What kind of positive or

Table 1. Pretest results: participants' most frequently appreciated living things (*name of plant specimen).

Living Thing(s)	F	%
Cat	15	65.2
Dog	13	56.5
Lion	11	47.8
Tiger	8	34.8
Snake	7	30.4
Daisy* / Cow / Crocodile	6	26.1
Kangaroo / Giraffe	5	21.7
Ant / Monkey / Shark	4	17.4
Bear / Cheetah / Cactus* / Worm / Penguin / Leopard / Mole / Platypus / Squirrel / Iguana / Turtle / Goat	3	13
Pine tree* / Grasshopper / Horse / Tulip* / Lungwort* / Sea calf / Elephant / Owl / Zebra / Water lily* / *Hippopotamus amphibius* / Rabbit / Butterfly / Spider / Raccoon / Chicken / Violet* / Rose* / Eagle	2	8.7
Lizard / *Vespertilio* sp. (bat)/ Whale / Ostrich / Rhinoceros beetle / Shield fern* / Marsh horsetail* / Fly / Lady beetle / Orchid* / Narcissus* / Pelican / Camel / Begonia* / Hermit ibis / Rooster / Lynx / Peacock / Gazelle / Deer/ Bussy lizzie* / Wolf / Mouse / Gorilla / Stork / Jellyfish / Octopus / Dolphin / Snowdrop* / Poppy* / Basil* / Cherry tree* / Pomegranate tree* / Petunia* / Plum tree* / Morella tree* / Snail / Plane tree* / Chrysanthemum* / Sunflower* / Frog / Beech*	1	4.3

Table 2. Posttest results: participants' most frequently appreciated living things (*name of plant specimen).

Living thing(s)	F	%
Palm*	13	56.5
Mullein*	12	52.2
Turkish sweetgum*	11	47.8
Oleander* / Cactus*	9	39.1
Sycamore*	8	34.8
Poppy* / Water lily* / Turtle	6	26.1
Thyme * / Parsnip* / Lion / Cat / Lizard	5	21.7
*Cercis siliquastrum** / Carnation* / Rose* / Euphorbia* / Poplar* / *Fritillaria imperialis**	4	17.4
*Phoenix theophrasti** / *Cupressus arizonica** / Calabrian pine* / Lavender* / Lily* / Dog / Cow	3	13
*Chorisia speciosa** / Medlar* / Eucalyptus * / Daisy* / Centaury* / *Aloe vera** / Donkey / Cheetah / Mouse / Fly / Monkey	2	8.7
Sunflower* / Nettletree* / Acacia* / Blackberry* / Helichrysum* / Eggplant bush* / Chaste tree* / Mint* / Mimosa* / Bamboo* / Apple tree* / Pear tree* / Palm tree* / Cistaceae* / Zebra / Common starfish / Bee / Seadog / Spider / Bear / Horse / Canary / Butterfly / Wolf / Giraffe / Frog / Sheep / Hyena / Shark / Piranha / Crocodile / Snake	1	4.3

negative contributions did the summer school make for you?" During the interviews, audio recordings were made.

Results of the Plant Awareness Questionnaire

In the analysis of data obtained from the first question in the questionnaire, frequencies and percentages were calculated for the list of 10 living things in the participants' responses. The living things most frequently appreciated by the students in the pretest are shown in Table 1. Before instruction, there were 86 different living things in the participants' lists in their pretest responses, of which only 23 (30%) were plants. For example, of the 10 living things most frequently appreciated by nearly or more than half of the students, three were animals: cat, dog, and/or lion; only two plants (daisy and cactus) were appreciated by 13% or more students (see Table 1). The living things most frequently appreciated by the students in the posttest are presented in Table 2.

Table 3. Pretest and posttest results: sources of students' knowledge about plants.

