Teaching Methods

Student Use and Perceptions of Virtual Plant Walk Maps as a Study Tool in Plant Identification Courses

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ADDITIONAL INDEX WORDS. ornamental horticulture, undergraduate education, laboratory, web-technology

SUMMARY. Virtual plant walk maps were developed for an ornamental plant identification (ID) course, with the goal of providing an additional study resource to potentially enhance student learning. The maps provided students an opportunity to revisit plants covered in lecture and laboratory sections at their own convenience, using either a computer or mobile device. Each map plotted the locations of the plants from the corresponding list and provided photographs of specimens, plant family, common and scientific names, and plant type information. At the end of the course, a survey was given to collect information about student use and perceptions of the virtual plant walk maps for two fall semesters ($n = 87$). Survey results indicated 63% of the students used the virtual plant walk maps as a study resource. Students who used the maps reported accessing the maps an average of 3.2 times between receiving the maps and taking the plant ID quiz in laboratory. Students mainly used the maps to study the most current plant list and accessed previous plant list maps to a lesser extent. About 67% of students who used the virtual maps, used the maps to visually review the plants online only, although 31% of students used the maps for both visual review and to physically retrace the plant walk to view the live specimens. Of the students who did not use the maps, most found other study resources/methods more useful or they forgot about the maps as a resource. When asked to rate usefulness of the maps on a scale from slightly useful (1) to very useful (3), 43% of students indicated that the virtual maps study tool was very useful, 25% indicated the maps were useful, and 8% indicated that the maps were slightly useful. A significant dependence between student use frequency and student usefulness ratings of virtual plant walk maps was observed. As students' use of the virtual maps increased, they perceived the maps to be more useful to their studies in preparing for ID quizzes. No differences between plant ID quiz scores were associated with virtual plant walk map use, learning style, or use by learning style. Our survey indicated that students used the virtual plant walk maps as a resource and perceived the maps as a useful tool in preparation for ID quizzes.

Plant ID courses are a significant component of undergraduate horticulture program curricula. Students are introduced to numerous plant species in these courses, often through instructor-guided walks around campus during the laboratory

(lab) sessions. Students are quizzed on plants from previously covered plant lists, with the expectation that students can visually identify the plants based on various morphological characteristics using live specimens and/or photographs (photos). In our

course, weekly ID quizzes account for $\approx 60\%$ of the course grade. Exams and projects aimed to test cultural and landscape use knowledge of the plant material accounted for the remaining portion.

Instruction techniques for undergraduate teaching have shifted toward student centered, facilitated learning as more teaching and learning resources and technologies have become available to instructors and students (Beaudoin, 1990; Davies et al., 1996). Technological resources provide valuable opportunities and resources for traditional in-class and distance horticulture plant ID courses to supplement lecture and laboratory information. Computer-assisted learning and supplemental online resources have been shown to maintain, enhance, and increase student learning (Anderson and Walker, 2003; Bing et al., 2012; Hoch and Dougher, 2011; Peterson and Keeley, 2012; Schitteck et al., 2001). Various computer-assisted learning resources include professional society message boards/chat rooms (Paparozzi and Williams, 2000), extensive web-based plant databases from public institutions (e.g., Missouri Botanical Garden, 2014; Oregon State University, 2014; University of Connecticut, 2014), software databases (Boufford, 1994; Gilman, 1994), dichotomous keys (Shaw, 1993; Wilson and Flory, 2012), interactive quizzes (Campbell et al., 2011), and virtual plant inventories/walks (Polomski and Polomski, 2013; Sabota et al., 1995; Starrett, 2016; Wilson and Danielson, 2005; Wilson and Miller, 2015).

