COMPARISON OF TWO METHODS UTILIZED TO TEACH SIXTH GRADE STUDENTS RECOGNITION OF STRUCTURAL DEFECTS IN TREES

By

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I dedicate this work to my mother, Linda Sanagorski, (1947- 2006).

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By

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Sixth grade students are capable of recognizing and comprehending the implications of structural defects in trees. Structural defects in trees were introduced to sixth grade students at three schools: Seminole Middle School in Plantation, Nova Middle School in Davie, Plantation Middle School in Plantation, all located in the Broward County, Florida school district. The schools represented Florida Comprehensive Assessment Test (FCAT) school grades of A, B, and C, respectively. These grades are assigned based on students' collective test scores at each school, and are used as a measure of how successful the school is at teaching statewide academic standards.

Two methods of instruction: hands-on, experiential instruction versus a passive, lecture-style instruction, were compared in teaching recognition of structural defects in trees. Through the use of a pre-test and a post-test, it was determined that students exposed to both methods of instruction were more successful in recognizing defects after instruction than they were before instruction. Moreover, it was determined that students exposed to defects in trees via lecture-style classroom instruction performed better in the post test than students exposed to the same material via a more hands-on approach. On both tests, students were asked to complete several

arboricultural general knowledge questions. The arboricultural general knowledge questions demonstrated that a significant arboricultural knowledge base exists within the sixth grade classes who participated in this study.

CHAPTER 1
INTRODUCTION

Trees, Children, and Education

Trees have been proven to be beneficial for children socially, physically, and emotionally. Learning about plants and trees is beneficial as well. With limited curriculum currently available on arboriculture and horticulture, education about plants and trees is extremely important, with tree structure being an item of particular significance.

Today's adults were exposed to the outdoors much more than today's children are. There is an unprecedented level of electronic media exposure today, of which the results are not yet known.

Trees in an Urban Forest

The urban forest encompasses the trees and plants within a city environment. An urban forest can be seen as an ecosystem with the rather unusual components such as pavement, homes, vehicles, commercial properties, and airports (Treepeople and Lipkis 1990). Care of urban trees is extremely different from the care of trees in a forest. Trees in an urban setting are confined to an "artificial habitat" that fails to provide an adequate amount of the light, clean water, unlimited healthy soil, and clean air that a tree requires (Treepeople and Lipkis 1990). For this reason, urban trees require special care, both for their well-being and for the protection of the property and individuals that share their environment. Principles of managing the urban forest must include the social aspect of spaces shared by both people and trees. The management of such trees is much more intensive than the management of trees in a typical, natural forest. Trees are dynamic, living systems. They do not heal, regenerate, or restore injured parts. They compartmentalize, or grow special wound-wood to stop the spread of decay (Shigo, 1989). This is one of their survival mechanisms, because trees are unable to move from detrimental forces.

One specific example of the intensive management required in an urban setting is the recognition and analysis of hazard trees. There are specific requirements for a tree to be deemed as a hazard tree. A hazard tree must have structural defects which create the potential to fail, be located in an environment favorable to failure, and be located in close proximity to a target that would be subjected to the impacts of a failure. The parts of the tree likely to fail must also be of a substantial size. For example, a tree with extremely large, codominant leaders and included bark located in the woods is not a hazard tree, even if it is likely to fail. This same tree located on a busy street over a park bench during hurricane season would be a hazard tree.

Structural Defects in Trees

Common structural defects of landscape trees include circling/girdling roots, a leaning/bent/broken/damaged trunk, included bark, codominant trunks, and attachments of equal sizes. Trees without structural defects are highly desirable in an urban landscape, because they have reduced risks of failure.

Hazard trees, as previously mentioned, have one or more of these structural defects. Hazard trees can cause injury to persons and damage to property. Hazard trees have shorter lifespans than trees with good structure, and are more costly to maintain.

Importance of Structural Defect Recognition

Hazard trees can be recognized when they are at a young age so that planting them can be avoided or proactive measures to correct the defects can be taken. People who handle trees, such as growers, landscapers, landscape maintenance crews, property management, and homeowners, should be able to recognize significant defects at each stage of trees' lives. Recognition of defects in trees relies on the education of those who handle them (Shigo, 2000).

Often, property owners may pay the price for the lack of knowledge regarding the presence of structural defects in trees.

Trees without structural defects are considered higher quality and may demand a higher price in the market. However, many buyers and sellers are unable to recognize the difference in tree quality due to lack of education, a real disadvantage. People need to be able to recognize structural defects in trees so that better quality trees can be planted in our landscapes and better quality urban forests produced.

Incorporation In To Education

There is a deficiency of horticultural and arboricultural subjects for students. However, recent additions to curriculum have been well-received by both instructors and students (Meyer et al., 2001). Professionals are encouraging research into what and how arboricultural and horticultural topics can be incorporated (Smith and Motsenbocker 2005). As an added benefits, it is known that these topics can facilitate the instruction of other subjects (Nyenhuis, 1994, and Dirks and Orvis, 2005).

While typical middle school instruction in Florida Public Schools is conducted toward preparation for the Florida Comprehensive Assessment Test , teachers are free to teach as they please (Anon., 2005). Structural defect recognition is one subject that can be incorporated into the schools. This study was conducted to find out if 6th grade is an appropriate time to present structural defects in trees as part of the curriculum. Two teaching methods were compared to find out whether traditional lecture-style classroom instruction or a more hands-on, experiential approach would be more effective.

Previous studies have shown that active, hands-on learning may be the most effective method of teaching students (Hancox, 2005, and Morgan, 1993).

CHAPTER 2
LITERATURE REVIEW

Benefits of Trees for Children

Trees provide aesthetic and environmental benefits, and also provide numerous societal ones. Arboriculture and horticulture have been stated as a foundation for healthy social ecology (Kuo, 2003) and cause improved life skills in children (Robinson and Zajicek, 2005). Children also really like to be around trees. They are more likely to congregate in heavily-canopied areas as opposed to less green spaces (Coley et al., 1997). Activities, such as creative play, tend to occur in green spaces (Faber Taylor et al., 1998). Children who have horticultural topics incorporated into their education perform better in their science classes than those that do not (Smith and Motsenbocker, 2005; Klemmer et al., 2005; Poston et al., 2005).