Source of knowledge	Pretest		Posttest	
	F	%	F	%
Real-life experiences	12	52.2	15	65.2
Teacher	5	21.7	3	13
Documentary	5	21.7	2	8.7
Parents	2	8.7	2	8.7
Book	2	8.7	5	21.7
TV and/or Internet	2	8.7	1	4.3
"A Journey to the Botanic World" summer school	0	0	12	52.2

Table 4. Pretest and posttest result: percentage of recall for each image.

Animal Image	Pretest		Posttest		Plant Image	Pretest		Posttest	
	F	%	F	%		F	%	F	%
Turtle	22	95.7	21	91.3	Pumpkin	18	78.3	17	73.9
Spider	5	21.7	13	56.5	Corn	6	26.1	15	65.2
Ladybug	10	43.5	12	52.2	Carrot	4	17.4	13	56.5
Starfish	11	47.8	13	56.5	Apple tree	12	52.2	15	62.5
Snail	10	43.5	11	47.8	Cactus	5	21.7	18	78.3
Frog	16	69.6	13	56.5	Palm tree	9	39.1	18	78.3
Seahorse	12	52.2	13	56.5	Rose	14	60.9	16	69.6
Dolphin	13	56.5	11	47.8	Sunflower	6	26.1	12	52.2
Jellyfish	6	26.1	8	34.8	Water lily	11	47.8	15	65.2
Centipede	6	26.1	9	39.1	Pine tree	7	30.4	15	65.2
Ray	14	60.9	14	60.9	Venus flytrap	6	26.1	13	56.5
Praying mantis	13	56.5	17	73.9	Oak tree	9	39.1	13	56.5
Salamander	16	69.6	16	69.6	Carnation	13	56.5	18	78.3
Moray eel	5	21.7	17	73.9	Daisy	14	60.9	12	52.2

In the posttest responses, there were 70 different living things in the participants' lists, 41 (59%) of which were plants. For example: palm, mullein, and Turkish sweetgum were appreciated by nearly half of the students; oleander, cactus, and sycamore by nearly 40% of them; and poppy and water lily by nearly a quarter of them. In the pretest, lion and cat were among the most appreciated 10 living things, whereas lion and cat were appreciated by only 21.7% of students in the posttest (see Table 2).

Table 3 shows the results of the analysis of the sources of students' knowledge about plants in the pretest and the posttest. In the students' responses to each test, the knowledge source and the number of students who stated each source were determined and their percentages were calculated.

Students' knowledge about plants was generally based on their real-life experiences. Other main knowledge sources were teachers and documentaries. After instruction, more than half of the students clearly indicated that their knowledge sources about plants were their observations in the summer school. Therefore, real-life experiences were the other main knowledge source about plants after instruction.

Results of Plant Blindness Test

The recall frequencies and percentages were calculated for each image in the plant blindness test (see Table 4).

In the pretest, it was found that the students had recalled more animal images than plant images. For example, only 5 of the 14 plants images were remembered by more than half of the students. Nearly 40% of the students remembered correctly three plant images. One plant image was remembered by 30% of the students. A quarter of the students remembered another three plant images. The remaining two plant images were remembered by nearly 20% of the students. For animal images, the turtle's image was remembered by 95.7% of the students, and more than half of the students remembered six animal images. Three animal images were remembered by >40%

Table 5. Results of paired-sample t-test for recall of plant images (* P < 0.05).

Test	Mean	n	SD	df	t	P
Pretest	5.82	23	2.3	22	−5.244	0.000*
Posttest	9.13	23	2.9			

Table 6. The result of paired-sample t test for recall of animal images (* P < 0.05).

Test	Mean	n	SD	df	t	P
Pretest	6.73	23	1.9	22	−1.828	0.081
Posttest	8.17	23	3.2			

of the students. A quarter of the students remembered two animal images. The remaining two animal images were remembered by 20% of the students. Recall of plant images increased from the pretest to the posttest. In the posttest, each plant image was remembered by more than half of the students. The turtle was again remembered by 90% of the students in the posttest; however, only nine animal images were remembered by more than half of the students in the posttest.

