Evaluation of CROPVIEW as a Crop Science Teaching Resource for Post-Secondary Educators[1]

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Abstract

Since less of the American population is involved in agriculture fewer students in university and high school biology courses are familiar with plant species that supply most of the world's food. Crop science concepts such as identification, adaptation characteristics, and current topics related to food production have traditionally been introduced in classroom lectures and reinforced using seed and plant specimens. This study investigated the development and efficacy of the website CROPVIEW as an educational tool in an agriculture curriculum designed for a diverse audience of college students enrolled in undergraduate courses in the College of Agriculture at three different universities. The target population consisted of all undergraduate students in those courses (N= 287). The researchers used a general knowledge instrument to gather data. The study's findings conclude that the website was equally as effective for student learning of agricultural information as traditional teaching methods.

Introduction

Since less of the American population is involved in agriculture, fewer students in university and high school biology courses are familiar with the plants that are responsible for feeding the world. Plants are generally less popular than animals as subjects in secondary school science classrooms, and the focus on understanding plants and their role in the environment has faltered accordingly (Bebbington, 2005; Darley, 1990). In fact, some authors have used the term "plant blindness" to describe the general public misanthropy towards plants (Wandersee and Schussler, 1999). Despite the waning popularity of plants in the science classroom, plant identification is highly important for proper communication across international borders, and naming plants properly is important for understanding them in scientific context (Nesbitt et al., 2010). For those in agricultural education, this paltry background in plant science is the starting point from which crop science education must proceed at the college level.

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Bringing crop science students to a basic level of knowledge of plant science and adaptation principles, along with identification of crop plants and seeds has traditionally been the goal of undergraduate lectures in university agricultural programs. Students must grasp these basics before they can understand concepts such as how climate change may impact food production in different parts of the world and for understanding the importance of agriculture to their personal lives in a civic or political context. In addition, an international focus in the agriculture curriculum is needed to prepare students for a globalized market and to understand the impact of agriculture on global events (Bruening and Frick 2004).

There are some significant logistical barriers when it comes to teaching crop science topics. For traditional in-class laboratory exposure, plant specimens and seeds must be maintained and can occupy valuable storage and growing spaces, which can be very expensive. Distance education, which is a rapidly-growing aspect of university education can potentially reach more students per instructor and save on educational costs (Nachmais et al., 2000). However, on a per-course basis, developing and implementing a distance education course can cost more than traditional delivery (Sterns et al., 2005). Presenting lecture information in an interesting and effective way that will include student laboratory experiences is especially challenging for distance education. Creating a reusable learning object (RLO) (Wiley, 2000) for crop science education that can be freely accessed and used by multiple institutions and course participants in both live and distance-delivered courses could potentially be more cost effective and more engaging than current instructional approaches.

In previous studies, instructors have used web-based images to teach or enhance plant identification learning with varying degrees of effectiveness. Anderson and Walker (2003) found that students scored suspiciously well on web-based identification exams and concluded that students might be memorizing the photos rather than learning actual identification skills. Kahtz (2000) developed a photograph-based program that showed identifying characteristics across seasons for each of the 300 plants available to students in a woody plants course. The students also participated in a traditional identification laboratory. The students in this course evaluated the computer-assisted instruction tool and deemed it to be helpful for review, but not for initial learning (Kahtz, 2000). Teolis et al. (2007) concluded that their distance learners may have benefited from a greater variety of images showing the plants at different times in the growing season and that illustrated specific identifying features. Their study also concluded that students should be encouraged to visit a botanical garden or other location where the plants studied could be observed directly.

Overview of CROPVIEW

The CROPVIEW (Comprehensive Resources for Observing Plants in a Visual Interactive Enhancement Window) program was developed as a RLO that would increase student understanding of global food production systems and the science of food production as it relates to agricultural practice, plant biology, geography, and climatology (https://www.purdue.edu/cropview/). A team of crop scientists, students, and artists from the Department of Agronomy, along with programmers, web designers and additional artists from the Center for Instructional Technology and Training, all at the University of Florida created the program. This RLO was intended to be utilized in both post-secondary and secondary level science curricula.

