Effectiveness of Web-based versus Live Plant Identification Tests

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Summary. Setup and administration of comprehensive live plant identification (ID) tests in horticulture classes is time-consuming and costly. The curricular goal of this study was to integrate Web-based plant ID self-tests and computer-graded tests into floriculture potted plant production classes to potentially replace live plant ID tests. This research was conducted during 2000 and 2001 with students enrolled in Hort 4051 at the University of Minnesota, St. Paul. All plant ID tests were mandatory, constituting 12% of the grade. In 2000, only Web-based ID tests were used, while both Web-based and live plant ID tests were used in 2001. Two separate self-tests were designed as study aids with 34 randomized photographs/test. Correct spelling was mandatory to receive full credit for genus, species, and family. Self-tests could be taken ten times each per student. Students then completed two for-credit (graded), unmonitored Web-based tests. Students completed a Website evaluation form at the end of the semester. The two live plant ID tests were conducted with the same materials and were monitored. Mean student scores for the Web-based ID tests in 2000 ranged from 73.5 to 99.5% with a class average of 91.9%; there were no significant differences

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among students' scores. Student Web-based ID test scores for 2001 had a similar range with a high class average of 93.8%. In contrast, the 2001 live plant ID tests had a wider score range of 21.7% to 100.0% and lower class average (72.2%). Web-based and live plant ID tests, students, and their interaction were all highly significant. Web site course evaluations demonstrated interesting trends in student perception of Web-based and live plant testing. The implications for future class use and potential modifications for continued Web-based instruction are presented.

In undergraduate horticulture classes, students engage in plant identification exercises to recognize taxa based on visual characteristics (Shaw, 1993). Students commit to memory the scientific name (genus, specific epithet) and family of the sample crops, as well as learning the distinguishing traits or features of dormant or actively growing vegetative or mature (reproductive) specimens. This prepares the students for exams to test their visual ID skills and working knowledge of the plant materials used in commercial horticulture. Many classes teaching horticulture use ID, ranging from woody plant and herbaceous materials, to production-based (nursery, fruit, turf, floriculture, vegetable) courses (Pokorny, 1988). In all instances, the purpose is to develop students with sight-recognition of each crop (Kahtz, 2000). Students often prepare flashcards with the names and distinguishing characters, providing a repetitive basis for automatic recall and correct spelling (Pokorny, 1988). Traditionally, plant ID is based on live plant specimens (indoors, outdoors). Such laboratories are time-consuming and expensive in the maintenance of stock plants at the proper stage(s) of development (particularly if they have a short life cycle), slide libraries, or dried herbaria specimens for ID purposes (Kahtz, 2000). The testing procedures are equally laborious to construct and grade (Pokorny, 1988).

With the advent of technology-enhanced learning paradigms in the classroom, photographs and slide libraries are presented via computer allowing for identification of permanent specimens. The accessibility of the worldwide Web, as well as class Websites, has provided modifications to the delivery of plant ID information and testing. Pokorny (1988) developed and tested a computer program for plant ID in a plant propagation class at the University of Georgia. Computer testing reduced instructor proctoring of ID tests and quiz grading from 6 to 7 h (conventional methods) to 3 to 3.5 h (Pokorny, 1988). Students' scores were not influenced by computer-assisted testing (Pokorny, 1988; Sabota, et al., 1995). Computer-assisted instruction has also been used in woody landscape classes at Washington State University (Shaw, 1993), Alabama A&M University (Sabota, et al., 1995), and the Chicago Zoological Society (Kahtz, 2000).

Conceptually, the advantages of computer-based instruction using class Websites, the worldwide Web, videodisc technology, and CD libraries for plant ID include easy and continuous access by students, accommodating individualized learning speeds, use of close-up views of morphology for improved identification, and color photographs (Gilman, 1994; Shaw, 1993; Shropshire, 1991; White, et al., 1990). Limitations of the system may be marginal photograph quality, limited numbers of plant photographs available, the added expense of computer hardware, lack of tactile learning experiences, and inability to adjust for differences in students' cognitive learning style (Kahtz, 2000).