According to Louv, children absolutely need nature for development and learning. He states that this is apparent by the [negative] result of a lack in exposure and by the “magic” that occurs when children experience the outdoors (Louv, 2005).

Youth Arboricultural Education

Youth horticultural education is important and beneficial (Phibbs and Relf, 2005; DeMarco et. al., 1999) Nature-related subjects incorporated into current subject topics increase childrens’ sense of place, teach them about their local trees and plants, and increase knowledge about local ecology (Spitz, 2002). Even young students can learn about trees. Second graders in New Hampshire collect data about tree diameter both at home and in forests surrounding their schools. This data has been used to help determine the age of New Hampshire’s forests (Lonergan, 1997).

Importance of Incorporating Arboricultural Subjects

There is a general need for improved arboricultural and horticultural education for children and adults. Education in urban forestry and arboriculture is extremely important (Elmendorf, 2005). Within this broad subject area, tree structure has been stated as one of the top five most important educational topics in urban forestry and arboricultural education (Elmendorf, 2005). If the general public were more knowledgeable about these and other arboricultural issues, urban forests would be more healthy, more structurally sound, and safer overall. Defects in tree structure could be introduced to elementary students to give them a general understanding of these concepts. It is highly important to introduce children to these topics when they are young in order to produce educated adults (Loucks-Horsely et al., 1990; Lohr and Mims, 2005).

State of Current Curriculum

There has been limited curriculum development for the purpose of teaching horticulture to elementary students. However, some recent programs and curriculum have been developed and have been well-received by students and teachers (Meyer et al., 2001). Youth horticultural education needs to be improved and new topics introduced. More research about incorporating arboriculture and horticulture into classrooms should be conducted (Smith and Motsenbocker, 2005). As an added benefit, the introduction of arboriculture into elementary curriculum can facilitate the instruction of math and history, as well as many other subjects in the classroom (Nyenhuis, 1994, Dirks and Orvis, 2005).

Trees in the Landscape

Trees may have life expectancies of many years, and their quality will greatly affect their life in the landscape. In addition, higher quality trees establish more quickly and require less maintenance after planting (Anon., 1998). Trees planted with structural defects can become increasingly hazardous as they mature (Anon., 1998). Tree failures are a safety issue in the landscape, but are predictable to the trained eye (Hayes, 2002). Trees in Florida are often graded for quality using the Florida Grades and Standards. Grades are assigned based on the characteristics of a tree's crown, trunk, branches, root system, and leaves. The presence of structural defects reduce a tree's grade (Anon., 1998).

Benefits of Trees for Children

Structural defects in canopy trees include absence of a straight single leader, co-dominant trunks, circling/girdling roots, narrow angles of attachment, and included bark (Hayes, 2002; Anon., 1998, Edberg and Berry, 1999; Kane et al., 2005; Anon. 1998 (b); Anon. 1993; Smith and Shortle, 2005). The absence or presence of structural defects in trees is the basis of the Florida Grades and Standards. These standards are frequently refered to in urban forestry applications, but are rarely explained to the layperson. Unless entering a related line of work, many people are never exposed to these concepts until either faced with code violations or minimum landscaping standards required by their municipality. This topic could be introduced to the standard elementary curriculum.

Importance of Comparing Methods of Instruction

While various methods of teaching may provide desired results (Saville, 2006), different methods of instruction should be studied for effectiveness, so that the best method can be utilized for specific situations (Anderson and Walker, 2003; Poston et al., 2005). In one study, plant propagation principles were taught to students using instructional video and face-to-face demonstration. Students who learned from the demonstration reported better clarity, while students who saw the video performed better on a quiz (Gomez, 2004). Behavioral methods of classroom instruction as opposed to a lecture format have been available and supported since the 1950s (Saville, 2006). Interactive instruction in horticultural topics is believed to produce better results than a formal “textbook” approach (Felmley, 1902). Interactive learning is generally perceived to be more successful than traditional classroom learning (Saville, 2006).

Factors for Success in Incorporating New Subjects into Curriculum

Communication is critical when adding horticultural topics to school programs. Lack of communication has historically been a considerable obstacle in incorporating arboricultural and horticultural subjects to a curriculum (Phibbs and Relf, 2005). Success in incorporating horticulture into the classroom is most realistic when teachers and administration staff are both highly involved (Klemmer et al., 2005).

Historically, Active Learning Outperforms Lecture and Passive Learning

Previous studies have shown that more active learning is highly beneficial in comparison to “passive learning”, such as playing versus watching others play (Bricklin, 1990). The more passive time, such as watching TV, a child or adolescent spent the more likely they were to have poor educational achievement (Hancox, 2005, and Morgan, 1993.). A previous study related girls’ exposure to greenery to increased test performance and concentration (Faber Taylor et al., 2002).

Students’ Learning Styles May be Changing

Exposure to television and other media has been compared to an “impending disaster” of which the final results are not yet known (Shifrin, 2006); specific interactions between media exposure and performance in school have not yet been determined (Borzekowski, 2005). This “disaster” is the unknown result of today’s youths’ extreme immersion in television and other media. Children are stated to be exposed to nature today only through “electronic detachment” (Louv., 2005). The effects will not be known until a multitude of studies are conducted on youth now, as they progress through social, emotional, and physical maturation, and as the adults they become. Today’s children are surrounded by more media, such as television and video games, than ever before (Reading, 2004). Preliminary, incomprehensive consequences to this exposure are beginning to surface. It has been shown that young adults who were exposed to the frequent visual stimulation of such media as children are more receptive to graphic novels with limited text than to standard text-only books (Bucher, 2004). This could certainly indicate that instead of media impeding students' ability to learn, it could be affecting the style in which they learn. Educators have been encouraged to include graphic novels, a growing genre, in middle and secondary classrooms (Bucher, 2004). Instead of media reducing academic achievement, it might change learning styles. This is a contrast to the generally- accepted perception that television decreases students ability to perform. More research is required to answer this question. If learning styles are being affected by media use among children, education will need to change drastically to reflect changed learning styles, or overall media use would need to be reduced so that instructional styles would not have to adapt.