Increasing availability of mobile technologies with Internet connection capabilities, such as smartphones and tablets, provide students with increased access to information and the ability to study and learn anywhere and anytime. According to the Pew Research Center, smartphone ownership among U.S. adults rose to 64% in 2015 from 58% in 2014, up from 35% when the research center first began to conduct surveys on smartphone ownership (Pew Research Center, 2014, 2015). Increased availability of data via cellular or wireless Internet on college and university campuses coupled with global positioning capabilities of mobile devices allow students to more readily access location-based resources

and media for their studies. In 2010, it was estimated that over 80% of U.S. public and private universities, 4-year colleges, and over 65% of community colleges have wireless local area networks (WLAN/Wi-Fi) connected classrooms (Green, 2010). These technological resources have the potential to provide valuable opportunities and resources for plant ID courses to supplement lecture and laboratory information. Students in plant ID courses can rely on several techniques to learn the plants, including revisiting exact plant specimens in a given area (e.g., campus, adjacent neighborhood, and arboreta), which were covered in the course. Web-based mapping technologies allow both instructors and students to create virtual plant walk maps containing the locations, ID, and descriptive information, as well as photos and videos for each plant specimen plotted on the maps (Wilson and Miller, 2015).

Sensory modalities theory of learning styles bases categories of learning styles on three of the five senses (vision, sound, and touch). Unlike the other learning style theories, visual, auditory, and kinesthetic (VAK) are based on students' perceptions of the environment around them and what mode (modality) student's best process received information using from the environment around them (Barbe and Milone, 1981). Barbe et al. (1979) and Barkley (1995) described that visual learners prefer to learn by reading information or using images such as pictures, graphs/tables, or timelines. Auditory learners prefer to learn through listening to lectures or engaging in class discussion. Kinesthetic or tactile learners prefer to engage in hands-on activities that replicate or accomplish

the skill to be learned, whereby information is learned physically through troubleshooting/trial and error (Barbe et al., 1979; Barkley, 1995). Most VAK studies have been conducted with primary school children and rarely with infants or adults (Barbe and Milone, 1981; Barkley, 1995). Review of agricultural education articles revealed one study evaluating VAK for students enrolled in two plant ID courses (Contreras et al., 2013).

Virtual plant walks using the Google Maps web application (Google, Mountain View, CA) were created and implemented in two semesters of the Landscape Plants I course at Kansas State University (Manhattan, KS). Students were provided with links to the plant maps with the plotted locations of the plants observed in the weekly laboratory period. The maps allowed students to either physically rewalk the laboratory route on campus and view live specimens alongside the map photos on their smartphone or tablet and/or virtually rewalk the plant walk observing photos of the plants on the laboratory route using mobile devices or a computer. The objective of this study was to characterize student use and perceptions of the virtual plant walk maps as a plant ID course study resource.

Materials and methods

Virtual plant walk maps were created weekly for two fall semesters (2013–14) of the HORT 374 Landscape Plants I course, by the teaching assistant and faculty, using the classic version of the map web application (Wilson and Miller, 2015). The plant species observed in the weekly laboratory portion of the courses were marked or "pinned" on the maps. Each plant pin included information such as nomenclature (i.e., family name, genus, specific epithet, and common name), plant type (e.g., annual, perennial, deciduous, or evergreen), and plant specimen images. Plant images were added to provide a systematic approach to plant ID, including photos of overall plant form/texture, leaf type, arrangement, venation, and margin, reproductive structures (e.g., flower and fruit), and other unique characteristics (e.g., buds and bark). No written ID information was included in the

description field for the maps as the images were meant to replicate the ID process discussed and observed during laboratory walks. Following observation of the weekly plant list in laboratory, instructors e-mailed the students with a web link for the corresponding plant walk map via the course management website (K-State Online; Axio Learning, Manhattan, KS). Students were not given map modification privileges, only the ability to view the maps. Individual map links remained active for the entire semester to allow students to use the maps to study plants from previous plant lists, because once a plant was introduced in the course, students could be quizzed on that species any given week, thereafter.

A voluntary survey instrument was administered at the completion of each course, both semesters ($n = 87$), to assess if students used the maps as a study resource and whether they perceived the maps as a valuable resource. Along with student demographics, the survey included questions about the number of hours students spent studying for weekly quizzes, usage (frequency), and perceived usefulness of the virtual plant walk maps. Four questions were included to characterize how students did or did not use the virtual plant walk maps: 1) How many times did you access the virtual plant maps between receiving the maps and taking the quiz? 2) Which maps did you primarily access (i.e., "previous plant lists," "current plant list," or "both" previous and current plant lists)? 3) For what purpose did you use the maps (i.e., visual review online, physical rewalking laboratory route, or both online and physical review)? and 4) If you did not use the maps, why not? Students were also asked to rate how often they used the virtual plant walk maps resource on a scale from did not use (0), rarely (1), occasionally (2), and too frequently (3). Students rated the usefulness of the virtual plant walk maps resource as: did not use (0), slightly useful (1), useful (2), or very useful (3).

