Teaching Methods

Introducing Tree Structural Defect Recognition to Youth: An Exploration of Feasibility Through a Comparison of Two Teaching Methods

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SUMMARY. Trees in urban settings require more care because they are more likely to develop structural defects that can be costly, dangerous, or more maintenance-intensive than those in natural settings. People need to understand how trees grow in the urban environment and how to recognize potentially hazardous structural defects, yet this is not a topic regularly presented in school curriculum. The objectives of this study were to determine if structural defect recognition in trees is an appropriate topic for sixth grade curriculum, and to explore the efficacy of two methods of teaching this topic. We introduced structural defects in trees to sixth grade students, as part of the normal science instruction at three public middle schools located in Broward County, FL. We found sixth grade students to be capable of recognizing and comprehending the implications of structural defects in trees following a short period of instruction. We compared hands-on, experiential instruction with a passive, illustrated lecture style instruction for teaching students to recognize structural defects in trees and determined that students exposed to both methods of instruction increased their ability to recognize defects overall. Moreover, we observed that students exposed to defects in trees via illustrated lecture style classroom instruction received significantly higher scores in the post-test than students exposed to the same material via a hands-on approach.

Trees have the potential to develop structural defects, which may include a circling or girdling root system, a leaning or damaged trunk, included bark, codominant leaders, and branches that are the same size as the trunk to which they are attached. These defects can cause a tree

to become hazardous and more likely to fail, potentially causing injury or death to people or damage to property. Structural defects in trees can be costly, dangerous, or maintenance-intensive, and thus it is advisable to identify and correct these defects before a failure. In an urban environment, trees require more care than those in natural settings due to the presence of targets, or the people and property

that can be harmed by tree failure (Matheny and Clark, 1994). For this reason, people need to understand how trees grow in an urban environment and how to recognize structural defects. Hazard trees can be recognized and often corrected at a young age so that proactive measures can be taken to correct the defects. People who live in association with trees, such as homeowners or property managers, benefit when they obtain appropriate education so they can recognize significant defects at each stage of trees' lives (Shigo, 1989).

Trees are the foundation for healthy social ecology (Kuo, 2003) and have proven to be beneficial for children socially, physically, and emotionally. Teaching about them is beneficial and results in educated adults with sensitivities to trees and nature (Lohr and Pearson-Mims, 2005). A deficiency of horticultural and arboricultural curriculum is available to students, yet recent additions of these fields have been well-received (Meyer et al., 2001), and further research into the incorporation of arboricultural and horticultural topics is being encouraged (Smith and Motsenbocker, 2005). As an added benefit, these topics have been shown to facilitate the instruction of other subjects (Dirks and Orvis, 2005; Nyenhuis, 1994), and can improve critical life skills in children (Robinson and Zajicek, 2005). Education in horticulture and arboriculture is considered highly important, and tree structure has been stated as one of the top five most important educational topics in urban forestry and arboricultural education (Elmendorf et al., 2005).

Neither adults nor children are regularly introduced to the important topic of structural defects in trees. We sought to begin a discussion on when and how this essential subject could be presented. The first objective of this study was to explore the feasibility of introducing structural defect recognition as a potential curriculum enhancement for sixth grade students. The second objective of this study was to evaluate two methods of

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937

teaching about this topic. Sixth grade is offered as a starting point for when this subject may be best introduced.

Materials and methods

We used a convenience sample totaling 180 sixth grade students from three public middle schools in Broward County, FL, for this study. Sixth grade was selected based on feedback from several science teachers who indicated that they felt the subject matter was reasonable for this age group. The sample was composed of complete classes whose teachers indicated interest in participating due to the instructional value they perceived. In each school, we selected three or four classes ranging in size from 20 to 25 students. The schools represented Florida Comprehensive Assessment (FCAT) school grades of A, B, and C (Florida Department of Education, 2006). The FCAT exam is given to students in first through twelfth grades to test their knowledge of the Sunshine State Standards, or statewide-accepted "broad statements of what students should know and be able to do" (Florida Department of Education, 2007). Based on overall test performance, grades of A, B, and C are assigned to schools, with the grade of A being the most desirable. An FCAT A school is considered to be highly successful in teaching its students the statewide academic standards, with schools graded B, C, D, and E, each considered less successful than the grade above them.