The team utilized the *ADDIE* instructional design model, which provides a step-by-step process that helps training specialists plan and create training programs (Gagne et al. 2004; Chan 2006), to create CROPVIEW. The ADDIE design model revolves around five components: analysis, design, development, implementation, and evaluation. In the analysis step , the team observed that students often photographed specimens and studied from digital images rather than notes or sketches of the seed and plant specimens presented in class. In the design step crop-science concepts were organized in discreet modules that were accessible from a central front page. This allowed students to study at their own pace. In the development step, four modules were created: (1) Introduction, consisting of plant science concepts such as photosynthesis and symbiotic nitrogen fixation; (2) Nutrition, which presented topics such as caloric needs for survival, amino acid balance, and an introduction to fatty acid types; (3) Biomes, which introduced the major world biomes and listed crops adapted to each; and (4) Plant and Seed identification virtual laboratory, which included seed images that could be magnified and rotated 360˚ by progressing through thumbnail images taken of a rotating seed, and high quality images of crop plants representing different phases of growth (Figure 1).

The plant and seed module also included identifying characteristics and additional information about each crop such as the scientific name, basic taxonomic data, adaptation, additional features, nutrients supplied, and anthropological notes (Figure 1). The plant image pages included the growth limitations of the crop,

Figure 1. Screen shot from the Seed/Plant identification module. The images showing the rotated seed are below the viewing window. Panning over the first of the images reveals characteristics to assist in identifying the seed. Additional information, including scientific name, scale, and key facts are given below the images.

such as temperature and rainfall ranges. It is worth noting that the crop adaptation data was presented three times in the series of modules, in biomes, with the seed images, and finally with the plant images. The information for the plant-seed module was drawn from a database into a template using a query system. This design method makes it possible to add to the module without extensive reformatting.

Quizzes with instant feedback were included at the end of each module to allow students to evaluate their own learning. Since student learning may be further enhanced through game play (Randel et al., 1992) a game called *"Feast or Famine"* was added to the CROPVIEW webpage to encourage higher level thinking skills, specifically, students' ability to identify biomes based on global location. The students had to choose crop seeds that would be well-adapted to the region and provide proper nutrition to the communities there (Unruh Snyder et al., 2011). The game also tested students' ability to identify seeds by providing more seed images and less identifying information on the seeds with each round.

Objectives and Hypotheses

The current study assessed the effectiveness of CROPVIEW as a classroom learning aid based on the implementation and evaluation steps prescribed by the ADDIE method (Gagne et al., 2004; Chan 2006). A preliminary objective was to profile the students' prior exposure to plant and crop science instruction. Then, we hypothesized that students with access to CROPVIEW would demonstrate more crop science knowledge than those without access at the end of a related course. We also hypothesized that students with access to CROPVIEW would develop better crop seed and plant identification skills than those without such access. The final objective was to evaluate student perceptions of CROPVIEW as a tool to enhance their understanding of crop science materials.

Materials and Methods

The research design for this study was causal comparative (Fraenkel and Wallen, 1993), used to identify possible causes; similar to a correlation, with the objective of testing the impact of CROPVIEW on student knowledge of basic crop science concepts and of seed identification skills in eight classes at two institutions over two years. In 2007, classes at University 1, (*N* =73 and *N* =42), were selected to evaluate CROPVIEW. In 2008, classes at University 2 (*N* = 56), University 2 (*N* = 22 and *N* = 53), and the University 1 (*N* = 42) evaluated CROPVIEW. Each of the classes was assigned to

Table 1. Descriptive information for courses participating in the CROPVIEW evaluation

Institution[z]	Course Title	Materials available	N	Year
UF	Plants that Feed the World[y]	Classroom only	42	2007
UF	Environment Food and Society[x]	CROPVIEW only	73	2007
VT	World Crops and Cropping Systems[w]	CROPVIEW only	56	2008
PU	Introduction to Crop Production[v]	Both	22	2008
UF	Plants that Feed the World	Classroom only	42	2008
PU	World Crop Adaptation and Distribution[u]	Both	53	2008

[z]UF = University of Florida; VT = Virginia Tech; PU = Purdue University.