Concerns over Standardized Testing

Education in schools across the nation is based on standardized testing. Standardized testing for schools specifically in Florida are based on the Sunshine State Standards, which are described as "appropriate things for students to know and be able to master" (Anon., 2005). Since 1988, the Florida Comprehensive Assessment Test (FCAT) has been the method used to measure and determine the success of schools throughout the state of Florida in meeting these standards. Approximately $42 million is spent annually by the State of Florida to develop, administer, and score the FCAT (Anon., 2005). Many have expressed concern that these tests may not be accurately measuring success in Florida schools (Anon., 2005).

Time allocated for recess and physical education has dramatically been decreased, and that is in the schools that still provide any type of this important activity. Time outdoors, including gym class, has been lost, slated as a waste, to time set aside for test preparation (Louv 2005).

CHAPTER 3
MATERIALS AND METHODS

To determine the ability of sixth grade students to comprehend and recognize structural defects in trees, one-hundred-eighty sixth grade students from Seminole Middle School in Plantation, Nova Middle School in Davie, Plantation Middle School in Plantation, in the Broward County, Florida school district, were studied. Class size ranged from 20 to 25. Either three or four classes were utilized from each school. The schools represented Florida Comprehensive Assessment (FCAT) school grades of A, B, and C (Anon. 2006). The FCAT exam is given to students in grades 1-12, to test their knowledge of the Sunshine State Standards, or statewide-accepted "appropriate things for students to know and be able to master" (Florida, 2005). The grades of A, B, and C, are assigned to schools based on their overall performance, with the grade of A being the most desirable. A school graded 'A' based on its FCAT scores is considered to be highly successful in teaching its students the Sunshine State Standards. Schools graded 'B', 'C', 'D', and 'E', are each considered less successful than the grades above them.

Five container grown mahogany (*Swietenia mahagoni)* trees (Figure 2-1) were used in this study to demonstrate the most common defects in trees. One species was used to eliminate confusion, which could have been caused by students perceiving a specie's unique traits as a structural defect. Using only one species allowed for less interference from multiple factors. The trees were potted in 3 gallon containers and clearly labeled to correspond with pre-test and post-test questions. The defects represented were: circling/girdling roots (Figure 3-2), leaning/bent/broken/damaged trunk (Figure 3-3), co-dominant trunks and included bark (Figure 3-4). A tree with no apparent defects was also included as an experimental control (Figure 3-5).

Trees on school grounds were used for the experiential, outdoor-instructed classes. Prior to this study, the school grounds at each school were inspected and representative trees with each of the structural defects were chosen for the hands-on, experiential instruction (Figures 3-7, 3-9). There was one tree representative of a tree with no apparent defects.

Preparations for the passive, lecture and photographic type of classroom instruction included photographing the structural defects and printing the photographs on 11½” 17” paper (Figures 3-6, 3-8). The photos were laminated for durability.

The classroom instruction was presented as an enrichment activity to each of the classes. Each class was presented with the 5 trees (Figures 3-1, 3-2, 3-3, 3-4, 3-5). The pre-test (Appendix A) was administered to all classes prior to instruction. The pre-test was in two parts; one part consisted of basic arboricultural knowledge and the second part measured the students’ ability to recognize structural defects. Students were given instructions to “take their best guess” if they did not understand the question. Students worked individually and were given 10 minutes to complete the pre-test (Klemmer et al., 2005).

All pre-tests were collected prior to the next step in the study. This was to ensure that no one had the advantage of recording the answers for the post-test. Following the pre-test, each class received their respective instruction: hands-on, experiential outdoor instruction or photographic, classroom-style instruction.

The classes designated to learn outdoors on their school grounds were given a very brief explanation of the defects they would be looking for. The proper growth structure, such a a straight, single trunk, was explained as the preferred structure to the defect, such as a codominant trunk that looks like a “Y”. Students were guided in a walk around their school campus and told to look for the specific defects. Members of each class were able to view at least one example of each defect in their school landscape (Figures 3-7, 3-9). Students were asked to look for the defects as they were led on a walk around their campus. While no defects were pointed out by the instructor, the instructor would ask the students to identify a defect in a particular tree if no one recognized it.

Classes designated for indoor instruction were shown all of the prepared photographs in a lecture-style presentation. The preferred structure, such as roots that grow away from the trunk, was either explained or shown in a photograph (Figure 3-10), and then compared to the defect, such as circling roots, in another photograph (Figure 3-6). Each photograph was walked around the classroom so that each student could get a close-up view of the particular defect.

After classes received their respective instruction, a Post-test (Appendix B) was administered. As in the pre-test, classes were instructed to answer a different set of questions regarding basic arboricultural knowledge in the one part and to record the defects they recognized in each tree in another part.

The data obtained from 180 pre-tests and 180 post-tests were subjected chi-square analysis. The main potential effects [method of instruction, FCAT school grade, gender] were analyzed to determine their effect on students' performance in both general knowledge questions and recognition of structural defects in trees.

Chi square analysis is used to compare data which falls into definitive categories. In a random, non-biased sample, it is expected that data will fall into categories with equal probability. The expected equal probability is known as the null hypothesis. Chi square analysis allows for a statistical analysis to explain deviations to the null hypothesis; deviations may be indicative of a reaction of a particular factor or it can be due to randomness. Chi square analysis can answer this.

Contingency tables (Appendix C) were set up to analyze data using the chi-square analysis. First, a count of responses, or observed values, was compiled. The observed values were converted into percentages. Next, the expected values were calculated. Each column and row of the observed values was summed, and a final value was calculated as the sum of all columns and rows. The expected value was calculated by taking the product of each position's corresponding row sum and column sum, and dividing this by the sum of sums. The chi-square value for each position was calculated by taking the square of the difference between each observed and expected value divided by the expected value. The sum of the chi-square values within each contingency table was compared to a critical value from the chi-square table. If the chi square value was larger than the critical value, it was stated that the groups being compared were statistically different, or the null hypothesis was rejected. If the chi-square value was smaller, the null hypothesis was accepted; the samples were not stated to be statistically different.