To the best of our knowledge, floriculture production classes have not used Web-based plant ID delivery systems or testing methodology to supplement or replace traditional plant ID. While many instructors use computers for lectures and maintain class Websites, computer-augmented plant ID has not been implemented. Floriculture curricula could ostensibly benefit from the use of computer plant ID or testing since there are numerous commercial crops. For instance, there are more than 100 potted flowering crops alone (Anderson, 2002); this number increases significantly when bedding plants, cut flowers, cut foliage, and potted foliage plants are included in the syllabus. Web-based learning offers opportunities to refine our information delivery, particularly when budgetary shortfalls place constraints on production and maintenance of plants for ID purposes. In production classes, students need to identify at least the most important crops and learn crop-specific production schedules.

The curricular goal of this study was to integrate Web-based plant ID self-tests and computer-graded tests into floriculture potted plant production classes to potentially replace live plant ID tests. The specific objectives of this study were to investigate 1) student performance using Web-based, replicated plant ID tests, 2) student achievement with Web-based and live plant identification tests in a potted plant production class, and 3) student attitudes towards different testing methods and Web-based learning.

Materials and methods

This research was conducted during 2 years (fall semesters in 2000 and 2001) with undergraduate and graduate students enrolled in a potted plant production class, Hort 4051, at the University of Minnesota, St. Paul. Prerequisites for this course included Herbaceous Landscape Plants (Hort 1011) and Greenhouse Management (Hort 3002). Students had already completed live plant ID tests in Hort 1011. Hardcopy and Website lists of the 34 crops for ID (Table 1) were provided to the students prior to taking the Web-based self-tests (not-for-credit) and graded tests. All plant ID tests were mandatory, constituting 12% of the grade for Web-based (Fall 2000) and 6% each for Web-based and live plant ID tests (12% total; Fall 2001). Integration of Web-based ID tests was accomplished with aid from the University of Minnesota Digital Media Center on the class WebCT (WebCT, Inc., Lynnfield, Mass.) Website, created in 1999 (Anderson, 1999). The Website has undergone annual revisions, including the conversion to WebCT3 for fall semester, 2001 (Anderson, 2001). The class Website is protected from the public domain and only enrolled students may log onto the Website using their university e-mail password.

IMAGE PRODUCTION. Images used in the Web-based plant ID tests were either already in digital form (jpeg), while others were slides. Slides were scanned at about 300 dots per inch (dpi) to retain as much information as possible and later resized to a Web-readable 72 dpi using Adobe Photoshop (Adobe Systems, Inc., San Jose, Calif.).

Considerable development time

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was spent seeking the best compromise between image file size and image clarity. Nearly 50% of the University of Minnesota undergraduates use a dialup modem connection as their primary method of accessing course Websites (J.D. Walker, unpublished data). The throughput, when accessing university servers with a dialup line, averages 1 to 5 kb/s. Minimizing download times was, therefore, an important goal particularly with the number of images students had to download for each test. A compromise file size of 18 to 25 kb for each photograph was used as larger sizes offered diminishing returns in image clarity. The batch processing function in Macromedia Fireworks (Macromedia, Inc., San Francisco, Calif.) was then used to create thumbnail images (3 to 5 kb) from each larger image.

Images were organized into a series of directories named in obvious ways, e.g., crossandra, with each containing a subdirectory with the thumbnails for that plant, i.e., crossan_thumb. A few images were uploaded to the WebCT site for testing purposes to uncover and correct several small technical problems, such as WebCT's prohibition on spaces in filenames. WinZip (WinZip Computing, Inc., Mansfield, Conn.) was used to zip all image directories into one archive file, upload that file to the WebCT site, and WebCT's internal unzip function was used to unzip the archive. This created a file and directory structure in the WebCT site that mirrored the structure on the local computer.