The following are the course descriptions directly from each University's website:

[y]Introduction to 25 of humankind's most important food crop plants with an emphasis on soil and climatic adaptations, major producers and consumers, nutritional attributes, processing needs and types of products.

[x]Global issues and trends in population growth, natural resource (soil, water and plant genetic biodiversity) utilization, climate change and potential impacts of current trends on agriculture, natural resources, global food security, and sustainability.

[w]An introduction to world crops, their primary regions of production, the factors that determine where they are grown, and their economic importance. Describes the various factors that can be managed to improve crop yields. Examines present and potential systems of farming for improved crop production in the major climatic and soil ecosystems of the world.

[v]Fundamental principles of crop production and distribution. Emphasis is placed on applying technological advances in agronomy to active crop-production situations, including basic soils, agricultural meteorology, and crop physiology and breeding.

[u]Examination of how environmental factors, including climate and soils, impact the global distribution of major food crops. Identification of the types of naturally occurring plant communities and comparison of these communities with those of environmentally and economically sound field cropping systems. Exploration of how man's intervention has maintained or modified the productivity of food crops in agricultural communities and how his intervention has affected the environment.

one of three categories with regard to plant and seed identification specimen exposure (Table 1). The classes had either no CROPVIEW exposure, but classroom exposure to the same topics, including plant/seed identification specimens (Classroom only); exposure to the CROPVIEW online specimens only (CROPVIEW only); or exposure to both the CROPVIEW website and classroom instruction on the same topics, including identification specimens (Both).

A skills assessment instrument was developed to evaluate knowledge of the material presented in each of the CROPVIEW modules. The assessment instrument consisted of 37 questions, four of which addressed prior knowledge of crop science topics, 24 of which addressed material presented by CROPVIEW, and nine which were satisfaction evaluations based on a Likert scale to evaluate student perceptions of CROPVIEW and of the related course in which they were enrolled. Demographic data such as gender, age, college, major, grade level, and state/country of origin, was collected through seven supplementary questions. A panel of experts reviewed the draft instrument for face and content validity and revisions were made to the resulting final instrument. University of Florida's Institutional Review Board approved the study protocol and all participants provided informed consent prior to participation in the study. Students were instructed to review the CROPVIEW materials outside of class by studying one of the four modules per week in the weeks leading up to the assessment. Students were given a small bonus point incentive for participating in the assessment, but their score did not impact their course grade. We asked in our assessment if the students were familiar with the CROPVIEW website as a means of measuring there use of CROPVIEW. In addition, we also set up a Google analytics account to track the number of times students entered the website from each location.

Statistical Analysis

A general linear model procedure (Proc GLM) using each class population and year as main effects, followed by a protected least significant difference (LSD) comparison of means ($\alpha = 0.05$), was used to evaluate the mean scores from the instrument using SAS software (SAS version 9.2, 2008). Further exploration of correlations with class performance and state/county, college, age, and gender was performed using the Statistical Package for the Social Sciences (SPSS, Cary, NC.).

Table 2. Percentage of students who had earned a given number of college credit hours on each subject areas or completed only a high school level course (N=287)

Topic	3 credits[z]	7.5 credits	High school only	No response[y]
Plant science/botany	38%	11%	26%	18%
Crop science	34%	10%	27%	19%

[z]Data representing percentage of students with only one credit hour not shown.

[y]The instrument did not differentiate between a student's intent to skip the question or to respond as no exposure to the subject.