Data collected from general knowledge question portions of both the pre-test and post-test were compiled to represent the knowledge base of the overall population. Data collected from general knowledge questions were also analyzed to compare responses based on gender and also to compare responses based on the FCAT grade assigned to each school. General arboricultural knowledge was not a part of the instruction. However, the data collected was analyzed between schools, gender, and instructional method.

Data collected in the structural defect recognition portion of the pre-test was compiled to determine the starting knowledge base for all students. This data was subjected to chi-square analysis to determine if students were equally able to recognize defects before instruction. Gender and FCAT grade assigned to each school was analyzed to determine if any group was more able to recognize structural defects prior to instruction.

Data collected in the structural defect recognition portion of the post-test was compiled to represent all students' performance after instruction. This data was compared to the pre-test structural recognition data for all students to determine if the instruction as a whole was successful. The data was partitioned into subsets of the whole population: all females, all males, all of school 'A', all of school 'B', all of school 'C', all students exposed to the outdoor, experiential instruction, and all students exposed to the lecture-style presentation.

Figure 3-1. Five mahogany trees (*Swietenia mahagoni*) used in this study.. Photograph taken April, 2006.

Figure 3-2. Mahogany tree (*Swietenia mahagoni)* used in this study to demonstrate circling/girdling roots. Photograph taken April, 2006.

Figure 3-3 Mahogany tree (*Swietenia mahagoni)* used in this study to demonstrate leaning/bent/broken/damaged trunk. Photograph taken April, 2006.

Figure 3-4. Mahogany tree (*Swietenia mahagoni)* used in this study to demonstrate attachments of equal sizes, codominant trunks and included bark. Photograph taken April, 2006.

Figure 3-5. Mahogany tree (*Swietenia mahagoni)* used in this study to demonstrate a tree with no apparent defects. Photograph taken April, 2006.

Figure 3-6. Photographs of circling roots used in the traditional lecture portion of this study. Photograph taken February, 2006.

Figure 3-7. Photos of circling roots on school grounds used in the experiential-style instruction portion of this study. Photograph taken in May, 2006.

Figure 3-8. Photos of codominant trunk used in the traditional lecture portion of this study. Photograph taken February, 2006.

Figure 3-9. Photos of codominant trunk on school grounds used in the experiential-style instruction portion of this study. Photograph taken May, 2006.

Figure 3-10. Photographs of desirable root system used in the traditional lecture portion of this study. Photographs taken February, 2006.


a.


b.

Figure 3-11. Photographs of broken, leaning, damaged trunks used in the traditional lecture portion of this study. Photographs taken February, 2006.

a.

b.

CHAPTER 4
RESULTS

Recognition of Structural Defects Pre-Test and Post-Test

There was a significant improvement in ability to identify to identify structural defects in the sample trees between the pre-test and post-test for the population as a whole (Table 4-1). Regardless of a school's FCAT grade, gender, or method of instruction, all groups improved in structural defect recognition (Tables 4-2, 4-3, 4-4, 4-5).

Recognition of Structural Defects Pre-Test and Post-Test as a Function of School

For trees, #1-5, there was a significant difference in school performances pre-test (Table 4-6), however this difference did not correspond to the schools' FCAT grades. A higher school score on the FCAT exam did not correlate to a higher score on the pre-test or on the post-test.

Recognition of Structural Defects Pre-Test and Post-Test as a Function of Gender

For all trees, #1-5, there was no significant difference between all males and females, both pre-test and post-test (Tables 4-3, 4-5). This indicates that both males and females performed equally both pre- test and made significant and equal progress in recognizing structural defects in trees. Neither males nor females performed better than the other.

Recognition of Structural Defects in Trees as a Function of Method of Instruction

For all trees, #1-5, there was a significant difference between performances based on methods of instruction (Table 4-6). Data indicate that students learned, but students taught in the indoor classroom performed better after instruction than did those who learned in the outdoor setting (Table 4-6). There is a significant difference between performances based on methods of instruction.

Performance in General Arboricultural Knowledge Questions

For all general knowledge questions in the pre-test, numbered 1-6, students recognized the correct response on average 67% of the time (Table 4-7). Rate of success ranged from 23.89% to 89.44% (Table 4-7).

60.00% of students are able to recognize that not all trees lose their leaves in the fall. 80.56% of students were able to recognize that trees planted in cities require more care. A majority of students, 83.33%, 75.00%, and 51.11%, respectively, were able to recognize the correct responses that when people care for trees properly, the trees might live longer, will be healthier, and will be safer. 70.56% of students were able to recognize that pruning can be beneficial but must be done properly. Only 23.89% of students were able to recognize that a Sequoia tree grew the biggest out of the four trees provided. (Table 4-7)

Performance in General Arboricultural Knowledge Questions as a Function of Gender

For all general knowledge questions in the pre-test, the null hypothesis, there was no significant difference in general arboricultural knowledge between males and females, is accepted (Table 4-8).

Performance in General Arboricultural Knowledge Questions as a Function School

Data collected for all general knowledge questions indicate that there is no difference in general arboricultural knowledge between the three schools. 2 out of 11 are significantly different in comparing schools graded A, B, and C to the total population (Table 4-9).

Table 4-1. Summary scores of all sixth grade students (n= 180), for pre-test and post-test on recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 level is 11.07; significant differences at the P= 0.05 level are indicated by *.

Tree Number	Defect on the tree	% All Students Identifying the Defect Correctly Pre-Test	% All Students Identifying the Defect Correctly Post-Test	Chi-Square
1	No defect	40.00	52.78	6.74
2	Trunk	82.78	88.89	7.88
3	Trunk	77.78	76.67	33.37*
3	Included Bark	27.78	25.00	33.37*
3	Codominant	21.11	57.22	33.37*
4	Trunk	53.89	52.78	31.23*
4	Codominant	31.11	81.67	31.23*
4	Attachments of Equal Sizes	30.00	37.22	31.23*
5	Circling Roots	46.11	78.33	23.80*

Table 4-2. Summary scores of all sixth grade students (n= 180), by school A vs. B vs. C, for post-test recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 is 18.31; significant differences at the P= 0.05 level is indicated by *.