QUIZ AND SELF-TEST PRODUCTION. Self-tests were created in WebCT's quiz module, rather than using the self-test tool, due to the greater flexibility which the quiz module offered. The quiz module, but not the self-test tool, permitted batch uploading of questions, supported short-answer questions, and facilitated image inclusion.

Quiz formulation began by producing a small number of prototype questions. Once these had been tested to remove programming bugs, a single question template was used to produce a text file specially formatted for upload to WebCT's questions database. That one question was copied multiple times into the text file and each instance of the question's use was then customized with the appropriate question text, image filename, and question answers. Since it was not possible to automate this process, the creation of this file was time-consuming. The text file was then uploaded to WebCT's questions database, where it produced all of the questions used in the self-tests and for-credit (graded) tests. Self-tests and graded tests were created using WebCT's question randomization function; each test contained a unique sequence of photographs.

FALL 2000. A total of nine students were enrolled, although one student audited the class and chose not to participate in the potted plant ID tests. This was the first class to test the use of Web-based plant ID tests. While the students grew many of the ID crops for laboratory experiments, live plant ID tests were not included, due to budgetary constraints. Students used two self-tests (not-for-credit) with 34 randomized photographs per test, consisting of four nonflowering and flowering photographs of each of the 34 crops on the plant ID list (Table 1). Not-for-credit tests were created for student use in developing their plant ID skills. Students typed their answers into three answer boxes for genus, species, and family; correct spelling was mandatory. Misspelled words were graded as incorrect answers with full point deductions.

Students began the two not-for-credit tests during the first week of the semester. They could take each of the two not-for-credit tests a maximum of five times. Therefore, each student could potentially take the tests 10 times with different images for each crop appearing randomly in each test. Each not-for-credit test had one photograph of each plant on the ID list for a total of 34 plants/test. Students clicked on the Save Answer button on the computer screen after entering the genus, species, and family. The computer scored each completed not-for-credit test and students

Table 1. Listing of genera, species, and families for 34 potted plant crops used in Web-based (self tests and graded quizzes) and live plant identification tests.

Scientific name	Family
Alstroemeria hybrids	Liliaceae
Aquilegia hybrids	Ranunculaceae
Begonia ×*hiemalis*	Begoniaceae
Begonia tuberhybrida	Begoniaceae
Calceolaria herbeohybrida	Scrophulariaceae
Crocus vernus	Iridaceae
Crossandra infundibuliformis	Acanthaceae
Cyclamen persicum	Primulaceae
Dahlia hybrids	Asteraceae
Dendranthema ×*grandiflorum*	Asteraceae
Dianthus carthusianorum	Caryophyllaceae
Euphorbia pulcherrima	Euphorbiaceae
Eustoma grandiflorum	Gentianaceae
Freesia ×*hybrida*	Iridaceae
Gerbera jamesonii	Asteraceae
Hibiscus rosa-sinensis	Malvaceae
Hyacinthus orientalis	Liliaceae
Hydrangea macrophylla	Hydrangeaceae
Kalanchoe blossfeldiana	Crassulaceae
Lagerstroemia indica	Lythraceae
Lilium hybrids	Liliaceae
Lilium longiflorum	Liliaceae
Narcissus pseudonarcissus	Amaryllidaceae
Pentas lanceolata	Rubiaceae
Pericallis ×*hybrida*	Asteraceae
Primula vulgaris	Primulaceae
Primula obconica	Primulaceae
Rhododendron hybrids	Ericaceae
Rosa hybrids	Rosaceae
Saintpaulia ionantha	Gesneriaceae
Schlumbergera truncata	Cactaceae
Schlumbergera ×*buckleyi*	Cactaceae
Streptocarpus ×*hybridus*	Gesneriaceae
Tulipa gesneriana	Liliaceae

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could view their scores by clicking on the View Results button; scores were not communicated to the instructor.