We selected five container-grown mahogany (*Swietenia mahagoni*) trees that had the most common structural defects found in an urban landscape and used as specimens for each class' pre- and post-test. A tree with no

visible defects was also included as an experimental control. We chose a single species to reduce potential interference caused by multiple factors and eliminate potential student confusion related to species' unique traits as a structural defect. The trees were potted in 3-gal containers and clearly labeled to correspond with pre-test and post-test questions. The defects represented were 1) circling and girdling roots, 2) leaning/bent/broken/damaged trunk, 3) codominant trunks, and 4) included bark.

We presented classes with the containerized trees to measure students' recognition of defects both before and after the class instruction. We developed the pre-test to collect students' recognition of defects for each tree. It was administered to all classes before the instruction; students were instructed to "take their best guess" if they did not understand the terms describing structural defects. Students worked individually and were given 10 min to complete the pre-test (Klemmer et al., 2005). Pre-tests were collected before the instruction to ensure that no one had the advantage of recording the answers for the post-test.

We presented half of the classes with experiential, outdoor instruction and the other half with traditional illustrated lecture-style instruction. Both types of instruction lasted about one hour. Regardless of teaching method, we ensured that all students were given the opportunity to closely inspect each type of defect as well as a tree with desirable structure. The defects were presented through trees on school grounds for the experiential, outdoor-instructed classes, in which the specific defect could be clearly seen on a tree. The defects

were presented through laminated images, 11.5 × 17 inches in size, for the lecture-instructed classes. Before the instruction, we briefly discussed the defects we would look at with students designated to learn outdoors on their school grounds and contrasted these defects with the desirable structure, such as a straight, single trunk, as the preferred structure to a codominant trunk. We then guided students around their school campus and asked them to look for the specific defects.

For each of the classes designated for indoor instruction, we presented a traditional, illustrated lecture-style session with support from the prepared photographs. Using verbal explanations supported by photographs, we explained the preferred structure, such as roots that grow straight away from the trunk, and then compared this condition to the corresponding defect, such as circling roots. Students were each given the opportunity to obtain a close-up view of each particular defect. After all classes received their respective instruction, the post-test was administered using the same five containerized trees that were presented in the pre-test to measure change in structural defect recognition.

We used the pre-test data to determine the starting knowledge base for all students and post-test data to measure all students' performance after instruction. Data were 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.

Table 1. Summary scores of all sixth grade students ($n = 180$) for pre- and post-test on recognition of observable defects in mahogany trees.^z

Tree no.	Tree defect	All students identifying the defect correctly pre-test (%)	All students identifying the defect correctly post-test (%)	χ^2_{y}
1	No defect	40.0	52.8	6.74 NS
2	Broken trunk	82.8	88.9	7.88 NS
3	Leaning/bent trunk	77.8	76.7	33.37*
3	Included bark	27.8	25.0	33.37*
3	Codominant	21.1	57.2	33.37*
4	Damaged trunk	53.9	52.8	31.23*
4	Codominant	31.1	81.7	31.23*
4	Attachments of equal sizes	30.0	37.2	31.23*
5	Circling roots	46.1	78.3	23.80*

^zThis data set differs slightly from Table 2 in that all 180 students were included in this analysis.

^yChi-square critical value at $P = 0.05$ is 11.07; NS, * nonsignificant or significant at $P < 0.05$, respectively.