Tree	Defect	% All Students Identifying Correctly Pre-Test	% School A Identifying Correctly Post-Test	% School B Identifying Correctly Post-Test	% School C Identifying Correctly Post-Test	Chi-Square
1	No defect	40.00	59.09	34.41	53.49	33.59*
2	Trunk	82.78	88.64	40.86	88.37	44.30*
3	Trunk	77.78	70.45	40.86	83.72	72.03*
3	Included Bark	27.78	20.45	21.51	30.23	72.03*
3	Codominant	21.11	50.00	15.05	65.12	72.03*
4	Trunk	53.89	31.82	40.86	72.09	92.39*
4	Codominant	31.11	75.00	15.05	72.09	92.39*
4	Attachments of Equal Sizes	30.00	25.00	13.98	39.53	92.39*
5	Circling Roots	46.11	68.18	24.73	79.07	50.95*

Table 4-3. Summary scores of all sixth grade students (n= 180), by gender, for pre-test recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 level is 11.07; significant differences at the P= 0.05 level are indicated by *.

Tree	Defect	% Males Identifying Correctly Pre-Test	% Females Identifying Correctly Pre-Test	Chi-Square
1	No defect	37.89	42.86	0.82
2	Trunk	83.16	83.33	6.42
3	Trunk	76.84	78.57	2.47
3	Included Bark	24.21	30.95	2.47
3	Codominant	21.05	21.43	2.47
4	Trunk	54.74	52.38	4.07
4	Codominant	35.79	25.00	4.07
4	Attachments of Equal Sizes	26.32	34.52	4.07
5	Circling Roots	41.05	52.38	3.33

Table 4-4. Summary scores of all sixth grade students (n= 180), by gender, for post-test recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 level is 11.07; significant differences at the P= 0.05 level are indicated by *.

Tree	Defect	% Males Identifying Correctly Post-Test	% Females Identifying Correctly Post-Test	Chi-Square
1	No defect	54.74	50.00	3.47
2	Trunk	86.32	91.67	9.85
3	Trunk	70.53	83.33	9.92
3	Included Bark	18.95	30.95	9.92
3	Codominant	64.21	48.81	9.92
4	Trunk	46.32	59.25	4.88
4	Codominant	82.11	80.95	4.88
4	Attachments of Equal Sizes	35.79	39.29	4.88
5	Circling Roots	80.00	76.19	1.44

Table 4-5. Summary scores of all sixth grade students (n= 180), by instructional method, traditional, photographic vs. experiential, hands-on, for pre-test and post-test recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 level is 18.31; significant differences at the P= 0.05 level are indicated by *.

Tree	Defect	% All Students Recognizing Pre-Test	% Traditional Recognizing Post-Test	% Experiential Recognizing Post-Test	Chi-Square
1	No defect	32.96	10.53	30.95	44.45*
2	Trunk	83.24	100	72.62	19.76*
3	Trunk	78.21	94.74	57.14	42.84*
3	Included Bark	27.93	28.42	21.43	42.84*
3	Codominant	21.23	56.84	58.33	42.84*
4	Trunk	54.19	67.37	36.90	58.29*
4	Codominant	31.28	95.79	66.67	58.29*
4	Attachments of Equal Sizes	30.17	43.16	30.95	58.29*
5	Circling Roots	46.37	96.84	58.33	48.71*

Table 4-6. Summary scores of all sixth grade students (n= 180), by school A vs. B vs. C, for pre-test recognition of observable defects in mahogany trees (*Swietenia mahagoni*). Chi-square critical value at the P= 0.05 level is 18.31; significant differences at the P= 0.05 level are indicated by *.

Tree	Defect	% School A Identifying Correctly Pre-Test	% School B Identifying Correctly Pre-Test	% School C Identifying Correctly Pre-Test	Chi-Square
1	No defect	47.73	34.41	44.19	29.18
2	Trunk	75.00	40.86	81.40	25.98*
3	Trunk	77.27	40.86	79.07	26.18*
3	Included Bark	27.27	21.51	39.53	26.18*
3	Codominant	15.91	15.05	27.91	26.18*
4	Trunk	56.82	40.86	46.51	28.88*
4	Codominant	18.18	15.05	46.51	28.88*
4	Attachments of Equal Sizes	22.73	13.98	27.91	28.88*
5	Circling Roots	34.09	24.73	51.16	22.85*

Table 4-7. Summary of all sixth grade students' (n= 180) performance on general arboricultural knowledge questions.

	Question #	Correct Question Response	Percentage of Students Recognizing
What does a tree need to live?	Pre-Test 1	1a: Water	89.44%
What does a tree need to live?	Pre-Test 1	1b: Soil	77.78%
All trees lose their leaves in the fall.	Pre-Test 2	2b: False	60.00%
Trees with good structure:	Pre-Test 3	3a: Will live longer.	75.00%
Trees with good structure:	Pre-Test 3	3c: Will be safer in the future.	39.44%
The bark on different trees:	Pre-Test 4	4d: Is different from tree to tree.	86.67%
A plant:	Pre-Test 5	5a: Is a living organism.	77.78%
A plant:	Pre-Test 4	5e: Is able to make its own food.	62.22%
Trees:	Pre-Test 6	6a: Need more care when they are planted in cities.	80.56%
When people care for trees properly:	Post-Test 1	1a: Trees might live longer.	83.33%
When people care for trees properly:	Post-Test 1	1c: Trees will be healthier.	75.00%
When people care for trees properly:	Post-Test 1	1d: Trees will be safer.	51.11%

The seed of an oak tree is called:	Post Test 2	2c: An acorn.	58.89%
Trees with good structure:	Post Test 3	3a: Will live longer.	80.56%
Trees with good structure:	Post Test 3	3b: Will be safer.	55.56%
Which tree grows biggest?	Post Test 4	4b: Sequoia	23.89%
When pruning a tree:	Post Test 5	5c: Pruning can be beneficial but must be done properly.	70.56%

Table 4-8. Summary all sixth grade students' (n= 180) performance on general arboricultural knowledge questions, males vs. females vs. all students.