After successful completion of the not-for-credit self-tests, each student advanced to the two for-credit (graded) tests with a total score of 102 points/test (3 points/photograph × 34 crops). The deadline for completion of the graded tests was 1 Nov. 2000. These tests were unmonitored, due to the unavailability of computer labs for student use, allowing students the freedom to take the tests at any time and place with computer access. Graded tests proceeded in the same fashion as the not-for-credit tests, containing 34 photographs (one of each plant on the ID list) for which the students needed to enter the correctly spelled genus, species, and family for full credit. Students could take as much time as necessary to complete each test. Upon completion, the computer automatically graded each student's test, provided the score on the screen and posted their score in a grade book on the Website (accessible only to the instructor). The scores for the two graded tests were averaged and the means reported.

A Website evaluation form was completed by each enrolled student at the end of the semester to evaluate student use of the class Website, their perceptions of advantages/disadvantages of Website plant ID tests. Nine questions were asked on the evaluation forms.

FALL 2001. Seventeen students enrolled in the class in which they completed the same self-tests (ungraded) and two graded Web-based plant ID tests, as completed by the students the previous year. The automatic grading and reporting on WebCT remained the same as in Fall 2000. In addition, students also completed two live plant ID tests in laboratory with the same plant species as in the photographs for comparative purposes. These live plant ID tests were monitored exams with one student per ID station. Live plant ID tests had a time limit of one hour/test and were completed in two separate laboratory sessions on 28 Sept. and 26 Oct. 2001. The due date for unmonitored Web-based, graded plant ID tests was 1 Nov. 2001. Students could potentially take the Web-based ID tests after they had completed the live plant tests. Using WebCT's tracking system, the date each student completed the Web-based ID tests was compared to the dates for the live plant ID tests (28 Sept. and 26 Oct. 2001).

A Website evaluation form was again completed by each enrolled student at the end of the semester. The purpose of filling out the evaluations was to re-evaluate student use of the class Website, their perceptions of advantages/disadvantages of Website plant ID tests for comparisons with the 2000 data. The same questions were asked on the evaluation forms, with the exception of one (question 4) that was changed to reflect the addition of the live plant ID tests in 2001.

DATA COLLECTION AND ANALYSIS. Data was collected for each participating student on all graded plant ID tests scores (Web-based, live plant), as well as the Website evaluation forms. Student scores (% values) from the Web-based, graded plant ID tests (Fall 2000 and 2001) and the live plant ID tests (Fall 2001) were analyzed using the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, Ill.) with the general linear model (GLM), univariate analysis of variance (ANOVA). When necessary, data was transformed using the square root function. For the 2001 data, plant ID test (Web-based vs. live plant) were the independent variables while test scores were the dependent variable. Mean separations, using Fisher's least significant difference (LSD) test at α = 0.05, were performed to compare student scores. Correlations were also performed for the fall, 2001, data. Website evaluation form data was not statistically analyzed since it was not replicated with each student. The evaluation data was summarized with descriptive statistics.

Results and discussion

Mean student scores for the Web-based ID tests conducted during fall semester, 2000, ranged from 73.5% to 99.5% (data not shown). Only 25% (2/8) of the students scored below 90% (A–), resulting in an unusually high class mean ± SD of 91.9 ± 17.2. There were no significant differences among students' scores (F = 0.76, P = 0.64; 5% LSD = 42.2). Student Web-based ID test scores from fall semester 2001, ranged from 78.0 to 100.0% (Table 2). The overall class average was similar to that of 2000, at 93.8% ± 8.0% with less than half the variance. In the 2001 class, 4/17 or 23.5% scored below 90%. One student chose not to complete either of the Web-based ID tests; this lack of participation was not due to a lack of computer accessibility (confirmed by the instructor).

In contrast with the 2001 Web-based ID tests, the live plant ID tests had a wider score range (21.7% to

Table 2. Student mean test scores (n = 2 replications/student) for Web-based versus live plant identification (ID) tests (Fall 2001; n = 17 students) in Hort 4051, Potted Plant Production.