Results

The student population consisted of 160 males, 116 females, and 11 unspecified (N=287) and included 25% freshman, 30% sophomores, 30% juniors, 7% seniors, 1% graduate students, and 7% unspecified. Forty-five percent of the students were enrolled in a college of agriculture and/or life sciences; the remaining students represented a wide range of colleges within each university, including liberal arts and sciences (26%), business (6%), engineering (5%), natural resources (4%), and journalism (2%).

We evaluated the students' prior exposure to plant and crop science instruction; of the students who responded, 38% had previously earned 3 or more college credits in a crop science course, and 38% had earned 3 or more credits in plant sciences or botany (Table 2). Ten percent of the students had earned 7.5 or more credits in a crop science course (Table 2). Some of the students had some high school level exposure to plants and crop science (26% and 27%, respectively; Table 2). The results of the correlations performed showed that previous college credit did not influence the test scores of the students.

Student performance on the 24 assessment instrument questions evaluating CROPVIEW module content was used to address our first hypothesis that students with CROPVIEW exposure would gain more crop science knowledge than those without this exposure. The year effect was not significant for these results, so student response results were pooled across years for each classroom population. Students scored an average of 14.85 (SD= 4.95), out of 24 in classes with Classroom only, CROPVIEW only (M=14.34; SD=5.23), and Both exposures (M=12.73; SD=5.43).

Students in the three exposure categories scored similarly on the seed identification section. Students correctly identified an average of 2.7 out of 5 grains presented (SD=1.55), regardless of whether they studied solely online or with in-class materials, however, those with access to both resources scored lower with only 1.9 correct answers (SD=1.7). Students with classroom only exposure correctly identified more of the five legumes presented (M=3.9, SD=1.1) than did students with CROPVIEW only, (M=3.0, SD=1.1). Students with access to Both resources did not have significantly different scores (2.9 of 5; SD=1.8) than

Table 3. Evaluation instrument scores grouped by exposure to in-class materials, online modules, or both resources for seed identification

Exposure	Introduction to plant science	Nutrition	Biomes	Seed identification	Overall % correct
	Number of correct answers				
	(5)	(5)	(4)	(10)	
Classroom only	3.3 a[1] (1.2)	3.9 a(1.1)	2.3 a (0.7)	5.9 a (1.7)	62 a
CROPVIEW only	3.0 a (1.1)	3.0 b (1.4)	2.1 ab (1.0)	6.5 a (2.9)	60 a
Both	2.4 b (1.2)	2.6 c (1.2)	2.0 b (1.0)	5.8 a (3.4)	53 b

[1]Means within a column followed by the same letter are not significantly different at the 0.05 probability level using the protected LSD. Standard deviation is provided in parenthesis.

Table 4. Student perceptions of course satisfaction and knowledge of seeds (N=287)

Survey Question	Delivery Method	Mean[1]	Std. Deviation	Std. Error
I am familiar with the use of the CROPVIEW website?[z]	Both CROPVIEW Classroom	2.9 b 4.3 a 1.7 c	1.3 0.7 1.0	0.15 0.06 0.11
I have a general knowledge of plant sciences.[z]	Both CROPVIEW Classroom	3.7 a 3.7 a 3.0 b	0.8 0.7 1.0	0.10 0.06 0.11
I am familiar with the terms used in identifying the seeds of major world crops.[z]	Both CROPVIEW Classroom	3.6 a 3.6 a 3.7 a	0.8 0.9 1.0	0.09 0.08 0.11
Overall, I was __with the course content and materials.[y]	Both CROPVIEW Classroom	3.6 a 4.1 b 4.5 c	0.9 0.7 0.8	0.11 0.06 0.09
I was __ with the navigation in Cropview.[y]	Both CROPVIEW Classroom	3.4 a 4.0 a .	0.8 0.9 .	0.12 0.08 .
I felt I had a positive learning experience in this class.[z]	Both CROPVIEW Classroom	3.4 a 4.3 b 4.6 c	0.9 0.8 0.6	0.11 0.07 0.07
I feel more confident in my ability to identify seeds.[z]	Both CROPVIEW Classroom	3.5 a 3.9 a 4.4 b	0.9 0.8 0.7	0.11 0.07 0.08

[z]1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree.
[y]1=very unsatisfied, 2=unsatisfied, 3=neutral, 4=satisfied, 5=very satisfied.
[1]Means within each question that have the same letter are not significantly different at the 0.05 probability level as determined by a protected LSD post-test.