In addition to the study resource survey, students completed a VAK learning style assessment at the end of both semesters using the instrument from Fleming and Mills (1992) as modified by Chislett and Chapman (2005) and used by Contreras et al.

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doi: 10.21273/HORTTECH03567-16

(2013). The VAK assessment consisted of 30 situational questions with three possible responses. Responses were categorized into each of the learning style preferences. Student learning style preferences were calculated as the dominant percentage of responses for a learning style type. For example, a student responding to the VAK with 40% visual, 30% auditory, and 30% kinesthetic would be classified as a predominantly visual learner. Many students exhibited a preference for a learning style to some extent in the VAK assessment. The learning style with the largest percentage of points was used to classify each student's dominant learning style preference. Students exhibiting equal percentages in two or more learning style categories ($n = 9$) were combined and categorized into a codominant group, as no primary learning style preference could be attributed to the student. Three responses were omitted from analyses associated with the VAK assessment, as no learning style could be attributed to two students who did not complete the VAK assessment and one student gave highly suspect answers in answering 100% of the VAK questions for one learning style. The responses for these individuals remained in statistics in which responses for all learning styles were combined. One response was omitted from comparisons of quiz scores between virtual plant walk map use and learning styles, as the individual's quiz grade was not representative of the quiz grades of the course (deemed as a statistically significant outlier using a conservative Bonferroni adjustment). The responses for the individual remained in the statistics not involving quiz score data. The study resource survey, VAK assessment data, and plant ID quiz grades were entered and coded for each student participant by a third party to anonymize the data and ensure objectivity in analysis of the data. The study resource survey, VAK assessment, and data collection procedures were evaluated and exempted by Kansas State University's Committee on Research Involving Human Subjects/Institutional Review Board (proposal no. 6911) under the criteria set forth in the Federal Policy for the Protection of Human Subjects.

Descriptive statistics, including frequencies, were counted and

percentages calculated for course demographics, student resource use, and resource perceptions. We separated map use characteristics, use frequency ratings, and usefulness ratings by the dominant learning style preferences reported by students in the

VAK learning assessment survey. Demographic information and map survey data were combined, containing all 87 student responses and were separated by learning style preference, 84 student responses. Data were analyzed using SAS (version 9.4; SAS

Table 1. Student demographics for two fall semesters (2013–14) of an ornamental plant identification (ID) course at Kansas State University.

Student demographics	Fall 2013 (n = 49)	Fall 2014 (n = 38)	Total (n = 87)
Academic standing		Students (%)	
Sophomore	53	24	40
Junior	25	52	37
Senior	18	24	21
Graduate student	4	0	2
Major		Students (%)	
Horticulture	43	95	66
Landscape architecture	41	0	23
Other ^z	16	5	11
Previous course in plant ID		Students (%)	
No	80	71	76
Yes	20	29	24

^zOther majors included agronomy, agricultural education, park management, life sciences, etc.

Fig. 1. Ternary plot of learning style preference percentages for students of two fall semesters (2013–14) of an ornamental plant identification course at Kansas State University ($n = 84$). Students with the same learning style preference scores overlap and are shown as one symbol. Students exhibiting equal percentages in two or more learning style categories were combined and categorized into a codominant group for data analysis, as no primary learning style preference could be attributed to the students.

Institute, Cary, NC) statistical analysis software with a level of significance set at $\alpha = 0.05$. A test of independence [chi-square analysis using a Fisher's exact test (i.e., Freeman-Halton test) for contingency tables larger than two by two] was performed between student use frequency and student usefulness ratings of virtual plant walk maps. A generalized linear mixed model with a beta distribution and logit link function was specified using the GLIMMIX procedure in SAS to estimate least squares estimates of mean quiz scores and make assessments of differences (type III test of fixed effects and pairwise comparisons) between virtual plant walk map usage, dominant learning style types, and their two-way interaction. Semester was included in the model as a random effect.