Student no.[z]	Web-based ID	Live plant ID
1	100.0 a[y]	82.2 ab [y]
2	99.4 a	40.0 bc
3	99.4 a	94.6 a
4	99.0 a	56.2 abc
5	98.0 a	54.2 abc
6	97.6 a	81.2 ab
7	97.0 a	100.0 a
8	97.0 a	61.6 abc
9	96.0 a	95.4 a
10	95.6 a	85.8 ab
11	92.1 a	21.7 c
12	90.2 a	97.1 a
13	89.3 a	77.9 ab
14	86.8 a	76.6 ab
15	82.2 a	79.8 ab
16	78.0 a	67.5 ab
17	---[x]	55.8 abc
Test mean (SD)	93.8 (8.0)	72.2 (23.3)
5% LSD	13.3	27.6

[z]Student numbers are in ranked order, based on the Web-based plant ID test scores.

[y]Mean separations within columns.

[x]Student no. 17 did not take either Web-based plant ID test.

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100.0%, Table 2). The class average (72.2% ± 23.3%) was lower than the Web-based ID tests. Web-based and live plant ID tests (F = 46.6, P < 0.001), students (F = 6.4, P < 0.001), and the test-type × student interaction (F = 3.0, P < 0.001) were all highly significant. Students scoring high on the Web-based ID tests did not necessarily score the same on the live plant ID tests. For instance, student numbers 2, 4, 5, 8, and 11 scored in the 92.1% to 99.4% range on the Web-based ID tests, yet their corollary live plant ID test scores fell below a passing grade (21.7% to 61.6%). As a result, correlation of the scores between test types was not significant (r = 0.02, P = 0.93).

Only 6% of the students completed the Web-based plant ID tests before completing the live plant ID tests. The remainder of the class (94%) took both Web-based tests in the 5 d after the second live plant ID test (26 Oct. 2001) and the due date for completion of the Web-based tests (1 Nov. 2001). It would be quite amazing that student numbers 2, 4, 5, 8, and 11, who scored below a passing grade on both live plant ID tests (21.7% to 61.6%) could receive a score of >90% on the Web-based ID tests without using supplemental material as an aid in the nonmonitored tests. Misspellings accounted for about 50% of the errors on live plant ID tests, whereas Web-based ID tests had a 5% error rate due to incorrect spelling (data not shown).

The Website course evaluations demonstrated several trends in student's perception of this testing type. In answer to question 1, 64% (2001) to 66% (2000) of the students responded that the photographs used in the Website ID tests needed greater detail/clarity (Table 3), despite the fact that a majority of the students in both years correctly identified most of the crops (receiving a score of 90% to

Table 3. Results (% response) from Website course evaluations of students enrolled in Hort 4051, Potted Plant Production, during the fall semester in 2000 (n = 9) and 2001 (n = 17).

Question	% Response	
	2000	2001
1 What could be improved with the crop species identification (ID) Website self tests and graded quizzes? (check all that apply)		
Greater detail/clarity in photographs	66.0	64.0
Photographs were acceptable	11.0	14.2
Tests took too much time	0.0	14.3
Change the format	0.0	14.3
No improvements necessary	0.0	14.3
2 Did you take the self tests or graded quizzes without using supplemental material (i.e., plant list, textbook, notes, etc.)?		
Yes	33.0	85.7
No	67.0	14.3
3 Do you think the honors system works well with students when taking unmonitored exams?		
Yes	67.0	57.1
No	33.0	42.9
4 Did you prefer ID quizzes with live specimens or self/graded quizzes on the Web?		
Live specimens	---	35.7
Self/graded quizzes on the Web	---	28.6
Both	---	35.7
5 What computer software, server, or modem problems did you experience when taking the self tests or graded quizzes? (check all that apply)		
Server down	11.0	0.0
Grading problems	0.0	7.1
Home computer problems (modem, crashing, etc.)	0.0	28.6
Lengthy grading time by the computer	0.0	14.3
None	89.0	64.3
6 Would you opt for future classes to use the Website or live plants for crop ID?		
Live specimens	12.0	42.9
Website	78.0	28.6
Both	0.0	28.6
7 About how many times did you visit the class Website? (average)	9.9	6.0
8 What were your reasons for going to the Website? (check all that apply)		
To obtain assignment	10.0	7.1
For crop ID self tests	27.0	100.0
For crop ID quizzes	24.0	100.0
To view crop production slides	24.0	64.3
View the syllabus	15.0	42.9
9 Have class Websites been a useful tool in your education?		
Yes	100.0	92.9
No	0.0	7.1