A statistical analysis was conducted to detect any significant differences between plant images recalled in the pretest and those recalled in the posttest. Every correct recall of plant images was equivalent to 1 point, and no recall = 0. Therefore, each student's score for recalling plant images could range from 0 to 14. The same analysis was conducted for recall of animal images. Data were inspected for normality using the Shapiro-Wilk test. All data were normally distributed (Shapiro-Wilk $P > 0.05$), so a paired-sample t-test was used. Table 5 shows the results of the paired-sample t-test for the recall of plant images.

Results of the paired-sample t-test showed that the mean scores for recalling plant images before instruction ($M = 5.82$, $SD = 2.3$) and those after instruction ($M = 9.13$, $SD = 2.9$) differed significantly at the 0.05 level ($t = 5.244$, $df = 22$, $P = 0.000$). Table 6 shows the results of the paried-sample t-test for recall of animal images.

There was no statistical difference at the 0.05 level between the pretest mean scores ($M = 6.73$, $SD = 1.9$) and posttest mean scores ($M = 8.17$, $SD = 3.2$) for recall of animal images ($t = 1.828$, $df = 22$, $P = 0.081$).

Results of Semi-Structured Interviews

The interview data were analyzed using the thematic content analysis method, a descriptive presentation of qualitative data (Anderson, 2007; Reissman, 2008). First, I transcribed the interview data and read the transcripts multiple times for in-depth understanding of the participants' responses. Then I generated the initial codes of the data to form patterns and meanings. Subsequently, I reread the transcripts to reexamine the codes and to eliminate any possible errors in data coding. In the next phase, the codes were combined and themes were developed. The data were also analyzed by one of the educators of the science summer school. Afterward, the results of the analyses were compared. Seven themes were obtained from the semi-structured interviews. These themes, and their frequencies and percentages, are presented in Table 7.

○ Discussion & Conclusion

According to the *Living Planet Report* (IUCN, 2012), biodiversity in the world decreased by 30% between 1970 and 2008. Fifty-two percent of the species at risk of extinction were plants (IUCN, 2006). Governmental, national, and international organizations have developed strategies to conserve plants and other living species. However, if people are not aware of floristic richness in their environment, it is nearly impossible for them to appreciate and preserve it (Fančovičová & Prokop, 2011).

The present study aimed at examining the effects of an instructional approach – based on integration of botany with chemistry and art – on children's plant awareness. Individuals with plant blindness are unable to notice plants in their environment or see their importance in the biosphere and in human affairs. These individuals are unable to appreciate plants' unique and aesthetic biological characteristics, believing that plants are inferior to other living things (Wandersee & Schussler, 2001). The results of the tests in the present study indicate that integrating botany with chemistry and art is a good way to improve children's plant awareness. Also, the four themes obtained from interviews – *realize the importance of plants to the biosphere, admire plant biodiversity*, *recognize new plant specimens*, and *achieve greater plant awareness* – supported results obtained from the questionnaire and the test. The other two themes indicated that integrating plant science and various disciplines using the thematic approach can provide students opportunities to learn about plant science. These results are consistent with those of other studies in the literature on teaching plants. For example, Radwanski and Ward (2007) integrated plant science with theater and the Hedberg Library's special collection. They reported that their instruction had positive effects on student learning about plants. Also, the results of the interviews in the present study indicate that integrating botany with chemistry and art can be a good way for students to realize the relationship between plants and other disciplines. Studies have revealed that U.S. adults seldom appreciate the importance of plants to culture and commerce (Wandersee & Schussler, 2000; Wandersee & Clary, 2006). It can be argued that integrating plant science with various disciplines is a good way for students to recognize the importance and use of plants in other disciplines.

Instructional integration of disciplines is philosophically consistent with widely accepted current teaching theories, which admit that learners have diverse abilities and that they construct their knowledge

Table 7. Results obtained from the interviews.