Question	Correct Answer	% of Males Answering Correctly	% of Females Answering Correctly	% of All Students Answering Correctly	Critical Value	Chi-Square
What does a tree need to live?	Water	89.47	89.29	89.94	12.59	3.30
What does a tree need to live?	Soil	77.89	78.57	78.21	12.59	3.30
All trees lose their leaves in the fall (True/False)	False	60.34	59.43	60.15	5.99	0.09
Trees with good structure:	Will live longer.	71.58	78.57	75.42	9.49	1.34
Trees with good structure:	Will be safer in the future.	40.00	39.29	39.66	9.49	1.34
The bark on different trees:	Is different from tree to tree.	84.21	89.29	87.15	12.6	0.14
A plant:	Is a living organism.	76.84	79.76	78.21	18.3	4.28
A plant:	Cannot move from one spot.	25.26	26.19	25.70	18.3	4.28
A plant:	Is able to make its own food.	65.26	58.33	62.57	18.3	4.28
The seed of an Oak tree is called:	An acorn.	65.26	51.19	59.22	12.6	3.60
Trees with good structure:	May live longer.	78.95	82.14	81.01	9.49	0.54
Trees with good structure:	Will be safer.	58.95	51.19	55.87	9.49	0.54
Which tree grows biggest?	Sequoia.	27.37	20.24	24.02	12.6	2.36

When pruning a tree:	Pruning can be beneficial but must be done properly.	77.89	61.90	70.95	9.49	4.38

Table 4-9. Summary all sixth grade students' (n= 180) performance on general arboricultural knowledge questions, school A vs. B vs. C vs. all students.

Question	Correct Answer	% of All Students Answering Correctly	% of School A Answering Correctly	% of School B Answering Correctly	% of School C Answering Correctly	Critical Value	Chi-Square
What does a tree need to live?	Water	89.94	84.09	93.55	86.05	16.9	16.28
What does a tree need to live?	Soil	78.21	75.00	75.79	41.67	16.9	16.28
All trees lose their leaves in the fall (True/False)	False	60.34	52.27	68.82	48.84	7.81	6.78
Trees with good structure:	Will live longer.	75.42	79.55	72.04	76.74	12.6	9.63
Trees with good structure:	Will be safer in the future.	39.66	27.27	47.31	34.88	12.6	9.63
The bark on different trees:	Is different from tree to tree.	87.15	84.09	91.40	79.07	16.9	17.77*
A plant:	Is a living organism.	78.21	70.45	86.02	67.44	25.0	2.82
A plant:	Cannot move from one spot.	25.70	25.00	32.26	11.63	25.0	2.82
A plant:	Is able to make its own food.	62.57	61.36	60.22	67.44	25.0	2.82
The seed of an Oak tree is called:	An acorn.	59.22	63.64	61.29	48.84	16.9	24.99
Trees with good structure:	May live longer.	81.01	81.81	38.71	81.72	12.6	5.94

Trees with good structure:	Will be safer.	55.87	50.00	23.66	60.22	12.6	5.94
Which tree grows biggest?	Sequoia.	24.02	20.45	27.96	18.60	16.9	26.70*
When pruning a tree:	Pruning can be beneficial but must be done properly.	70.95	68.18	32.26	75.27	12.6	9.08

CHAPTER 5
DISCUSSION

General Observations

Students seemed to generally enjoy this instruction, as did their classroom teachers. During the pre-test, students expressed feelings of frustration in that they were being tested on concepts that had not previously presented to them. This may be a result of the "test-preparation" mentality to which students are exposed. Sit seemed as if students were not very prepared to learn about everyday, real life subjects. This could impede their acceptance and enjoyments of studying subjects for reasons other that success on an exam.

Many of the students exposed to the outdoor, hands-on instruction in tree defects seemed less interested in the class and highly distracted. In comparison to the traditional, indoor, photographic-type sessions, the outdoor class sessions were more difficult to control. Many of the students who were taken outdoors exhibited poor behavior.

It was suggested that students may not spend enough time outdoors during the school day. The outdoor class sessions may have felt like a recess to many students. While they were being introduced to new concepts, they seemed almost indifferent to being surrounded by their everyday environment. In contrast, students exposed to the photographs seemed interested, fascinated, and delighted by the images. This could imply an extremely visual inclination in 6th grade students who participated in this study. Students may be accustomed to intense visual exposure, so much that they need this impact in order to respond. Another possible explanation to this phenomenon could be that the instructor may have been more skilled in the lecture-type instruction and less effective in leading a hands-on session.

Most students reacted positively to the post-test. It was observed that students were proud of being able to recognize the correct answers. Several students indicated a desire to be more involved with the care and selection of trees both at home and around their school grounds. This was considered a success, in that many students made cognitive associations what they learned in one instruction to what went on in their outdoor environments, as opposed to connecting it to only a correct answer on an exam. Student comments indicative of their new interests showed that they can easily grasp these concepts and can become more caring stewards for our urban forests.

One significant obstacle in setting up this study was to schedule time with the classes. It was alarming that teachers were concerned that the instruction on tree structural defects was not on the FCATs and that one class period of FCAT preparation would be lost. Most students' frustration in that they were being tested on concepts in the pre-test that had not previously presented to them suggests that they are being conditioned to perform well on tests. Many students had a lot of trouble making guesses and thinking outside of test-related studies.

Students are being taught to be successful on the FCATs, as a school's overall score is beneficial to the school. For this reason, students may not be as ready to explore subjects that are related to success in daily life, as opposed to success on standardized exams. Students exposed to the photographs were interested, fascinated, and delighted by the images. While the images may have been of unfamiliar concepts, they were examples that were not outside of their ability to comprehend. The excitement over the images was surprising and unexpected.

Recognition of Structural Defects Pre-Test and Post-Test as a Function of FCAT Grade

For all trees, #1-5, there was a significant difference between school performances pre-test. However, this difference did not correspond with the 'A' school consistently performing better that the other schools. Test results indicated that school C students were most successful in recognizing the correct structural defects on most pre-test and post-test questions, with school A students in the middle, and school B students identifying the fewest.