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100%). Students may have memorized the computer images, rather than learning the plants. A smaller percentage felt that the photographs were acceptable, i.e., 11% (2000) and 14.2% (2001). In the 2001 evaluations, 14.3% of the students felt that the photographs did not need any improvements (Table 3). The remaining students did not complete the evaluation of photograph detail and clarity. In 2000, none of the students felt that the tests took too much time or that the format should be changed (Table 3), whereas in 2001, 14.3% responded in the affirmative to both questions.

Students' answers to question 2 displayed another dimension to the participant's perceptions. For this question, 33% (2000) and 85.7% (2001) of the students responded that they attempted to take the self-tests or graded quizzes without using supplemental material (Table 3). However, the 85.7% (2001) who responded that they did not use supplemental material was not correlated with their knowledge of the plant material, since Web-based and live plant ID test scores differed significantly.

In contrast with the response to question 2, answers to question 3 added an additional twist to students' perceptions. For question 3, 67% (2000) and 57.1% (2001) of the students responded that the honors system works well when taking unmonitored Web-based exams (Table 3). This is despite 67% (2000) and 14.3% (2001) of the students declaring they used supplemental material.

The 2000 class preferred the Website (78%) over live plant specimens (12%) or both (0%), even though the students only took Web-based ID tests. In 2001, 35.7% of the students preferred live specimen ID tests (question 4) than Web-based ID tests (28.6%) or both (35.7%, Table 3). In contrast, several students changed their minds when asked whether they would opt for future classes to use Website versus live plant ID tests (question 6). Live specimens were favored by 42.9% of the class, while the Website method remained the same (28.6%) but the Both category decreased to 28.6% (Table 3).

On average, students in the class visited the Website 9.9 (2000) and 6.0 (2001) times (question 7, Table 3). While the number of 2001 semester Website visits is lower, it is unclear whether this is due to the use of live plant material for ID purposes (potentially less time spent with Website self-tests), or students spent longer periods on the Website. Since the class Website remained the same during 2000–01 (with the exception of updates to the syllabus, class schedules) it is not a causative factor. Further testing would be necessary to clarify the factor(s) causing the drop in usage.

Reasons for students to visit the class Website (question 8, Table 3) were different between years. For instance, in 2000, students visited the Website to obtain assignments (10%), for crop ID self-tests (27%), for crop ID quizzes (24%), to view production slides (24%), or to view the syllabus (15%). With the exception of obtaining assignments, all usage for these reasons increased with the 2001 class (Table 3). Class Website visits for crop ID self-tests and graded quizzes reached 100%. The increased visitation to the Website during 2001 may have been due to the use of live plant ID tests or a larger student sample size, since all other factors were constant. A majority (100% in 2000, 92.9% in 2001) felt that class Websites had been a useful tool in their education (question 9, Table 3).

Implications

While many horticulture classes can use graphical computer-based instruction, the use of Web-based plant ID self-tests and graded exams have several inherent advantages and challenges in conferring information and testing students' knowledge (Shaw, 1993). A difference between live plant and Web-based plant ID is the 24-h accessibility conferred with class Websites and Web-based testing. Many students reported using the self-tests during late evening or early morning hours, which would have not been possible with live plant materials. Similar to the findings of Pokorny (1988), students were not intimidated by the new challenges of computer-based testing. Immediacy of the self-test grading was appreciated by the students.