Results and discussion

Eighty-seven students participated in the voluntary survey resulting in a participation rate of 92.5% (total students enrolled = 94). The total number of survey participants for both semesters, consisted of 40 female and 47 male students, composed of 35 sophomores, 32 juniors, 18 seniors, and 2 graduate students. Most the students were horticulture majors ($n = 57$), followed by landscape architecture ($n = 20$), and other majors [e.g., agriculture education, agronomy, parks management, etc. ($n = 10$)]. About 76% of the class had not previously taken a plant ID course (Table 1). Percentages from the VAK learning style assessment scores ($n = 84$) identified 28 (33%) students as mostly visual learners, 8 (10%) students as auditory learners, 39 (46%) students as kinesthetic learners, and 9 (11%) students as codominant or balanced learners (Fig. 1). With exception of the presence of codominant learners, the percentages of learning styles were similar to those of Contreras et al. (2013) and in agreement with Barbe et al. (1979) who observed codominant modalities in their assessments.

Students reported studying for an average of 4.1 h for the weekly ID quizzes (Table 2). When surveyed whether the students used the virtual plant walk maps, 63% ($n = 55$) of the respondents indicated they used the maps, whereas 37% ($n = 32$) did not

(Table 2). The percent of total students who reported to use the maps in the map use characterization question (63%) of the survey (Table 2) differed from those in the map use frequency rating question, in which 77% of students reported to use the maps resource (Fig. 2). It is believed that not all students continuously used the maps resource throughout the semester but may have used them at least once, hence contributing to the discrepancy. This may be explained that although 77% ($n = 67$) of the students tried the maps as a study tool at least

once (Fig. 2), 55 students (63%) continued to use the maps throughout the semester (Table 2). Students used the virtual plant walk maps an average of 3.2 times per week before taking the quiz (Table 2). Considering those who reported using the maps, 68% of visual learners, 50% auditory, 59% as kinesthetic, and 67% characterized as codominant learners used the virtual plant walk maps resource.

When asked how they used the maps in preparation for weekly ID quizzes, 47% of students (across all

Table 2. Characterization of student study habits and use of virtual plant walk maps to study for plant identification (ID) quizzes based on student responses to survey questions in two fall semesters (2013–14) of an ornamental plant ID course at Kansas State University.

	All ^y	Learning style preference ^z			
		Visual	Auditory	Kinesthetic	Codominant
Student study and map adoption characteristics	$n = 87$	$n = 28$	$n = 8$	$n = 39$	$n = 9$
Average time spent studying before quiz (h)	4.1	4.3	4.1	3.9	4.9
Students who used the maps (%)	63	68	50	59	67
Student map use characteristics	$n = 55^x$	$n = 19$	$n = 4$	$n = 23$	$n = 6$
Average map accessions before quiz (number)	3.2	3.6	2.3	2.8	4.0
When students used the maps (%) ^w					
Primarily to review previous plant lists	6	5	0	9	0
Primarily for the current plant list	47	53	75	43	33
Both current and previous plant lists	47	42	25	48	67
How students used the maps (%)					
Visually review (online)	67	79	25	74	50
Physically rewalk laboratory route	2	0	0	4	0
Both visually and physically	31	21	75	22	50
Reasons for not using the maps ^v	$n = 32$	$n = 9$	$n = 4$	$n = 16$	$n = 3$
Other study methods more useful (%)	63	78	75	56	33
Forgot about the maps as a resource (%)	34	22	25	38	67
Could not find or access the maps (%)	3	0	0	6	0

^zStudents characterized by dominant or codominant learning style from the visual, auditory, kinesthetic assessment [VAK ($n = 84$)]. Students exhibiting equal percentages in two or more learning style categories were combined and categorized into a codominant group, as no primary learning style preference could be attributed to the student. Three students' responses were omitted from the learning style portion of the study and map use characteristics since two students did not take the VAK assessment and one student had suspect answers to the assessment.

^yStudents from two fall semesters of a plant ID course ($n = 87$).