This study resulted in an overall increase in the ability of students to recognize structural defects in trees following both types of instruction. The biggest contrast in expectations was that the students who were instructed with the traditional photographic classroom method scored higher in the post-test than those who learned in the experiential method. One explanation might be that there were fewer distractions in the classroom. The indoor classroom is the typical environment to which students are accustomed. Another explanation could be that today's youth are more completely immersed in media: they watch more television and play more video games than previous generations. Learning styles may be changing because of the intensive media exposure. The results of this study could raise an important question: Does education need to shift teaching methods to reflect this change in youth activities?

Recognition of Structural Defects Pre-Test and Post-Test as a Function of Gender

Success in structural defect recognition significantly increased from the pre-test to the post-test. Defect recognition in the trees both pre-test and post-test was not affected by gender. This shows that males and females were equally competent in both recognizing tree structural defects presented in this study and in learning to recognize them. While there may be previous assumptions that scientific ability is predetermined by gender (Tindall 2004, Nordvik 1998, and Sonnert 1995), neither gender had any advantage over the other in this study, a positive sign for today's equality-conscious society.

Recognition of Structural Defects in Trees as a Function of Method of Instruction

While all groups were successful in learning to recognize structural defects in trees, the group that learned via the traditional classroom lecture with photographs had higher scores following their instruction. As previously mentioned, students may currently be less exposed to outdoor experiences and therefore could be more easily distracted outside of their classroom. The difference between instructional methods may also be attributed to the skill or deficiency of the instructor. An additional possible explanation may be the students' attraction to the visually-stimulating photographs.

Performance in General Arboricultural Knowledge Questions

It is gratifying to know that most students were able to understand many basic arboricultural knowledge principles without prior instruction. A majority of students understand that trees need more care when planted in cities, and that proper care and tree structure result in healthier, safer trees that will live longer. Most students recognized that a difference exists between the right way and a wrong way to prune a tree, and that correct pruning can be beneficial to the tree.

The existence of a good base of arboricultural knowledge is a positive indication that sixth grade students are prepared to learn more complex principles of tree care.

Performance in General Arboricultural Knowledge Questions as a Function of Gender

For all general arboricultural knowledge questions, there was no significant differerence in test scores between males and females, suggesting that sixth graders have equal general arboricultural knowledge regardless of gender. As with the success in structural defect recognition, this success could be considered to be a positive finding for our equality-conscious society.

Performance in General Arboricultural Knowledge Questions as a Function of School

Only two responses resulted in significant difference between schools; the majority was statistically the same. Pre-test question #4, the bark on different trees is… (different from tree to tree), post-test question #4, which tree grows biggest?... (sequoia) were the only questions for which results indicated significant differences between schools. More students from school B recognized correct answers on pre-test question #4 and post-test question #4. This is in direct contrast with pre-test and post-test tree structural defect recognition, in which school B repeatedly recognized the correct answer less often than the other two schools. It was expected that the school with an FCAT grade of A would be most successful on the general knowledge questions, as FCAT schools with a grade of A are generally assumed to be more successful. More information and study would be needed to make any claims regarding the successes or deficiencies in the FCAT's ability to measure students' knowledge.

FCAT exams are a standard, minimally subjective measure that are currently applied on a state-wide level. Data collected from the general knowledge questions indicates there is no difference in general arboricultural knowledge based on FCAT grade. There is no logical pattern such as students from School 'A' being consistently more successful in identifying the correct answer.

Recommendations

Children may have been so distracted in the outdoor instructional sessions because it is not a common experience for them. The findings of this study may suggest that a combination of two items needs to occur: education needs to change to mirror the changing needs of children exposed to high levels of electronic media, and children need to be exposed to the outdoors much more than they currently are, so that they can appreciate and learn from an outdoor educational experience. These two options need to be investigated more thoroughly. Future studies should focus on current learning styles as related to the results of excessive media exposure. There are a multitude of benefits associated with children spending time outdoors; it would be highly beneficial for them to spend more time outside and less time immersed in media.

Students and teachers would benefit from a more unified curriculum across the board, with more focus on real-life experience and less on standardized exam performance. The development of stronger critical thinking skills in children should be an aspect of future curriculum changes.

Children should run, play, and learn from the environment around them – the trees, plants, grass, and insects – not the TV and video games. This study sends a clear message: children desperately need to get outside to play and learn!

CHAPTER 6

FUTURE WORK

Incorporating Arboriculture and Horticulture Into the Curriculum

This study has shown that principles of arboriculture and horticulture can positively and easily be incorporated into existing curriculum and that students can learn them effectively following passive, photographic instructional format. Structural defect recognition in trees and other critical thinking exercises could be presented to different ages and grades. Other important arboricultural and horticultural concepts should be studied as to the feasibility of their incorporation into the elementary and high school curriculum. Examples of some of these concepts are: proper planting, pruning young trees for structure, care and maintenance of maturing and mature trees, and recognizing nutritional deficiencies, common pests and diseases in the landscape.

Effectiveness of Measuring Knowledge through FCAT Exams

More research is necessary to determine whether test-taking ability or actual knowledge is the focus in schools in the state of Florida. The relationship between a school's FCAT performance, their actual collective knowledge, their test-taking abilities, and their ability to learn should be explored.

Effective Methods of Instructing Youth

The higher post-test scores among students who were taught using a passive photographic format may raise the important question of whether education needs to shift to reflect changes in youth exposure to media. This issue should be studied more comprehensively using varied populations, arboricultural and horticultural subjects, and instructional methods.

APPENDIX A
PRE-TEST

Pre-test used in this study and given to all students prior to exposing them to their designated method of instruction. Side (page) one provides space to record demographic information: student's name, age, gender, class, and grade. This information was used to ensure pre-test and post-test data was grouped appropriately. Side (page) one provides space to record the defect(s) present in each tree. Side (page) two presents general arboricultural knowledge questions. This pre-test was presented in-class regardless of designated instructional method and collected immediately upon completion and prior to the instruction on structural defect recognition in trees. For all questions on both sides one and two, students were instructed that more than one answer might be correct and to circle as many as they believed were correct. Administered in May, 2006.

PRE-TEST

NAME	
AGE	
SEX	
CLASS	
GRADE	

Look at the trees, labeled #1 - #5 and use them to answer the following. More than one answer can be circled.

Tree#1	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree#2	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #3	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #4	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #5	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects

PRE-TEST

More than one answer can be circled.