Typical difficulties encountered by 7.1% to 28.6% of the students using the Web ID tests (Table 3) were blank photographs downloading during times of peak server usage, particularly on weekend evenings, low computer random-access memory (if the student chose to print photographs), grading problems (a few students had to retake tests), lengthy grading time by the computer, and home computer problems (modem limitations even when downloading the small photograph size). These problems were surmountable and mirrored those reported previously (Sabota et al., 1995). For instance, students quickly adjusted their schedules and avoided accessing the Website during peak server use. Those students with slow computers or modems frequently accessed the Web-based ID tests using the university's computer or library labs. During 2000 and 2001, most students (64% to 66%) responded that greater detail/clarity was needed in the Web photographs (Table 3). However, this did not prevent them from obtaining high scores on Web-based ID tests (Table 2).

The lack of instructor monitoring on Web-based exams is problematic, as reflected by the consistently high student scores during both test years (Table 2). Effective grading of on-line class activities was problemmatic with chat room discussions in a plant nutrition course (Paparozzi and Williams, 2000). In the present study, class mean scores also differed significantly from comparable live plant ID test scores in 2001 ($F = 46.6$, $P < 0.001$). There are few safeguards preventing students from using supplemental materials or group answers when taking unmonitored Web-based tests. In particular, the list of crops on the ID tests (Table 1) possibly may be the biggest reason for higher performance on Web-based ID tests. A total of 33% (2000) to 85.7% (2001) of the students asserted they did not use any supplemental material when taking the Web-based tests (Table 3). While students with failing grades on the live plant ID tests (21.7% to 61.6%, Table 2) could have studied and learned the plant material in the five day time period between 26 Oct. and 1 Nov. 2001, this scenario is unlikely. These students did not learn to identify the plant material during a much longer time period of September to October (about 50 d). Successful computer testing appears to require monitoring (Pokorny, 1988). Unfortunately, in both 2000 and 2001, no computer labs were available in the department or college to test the potential effects that monitoring would have on Web-based ID test scores.

Another factor is the amount of time allotted to take Web-based tests,

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when the live plant ID tests had a definitive limit. Future Website testing should include a time-out limit for each ID specimen.

With live plant ID self-testing, students make a special effort to view the plant materials and test their skills at times other than scheduled in-class sessions. The limited accessibility to the live plant material encourages students to make careful notes of the diagnostic traits, write down names and traits on flashcards, thus committing the information to memory (Shaw, 1993). Students failing to learn the materials had statistically significantly lower live plant ID test scores (Table 2). Thus, the current Web-based ID tests significantly over-estimated a student's ability to correctly ID plants.

While several problems encountered in this study were overcome with student adjustments, others require a more thorough re-evaluation of Web-based instructional pedagogy. Agreeably, computer-based instruction has been used a little more than a decade in agriculture-based classrooms. Many horticulture faculty have added class Websites and computer assignments to supplement existing courses (Pokorny, 1988; Johnson and Oltenacu, 1991), and 92.9% to 100% of the 2000–01 students in Hort 4051 qualified that Websites had been useful tools in their education (Table 3). However, survey results from 2001 demonstrated that 42.9% of the students wanted live specimens for ID, rather than the Web (28.6%) or an option of both (28.6%; Table 3). Perhaps students missed the educational value of student-student and student-instructor interactions occurring with live plant ID. Likewise, three-dimensional learning may enhance retention over two-dimensional photographs, image memorization, along with the time-honored knowledge building by repetitive note copying and flashcards. Future research is needed to clarify the potential causative factor(s).

Although still in its infancy, Web-based learning can benefit from asking thought-provoking questions. Should all plant ID self-tests and graded exams be conducted on the Web? Clearly the lack of instructional monitoring of Web-based exams is a major impediment to accurate testing of student knowledge in correctly identifying plant material. A balance between plant ID and exam methodologies is needed. In the case of the present study, a possible modification would be to require students to take the graded exams on monitored computer terminals. Investments in a computer laboratory for such testing is imperative for continued, effective use of WebCT by horticulture students at the University of Minnesota, particularly for those enrolled in plant ID classes. If Web resources are to be used to their fullest potential, technological challenges must be surpassed.

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