^xNumber of students who reported using the maps resource.

^wAll values reported below are percentages of student responses to questions (rows and subrows) by column categories.

^vNumber and percentages of student responses to questions (row and subrows), by column categories, for student respondents who reported not using the maps resource.

learning styles) indicated they used the maps to primarily study the current plant list, and 47% of students to study both current and previous lists before the quiz (Table 2). Very few students used the maps to primarily study only previous plant lists. Student responses to the question, “for what purpose did you use the maps (i.e., visual review online, physical rewalking lab route, or both online and physical review)” indicated most of the students (67%) viewed the

maps online for visual review of the plants using the images included for each plant pinned to the map and 31% of students used the maps for visual review combined with physically rewalking (Table 2). Seventy-nine percent of visual and 74% of kinesthetic learners mainly used the maps for visual review of the plant list specimens online. About 21% of visual and 22% of kinesthetic learners used the maps to both review the plant list online and follow the map

to physically rewalk the laboratory route (Table 2). Auditory learners mostly used the virtual plant walk maps to both visually review the plant lists online and physically rewalk the laboratory route (75%) with 25% using the maps only to review the plant material online (Table 2). Considering the maps had no audio information associated with a pinned plant, the use of two implementation strategies may have proven useful for auditory learners.

Fig. 2. Percentages of self-reported student use and usefulness of virtual plant walk maps for or two fall semesters (2013–14) of an ornamental plant identification course at Kansas State University combined [Total (n = 87)] and separated by dominant learning style preference (n = 84).

Table 3. Mean plant identification (ID) quiz scores and 95% confidence intervals (CIs) for virtual plant walk map usage and dominant learning styles for two fall semesters (2013–14) of an ornamental plant ID course at Kansas State University (total n = 83).

Dominant learning style	Plant walk map usage ^z				Main effect	
	Did not use (n = 31) ^y		Used (n = 52) ^x			
	Score [mean ± SE (%)]	CIs	Score [mean ± SE (%)]	CIs	Score [mean ± SE (%)]	CIs
Visual (n = 27)	86.4 ± 3.9	76.7, 92.4	83.8 ± 2.8	77.5, 88.7	85.2 ± 2.5	79.4, 89.5
Auditory (n = 8)	80.6 ± 6.2	65.2, 90.2	76.0 ± 6.8	60.2, 86.9	78.4 ± 4.7	67.6, 86.3
Kinesthetic (n = 39)	81.8 ± 3.2	74.5, 87.3	78.6 ± 2.9	72.2, 83.9	80.3 ± 2.3	75.2, 84.5
Codominant (n = 9) ^w	80.2 ± 7.2	62.1, 90.9	90.2 ± 3.9	79.4, 95.6	85.9 ± 3.9	76.4, 92.0
Main effect	82.4 ± 2.8	76.2, 87.2	82.9 ± 2.4	77.6, 87.2		

^zThe 95% CIs are reported along with the means, since standard errors may not be perfectly symmetrical around the mean due to model specification (beta distribution).

^yOne student's quiz score was omitted from comparisons of quiz scores as their quiz score was not representative of the quizzes for the course (deemed as a statistically significant outlier using a conservative Bonferroni adjustment).

^xThree students' responses were omitted from the learning style portion of the study and map use characteristics since two students did not take the kinesthetic assessment and one student had suspect answers to the assessment.

^wStudents exhibiting equal percentages in two or more learning style categories were combined and categorized into a codominant group, as no primary learning style preference could be attributed to the student.

In future maps, it may be beneficial to include audio information to enhance the study resource for auditory learners. Students who did not use the maps indicated that they found other study resources/methods more useful, whereas the second most cited reason for not using the digital maps was that they forgot about them as a resource, despite receiving a weekly e-mail and verbal reminders (Table 2).

Students who reported using the virtual plant walk maps resource were asked to rate how often they used the resource; did not use (0), rarely (1), occasionally (2), or frequently (3), results indicated students used the maps occasionally to frequently. About 28% of students used the maps frequently, 31% occasionally, and 18% rarely. Codominant learners (66.7%) and visual learners (60.7%) reported using the maps occasionally to frequently, whereas 56.4% of kinesthetic and 50% of auditory learners reported using the maps resource occasionally to frequently (Fig. 2).