Themes	F	%	Examples of students' statements
Realize the importance of plants to biosphere	9	45	"I understood that plants were very important for human beings and other living things." (Funda)
Admire plant biodiversity	8	40	"I saw incredible views in the botanic garden. I will never forget the plants such as water lily, and white floss silk tree. There were many plant species and every one of them had different characteristics." (Funda)
Recognize new plant specimens	13	65	"I learned about the plants which I have never seen, heard, or known up till now." (Ali)
Achieve greater plant awareness	12	60	"I thought that I was an environmentalist. But through this science summer school I felt that I neglected plants in my environment. Now, I see nature differently. I want to shout while saying the names of the plants in my environment." (Bahar)
Learn the common and scientific names of plants	10	50	"I learned the names of many plants. I don't call the plants in my environment as grass or tree. I just tell their specific names such as Calabrian pine, sycamore, and mullein." (Ahmet)
Realize the relationship between the plants and other disciplines	8	40	"I learned that some plants had secretion and some had special aroma. I also learned that some plants had pigments. Moreover, I learned that these qualities of plants were used for some purposes. I smelt the aroma of Turkish sweetgum (*Liquidambar orientalis*) and I learned that oil was produced from Turkish sweetgum and soap and other things were made from it. " (İsmail)
Learn some concepts in botany	7	35	"I learned endemic plants. There are a lot of endemic plants in Turkey. I know what a herbarium is and how it is made. It is the first time I have heard of an arboretum. I know now what it is." (Ayşe)

in multiple ways (Gardner, 1999). Instructional integration of disciplines might help facilitate learning by providing multiple ways for learners to process their knowledge, giving them opportunities to use knowledge and skills in different disciplines in order to find solutions or generate new knowledge (Stoddart et al., 2002; eMINTS National Center, 2008; Wood, 2010). For instance, the instruction implemented within the context of the present study provided opportunities for the students to explore plants not only with knowledge of botany but also with that of chemistry and visual art.

The positive results of the study may be due to other effects, apart from the instructional integration of disciplines. The instruction in the science summer school gave the students opportunities to collect their own plant specimens, plant their own trees, take photos of the plants, and smell them. The literature commonly reports that garden-based, outdoor and/or active interaction of learners with plants has positive effects on their knowledge about plants (e.g., Fančovičová & Prokop, 2011; Rye et al., 2012) and attitudes toward plants (e.g., Lohr & Pearson-Mims, 2005). The effects of the instructional integration of disciplines in the present study have not been compared with those of other commonly praised methods, such as outdoor or garden-based teaching. Therefore, future studies might compare the effects of the instructional integration of disciplines, outdoor learning activities, and gardening programs on improving students' awareness of plants.

Science teachers do not need complex and expensive tools to carry out the activities presented here; these activities can be implemented easily in regular science courses. The 10 activities introduced here spanned 8 days. In regular school settings, teachers might have limited time for teaching plants. It is possible for teachers to shorten these activities. For example, in the present study, students collected plant specimens from a forest that is 60 km away from Muğla for preparing their herbarium specimens. In a regular science course, students might collect plant specimens from areas around their school. In the "My Egg Is Colorful" activity, students collected plants that included natural pigments, such as walnut and pine, from campus; teachers might prepare experimental tools for implementing this activity in limited time. Some activities in the science summer school were art based. Science teachers might collaborate with art teachers to implement these activities in an art course.

The science summer school integrated visual art and traditional Turkish handicraft with students' learning about plants. Other branches of art can also be incorporated into activities for learning about plants in teaching based on the instructional integration of disciplines. For example, many musical instruments (e.g., violin and guitar) are made from plants and, thus, can be used in activities for learning the links between plants and music. In the science summer school, the students showed interest in the cosmetic and pharmacological characteristics of plants. Therefore, these disciplines can be integrated with botany to enhance students' awareness of plants. The effects of the instructional integration of disciplines on the students' plant awareness were assessed here; future studies might further investigate how teaching plants with integration of various disciplines affects students' attitudes toward plants and biology.

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