#1	What does a tree need to live? a. water b. soil c. earthworms d. grass
#2	All trees lose their leaves in the fall a. True b. False
#3	Trees with good structure: a. will live longer b. are no different than trees with bad structure c. will be safer in the future
#4	The bark on different trees: a. Is exactly the same b. Is always rough c. Is not important to the tree d. Is different from tree to tree
#5	A plant : a. Is a living organism b. Cannot move from one spot c. Is only different from an animal because it cannot talk d. Is always grown in soil e. Is able to make its own food f. Always has green leaves
#6	Trees a. need more care when they are planted in cities b. don’t need people to do anything for them

APPENDIX B
POST-TEST

Post-test used in this study and given to all students following exposure to their designated method of instruction. Side (page) one provides space to record demographic information: student's name, age, gender, class, and grade. This information was used to ensure pre-test and post-test data was grouped appropriately. Side (page) one provides space to record the defect(s) present in each tree. Side (page) two presents general arboricultural knowledge questions. This post-test was presented in-class regardless of designated instructional method and was collected immediately upon completion. For all questions on both sides one and two, students were instructed that more than one answer might be correct and to circle as many as they believed were correct. Students were required to work independently on the post-test. Administered in May, 2006.

POST-TEST

NAME	
AGE	
SEX	
CLASS	
GRADE	

Look at the trees, labeled #1 - #5 and use them to answer the following. More than one answer can be circled.

Tree#1	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree#2	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #3	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #4	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects
Tree #5	a. circling/ girdling roots b. leaning/bent/broken/damaged trunk c. included bark d. codominant trunks e. attachments of equal sizes f. no apparent defects

POST-TEST

More than one answer can be circled.

#1	When people care for trees properly: a. trees might live longer b. they are wasting their time c. trees will be healthier d. trees will be safer
#2	The seed of an oak tree is called a. an apple. b. a bulb c. an acorn d. a mushroom
#3	Trees with good structure: a. will live longer b. will be safer c. are no different than trees with poor structure
#4	Which tree grows biggest? a. Crepe Myrtle b. Sequoia c. Oak tree d. Yellow Tabebuia
#5	When pruning a tree: a. there is no right or wrong way b. trees should not be pruned c. pruning can be beneficial but must be done properly

APPENDIX C
EXAMPLE CONTINGENCY TABLE

Example contingency table. Calculated June-September, 2006. Chi-square analysis is used to compare data which falls into definitive categories. In a random, non-biased sample, it is expected that data will fall into categories with equal probability. The expected equal probability is known as the null hypothesis. Chi-square analysis allows for a statistical analysis to explain deviations to the null hypothesis; deviations may be indicative of a reaction of a particular factor or it can be due to randomness. Chi-square analysis can answer this. Contingency tables are set up to analyze data using the chi square analysis. First, a count of responses, or observed values, is compiled. The observed values are converted into percentages by dividing the number of responses by the total population of the group. Next, the expected values are calculated. Each column and row of the observed values is summed, and a final value is calculated as the sum of all columns and rows. The expected value is calculated by taking the product of each position's corresponding row sum and column sum, and dividing this by the sum of sums. The chi square value for each position is calculated by squaring the difference between each observed and expected value divided by the expected value. The sum of the chi-square values within the contingency table is compared to a critical value from the chi-square table. If the chi square value is larger than the critical value, it is stated that the groups being compared are statistically different, or the null hypothesis is rejected. If the chi-square value is smaller, the null hypothesis is accepted; the samples are not stated to be statistically different. In this example, the null hypothesis is accepted; samples are not considered statistically different.

Tree #3							
Observed Values	Incorrect	Correct	Correct	Correct	Incorrect	Incorrect	
	Circling roots	Trunk	Included bark	Codominant trunks	Attachments of equal sizes	No apparent defects	**Totals**
Pre-Test, Traditional	28	89	33	25	27	19	221
Pre-Test, Outdoor	14	51	17	13	18	10	123
Observed Values, %							
							Total
Pre-Test, Traditional	25.23%	80.18%	29.73%	22.52%	24.32%	17.12%	199.10%
Pre-Test, Outdoor	20.29%	73.91%	24.64%	18.84%	26.09%	14.49%	178.26%
Total	45.52%	154.09%	54.37%	41.36%	50.41%	31.61%	377.36%
Expected Values							
Pre-Test, Traditional	24.01%	81.30%	28.68%	21.82%	26.60%	16.68%	
Pre-Test, Outdoor	21.50%	72.79%	25.68%	19.54%	23.81%	14.93%	
Chi Square Values	Chi-square = (Observed Value- Expected Value)^2 / Expected Value						
Pre-Test, Traditional	0.00	0.00	0.00	0.00	0.00	0.00	
Pre-Test, Outdoor	0.00	0.00	0.00	0.00	0.00	0.00	
Totals	0.00	0.00	0.00	0.00	0.00	0.00	
Chi-square	0.73						

Because the chi-square, 0.73, is smaller than the table value (11.07) at the 0.05 level with 5 degrees of freedom, we accept the null hypothesis (that there is no difference between the students assigned to the two methods of instruction Pre-test) for tree #3.

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BIOGRAPHICAL SKETCH

Laura Sanagorski was born on December 2, 1980, as the middle child of three girls. She came to Florida from South-Central Pennsylvania in 2000. Her study of marine biology brought her to Florida, but a new-found love of tropical and sub-tropical trees persuaded her to make it her home. She graduated summa cum laude with a Bachelor of Science degree in environmental horticulture from the University of Florida Tropical Research and Education Center in Homestead. She is currently the City Landscaper for the City of Deerfield Beach, Florida.

Professional affiliations include the executive committee of the Florida Urban Forestry Council, International Society of Arboriculture, Society of Municipal Arborists, Society of American Foresters, and Professionals Educating and Advocating for Respect in Relationahips (PEARR). She is an International Society of Arboriculture Certified Arborist.

Sanagorski’s career goals and passions include increasing and improving our urban forests, and to improve the health, soundness, and aesthetics of our environments and living spaces specifically through proper arboricultural and horticultural practices, and through the education of others.