Student perceptions of the usefulness of the virtual plant walk maps resource, rated on a scale from did not use (0), slightly useful (1), useful (2), or very useful (3), indicated that most students who used the study resources perceived virtual plant walk maps as very useful. Nearly 43% of students rated the virtual plant walk maps as very useful with 50% of visual learners rating the maps as very useful compared with 37.5% of auditory learners and 38.5% of kinesthetic learners (Fig. 2). Twenty-one percent of students classified as visual learners, 12.5% of auditory, and 30.8% of kinesthetic learners rated the maps as useful. Eight percent of students rated the maps as slightly useful. No auditory learners rated the maps as slightly useful (Fig. 2). A test of independence [chi-square analysis using a Fisher's exact test (i.e., Freeman-Halton test) for contingency tables larger than two by two] indicated a significant dependence between student use frequency and student usefulness ratings of virtual plant walk maps ($P < 0.0001$, $df = 4$). The significant dependency suggests as students' use of the virtual maps increased, they perceived the maps to be more useful to their studies in preparing for ID quizzes.

No difference was found for the two-way interaction between virtual

plant walk map usage and dominant learning style ($P = 0.480$). The mean quiz scores of students who did not use and those who used the virtual plant walk maps resource were similar ($P = 0.873$) and similar across learning styles ($P = 0.279$). Table 3 shows the least squares mean plant ID quiz scores by map use, learning style, and map use by learning style. It must be noted this analysis is of the data from an observational study rather than an experiment and is a measure of the possible differences between quiz scores associated with map use or learning style rather than differences attributed to experimental units, where subjects are assigned to treatment groups (e.g., no map use or map use) and tested using standardized exams (e.g., pre- and posttests). Further work using pre- and posttests for control and map use groups should be performed to assess the effect of the virtual plant walk map resource on student performance in plant ID quizzes.

Students were open to using the virtual plant walk maps as a study tool, as nearly 77% of the students tried the maps (Fig. 2) and 63% of the class continued to use the maps for study purposes as based on the map use characterization portion of the survey (Table 2). Students used the virtual plant walk maps mainly as a visual study resource and to lesser extent, a resource to retrace the plant walk to view live specimens. Nearly all students who used the maps studied the most current plant list during the semester and around half of them used the maps to study previous plant lists in addition to the most current list. Virtual plant walk maps were viewed about three times before the quiz each week. Students who used the maps perceived the study tool to be useful to very useful in their preparation for ID quizzes as were Internet, notes, and flashcard study resources (data not shown). Students who did not use the maps perceived other resources (e.g., Internet, notes, and flashcards) as more useful to helping them study for plant ID quizzes. No differences between plant ID quiz scores were associated with virtual plant walk map use or use by learning style. The virtual plant walk maps can be modified to include audio, videos, and text in the description field of the pins and be

implemented as interactive activities such as scavenger hunts to locate, identify, and pin plants on their own or matching descriptions provided by unnamed pins on a collaborative map. With inclusion of such enhancements, instructors may be able to encourage more students to use virtual plant walk maps as a study resource and provide multiple methods for students of all learning styles to learn plant ID suited to their learning style preference. Although supplemental resources have been shown to increase learning, the effectiveness of these resources/tools to increase learning beyond traditional teaching approaches have mostly proven ineffective, but were comparable for agriculture courses (Anderson and Walker, 2003; Contreras et al., 2013; Hallman et al., 1992; Kahtz, 2000; Kappes and Schmidt, 2002; McCaslin and Na, 1994; Peterson and Keeley, 2012; Seiler et al., 2002; Taraban et al., 2004; Teolis et al., 2007). Technological resources have the potential to provide valuable opportunities and resources for plant ID courses to supplement lecture and laboratory information comparably to traditional in-class instruction. Our survey results indicated that students used the virtual plant walk maps as a resource and perceived the maps as a useful tool in preparation for ID quizzes. Virtual plant walk maps as a study tool in plant ID courses may be a resource to use in addition to traditional study resources.

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