We used chi-square analysis to interpret the data obtained from 180 pre-tests and 180 post-tests and analyze the main potential effects, method of instruction, FCAT school grade, and student gender on students' performance in recognition of structural defects in trees. The classroom instructional format and research protocol was reviewed and approved by the Broward County Public Schools and by the University of Florida Institutional Review Board before the beginning of this research.

Results

Student performance on the post-test varied (Table 1). No significant ($P < 0.05$) differences existed between pre-test and post-test scores regarding tree number 1 (Tree 1), the control, which had no observable defects, and Tree 2, which had a broken trunk. Students improved in their post-test scores for four of the seven defects represented in Trees 3–5. The four defects recognized correctly were attachments of equal sizes, circling roots, and two instances of codominant trunks. However, students' overall post-test scores were lower for three of the seven defects represented in Trees 3–5: included bark, leaning/bent trunk, and damaged trunk.

For Trees 1–5, a significant difference ($P < 0.05$) existed between school performances pre-test; however, higher school score on the FCAT exam did not correlate to a higher score on the pre-test or on the post-test (data not presented). On the post-test, each school improved in recognizing about two-thirds of the defects in Trees 1–5,

and scored about the same on the remaining defects.

For all Trees 1–5, no significant ($P < 0.05$) difference existed in scores between male students and female students (data not presented), both pre-test and post-test.

For all Trees 1–5, student performances differed based on instructional method (Table 2). Data indicated that all students improved in ability to recognize structural defects overall, but students taught in an illustrated lecture format received higher post-test scores than those who were subjected to instruction in an outdoor setting. The students who participated in the lecture scored higher on the post-test for all except for the control with no observable defects and the codominant trunk in Tree 3. The students who participated in the experiential learning also scored lower on the control as well as on four of the other defects. Their score improved in recognizing three additional defects. Some of the students did not complete the item that identified them by class and instructional method, and therefore, the data set we used for this analysis ($n = 163$) was slightly smaller than the total sample ($n = 180$).

Discussion

The limitations of this study are characteristic of other studies using convenience sampling in schools. In addition, the classes that participated did so because their teachers were willing and interested in being a part of this study. Although the teachers indicated that the topic we presented

had not been a part of their previous classroom instruction, we did not explore whether the students had been exposed to this subject matter at home or in another environment. Finally, our study was limited to students who were enrolled at the three schools during the study period, and further limited to the individuals who were in attendance on the days their classes were scheduled to participate. An additional restriction of the study was that the students who received outdoor instruction were limited to the trees on their school grounds, whereas the students who viewed the laminated images viewed standard images selected specifically for this instruction. As is the case with any outdoor classroom, we were limited to the trees on each school's campus for the outdoor portion of our study.

Overall post-test scores improved, but post-test scores decreased for the control with ideal structure and for some of the represented defects. We believe this is an indication that sixth grade students can learn about this topic, but may find it to be a difficult subject to master in a single, 1-hour instruction. Students were most successful in learning to recognize circling roots, codominant trunks, and attachments of equal sizes. We suggest that these three defects should be the first defects introduced in sixth grade curriculum, as they were the easiest for the students to identify. In addition, we suggest introducing structural defects in trees as a recurring topic, not as a single, stand-alone module. Ultimately, we concluded that structural defect recognition in trees

Table 2. Summary scores of all sixth grade students ($n = 163$) by instructional method, traditional, photographic versus experiential, hands-on, for pre-test and post-test recognition of observable defects in mahogany trees.^z

Tree no.	Tree defect	All students identifying the defect correctly pre-test (%)	Students identifying the defects correctly (%)		χ^2_{y}
			Traditional method—post-test	Experiential method—post-test	
1	No defect	33.0	10.5	31.0	44.45*
2	Broken trunk	83.2	100.0	72.6	19.76*
3	Leaning/bent trunk	78.2	94.7	57.1	42.84*
3	Included bark	27.9	28.4	21.4	42.84*
3	Codominant	21.2	56.8	58.3	42.84*
4	Damaged trunk	54.2	67.4	36.9	58.29*
4	Codominant	31.3	95.8	66.7	58.29*
4	Attachments of equal sizes	30.2	43.2	31.0	58.29*
5	Circling roots	46.4	96.9	58.3	48.71*

^zThis data set differs slightly from Table 1 in that a total of 163 students completed the survey item that associated them with a specific class and instructional method.