Table 5. Representative themes derived from student responses

Theme	Student Comments
Extremely useful class and website materials. (35%)	R (1):*"I loved the crop science modules. I think they're a great learning tool that is much more effective than reading from a book or hearing a lecture, very useful"* R (12): *It was an informative program.*
Cropview was a great experience (60%)	R (2):*"It was a very eye opening and helped me understand practical application of crops/where they are found* R (3): *"It was an excellent simulation."* R (10): *"I liked the computer simulation, I thought it was neat that it was self paced and very interactive. Having to use critical thinking was definitely advantageous."*
Hands on learning is better (2%)	R (11): *"The course definitely enlightened me to my own deep interest in soil, water, and plant science. I took it as an elective but now I want to change majors."*
Improve seed pictures (3%)	R (4): *"Seed pictures are too small."*

[z]Minimal feedback was received (N=28 out of 287).

those with CROPVIEW only access to seed and plant identification materials.

There was no significant difference in student confidence in their ability to identify crop seeds and plants between the exposure groups. The students with classroom only plant and seed materials were most satisfied with overall course content and materials and overall had positive learning experiences, while the students with both web and live materials were the least satisfied (Table 4). The students that used CROPVIEW were satisfied with the website overall. The students in the course with live materials were most confident in their ability to identify seeds followed by the website only and then the both (Table 4).

Discussion

Although our student population had a higher percentage of students with some previous exposure to plant sciences than what most educators have experienced (Wandersee and Schussler, 1999), the idea of creating examples to educate students to this subject content is critical for their understanding our global food system. Judging from student responses, we were effective in producing an easily-navigated website, we had positive comments about the RLO based on 60% that said that they had enjoyed the experience, had high satisfaction based on written comments (Table 5).

While student crop science knowledge may not have been significantly enhanced by the CROPVIEW RLO, as determined by the approximately 50% correct scores on the assessment (Table 3), students where CROPVIEW was offered alone had an enjoyable class experience (Table 4). It is worth noting that this assessment was not a part of the students' grades, and there was no penalty to the student for a poor score. The developers speculate that if CROPVIEW had been presented as an integral part of the curriculum rather than supplemental material, the scores may have been quite different.

The scores on the seed identification portion of the assessment may indicate that CROPVIEW was as effective as live materials in developing this skill. The students' somewhat poor performance on the general knowledge test in this study does raise concern on the instructors should best approach this teaching subject of world food crops. However, the researchers feel that the basic knowledge in this area is somewhat challenging to teach and student exposure to this information needs to be integrated in other curricula where appropriate, especially with regard to crop facts and seed and plant identification of major food crops that feed our world.

The designers are hopeful that CROPVIEW will be an effective tool for presenting crop science information to a global audience. A true test of this RLO as a method of introducing crop science materials to students with little to no prior knowledge of the subject matter has not been met. Although many students in the current study had not had a prior course in plant or crop science, they were currently enrolled in a course with similar material. The modules would need to be presented to college students in a class studying an unrelated subject or to a group of high school science students to determine the efficacy of the CROPVIEW RLO as a mode of instruction and interest-building for students who have had no prior instruction in the science of world food production.

Additions that have been made to CROPVIEW during its brief residency at Purdue University have already demonstrated the ease of incorporating new technology such as Google Maps into the program. In addition, the website now includes a database that can be updated by the web administrator to include more seed pictures.

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