^yChi-square critical value at the $P = 0.05$ level is 18.31; * significant at $P < 0.05$.

was an appropriate subject for sixth grade students (Objective 1).

We found it interesting that students were more successful in recognizing that the control tree had no defects before the instruction, and suggest that students may have become confused. When preparing students for the pre-test and post-test, we did explain that there could be a tree that had no defects, but may not have spent enough time highlighting the desirable structure. We recommend that teachers take this into consideration and emphasize good structure when teaching about structural defects in trees.

Successful structural defect recognition significantly increased from the pre-test to the post-test for most trees for all students following both types of instruction. However, school C students were most successful in recognizing the correct structural defects on most pre-test and post-test questions. In this study, higher scores on the FCAT exams did not correspond with higher performance in recognition of tree structural defects. We found this noteworthy and suggest that future studies be conducted to explore a potential relationship between standardized test performance and learning.

Defect recognition in the trees both pre-test and post-test was unaffected by gender. Based on this finding, we concluded that both male and female students made significant and equal progress in learning to recognize structural defects in trees. While previous research has stated that scientific ability is predetermined by gender (Nordvik and Amponsah, 1998; Sonnert, 1995; Tindall and Hamil, 2004), neither gender had any advantage over the other in this study, an indication that both males and females can learn complex arboricultural subjects at an early age, and learn equally well.

Both methods of instruction were effective in improving students' recognition of structural defects (Objective 2), and students who received the indoor lecture performed better on the post-test than those who received the outdoor instruction. Previous studies have shown that active, hands-on learning was the more effective method of teaching students (Morgan, 1993; Smith and Motsenbocker, 2005). We believe a number of explanations exist. First, the photographs shared in

the classroom were novel and had not been previously seen by any of the students. The trees we viewed on the school grounds may have been less interesting because the students were exposed to them every day. In addition to the measured post-test performance, we observed that students who were instructed with the traditional photographic classroom method seemed more interested in the instruction than those who learned through an experiential method and also scored higher in recognizing tree defects on the post-test. In contrast, many of the students exposed to the outdoor instruction seemed disinterested, and many had difficulty paying attention. One explanation might be that the indoor classroom supported by photos and other media resources is a more typical learning environment, whereas the outdoor classroom is not a common learning place for all schools. For this reason, we strongly agree with others (Louv, 2005; Mainella et al., 2011) who emphasize the current state of play deficit and an inadequate time spent outdoors engaged in unplanned activities and connecting with nature, which may have made the outdoor class sessions feel like a recess to many of the students. We recommend that educators who use school grounds to support their teaching should be aware that distraction may be an issue and take into consideration a need to include time for students to acclimate to the outdoor environment.

We observed that students reacted positively to the post-test and most exhibited pride in successfully recognizing structural defects in trees. We emphasize that this highly important topic is rarely presented in middle or even high school curriculum. As a result of this instruction, a number of students expressed their desire to be more involved with the care and selection of trees both at home and around their school grounds. We observed that many students made cognitive associations with what they learned in a single instruction to their real-life outdoor environments. The findings of this research may be useful to other educators and is translatable to other classes. We recommend that educators incorporate topics such as tree structure into their teaching. The students' positive reaction to this instruction supports our conclusion that youth can grasp and successfully apply

technical arboricultural concepts and become caring stewards for our urban forests, even at a young age. We found that introducing structural defect recognition as a curriculum enhancement for sixth grade students is feasible and that both indoor and outdoor instruction were effective methods of teaching this topic.

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