Student Perceptions and Performance of an Online Tool Introducing the Concepts of Plant Breeding[1]

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Abstract

There is a need to develop multimedia tools that can be incorporated into curricula to introduce the basics of plant breeding as a method to recruit and to encourage students to pursue plant breeding programs. To fill this need, we developed an online module that permitted the understanding of the basic techniques and concepts of plant breeding. The design of this study was pre-test and post-test descriptive and comparative, which involved the use of general knowledge instrument to gather pre-test and post-test data for measuring differences resulting from a treatment, which was the introduction of a "Plant breeding" module. In addition, student perception questions were collected. The target population consisted of all undergraduate students (N=133) enrolled in the College of Agriculture at Purdue University during the Fall and Spring semesters of 2010, as well as, the Spring semester of 2011. Students' post-test knowledge scores were slightly lower than pre-test scores, even though the percent change was minimal. We found that this module was a beneficial tool for student-learning and recommended it to be used by faculty to simulate an authentic hands-on learning experience.

Key words: corn, online-module, plant breeding, sorghum, student-learning, STEM

Introduction

Developing well-designed learning materials improves both teaching and learning in an online environment (Capri and Mikhailova, 2003). As Stemler (1997) indicated, learning with multimedia "becomes active, not passive and it ensures that users are doing, not simply watching ." Thus, creating well-designed on-line modules that includes the previous authors' research is critical. Elliot (2007) provided an overview of how authentic learning can transform both student and teachers' success.

The practice of plant breeding is one of the oldest disciplines in the world that has been applied with the goal to feed the human population (Kingsbury, 2009). This area of science is indispensable for the growing population with the environmental challenges that the world will face in the future years. Growing populations, urbanization and environmental factors like climate are affecting food security. This entire scenario has surfaced as we approached approximately a billion of the world's population living in hunger (FAO, 2010). The need to expose new generations (post-secondary students) to the plant breeding discipline is essential to achieve future demand of food products, mainly in the plant science field (Wolinsky, 2010a). Based on Wolinsky (2010b), as the science has been reaching new accomplishments at molecular levels, genome sequencing and structure, the amount of students interested in plant breeding at the graduate school level has been decreasing. In addition, there is a need to encourage urban (non-agricultural background) students to be interested in this field of study that normally is unfamiliar for them since they are not exposed to agricultural careers. Moreover, the disciplines that consist mainly of laboratory bench work and computer analysis are usually more attractive to students compared to the plant breeding programs, which involves intense fieldwork (Wolinsky, 2010b).

[1]Acknowledgments: Development of this learning activity was supported in part by Purdue University's Teaching and Learning Technology Digital Content Development Grant through the Information Technology at Purdue (iTaP) Department. Editing and careful review were done by Trulie Campbell, Anthea C. Saez and Sarah Williams, who are three passionate research and teaching students interested in agricultural education.

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Student Perceptions

The number of students pursuing a plant breeding career at a higher education level is decreasing; especially at the master and doctoral degrees levels, while the world-wide demand for professionals in this career has increased (Bliss, 2007; Guner and Wehner, 2003; Morris et al., 2006; Gepts and Hancock, 2006; Repinski et al., 2011; Wolinsky, 2010b). Organizations such as the Crop Science Society of America have started mentoring programs such as the "Golden Opportunity Scholars" program to help recruit undergraduate students into the Crop Science disciplines, particularly those that might be interested in plant breeding (CSA, 2012). A normal classroom sometimes can fail to bring a broad scenario of field techniques and skills into the classroom because of lack of funding, expertise or even the season in which the course is taught. During the winter season in the Midwestern United States, teaching of field techniques and skills are limited by weather and climate. These fields' techniques and skills have been rated as priority knowledge needed for this career according to plant breeders in diverse institutions and countries (Repinski et al., 2011). Repinski et al. (2011) surveyed plant breeders to determine the important knowledge categories needed in this career to supply the oncoming need for food sources. The results of the survey revealed three sectors: field design, technique and analysis and plant breeding methods for self and out-crossing systems. The teaching of this knowledge is complicated when the course schedule does not coincide with the growing season. Consequently, it is important to look for ways to introduce this discipline so that students with different backgrounds can be well prepared professionals and potentially understand plant breeding as a career. Thus, it is important for students to have an authentic real-world training experience related to the priority knowledge needed as stated by Repinki et al. (2011).

Using technology or multimedia in the classroom can be an effective way to introduce the content that demonstrates the element of the professional job in order to promote learning and recruitment of the next generation of future scientists. Elliot (2001) and Sparks (1994) indicated that the essential element of job-embedded professional development is that the learning takes place within the context of one's daily work environment. In the case where the students experience the multimedia utilizing the plant breeding module, the students will encounter the professional job situation which could be an attractive solution to promote learning in the "modular" work environment. This statement is supported by the findings by Rieber et al. (2004) who reported that students find that utilizing simulations to be effective in learning new content. Our objective was to develop a tool to introduce post-secondary students at the college level to the plant breeding discipline.

Purpose of Study

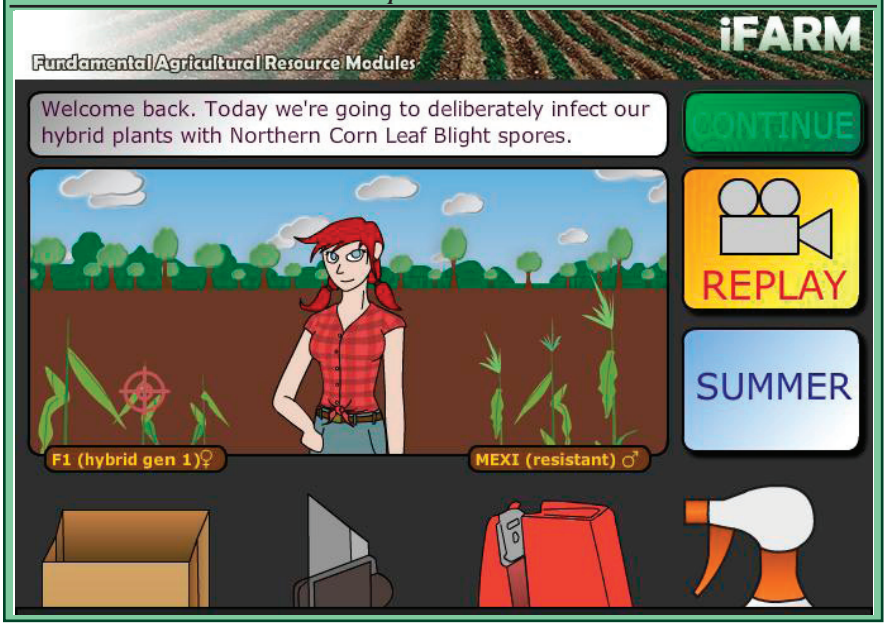
The purpose of this study was to investigate the plant breeding competence and perceptions utilizing an online plant breeding module to a group of college students who were enrolled in "World Crop Adaptation and Distribution" and "Crop Production," undergraduate elective courses for both College of Agriculture majors and non-majors. The design of this study was pre-test and post-test descriptive and comparative, which involved the use of general knowledge instrument to gather pre-test and post-test data for measuring differences resulting from before and after the treatment, which was the introduction of a "Plant breeding" module. In addition, we collected student perceptions of their previous experiences with plant breeding as well as their opinions on the use of the module related to their career goals.

Materials and Methods

Design and Components

The authentic learning framework led to the development of the "Plant breeding" modular unit as part of the interactive tool called Interactive Fundamental Agricultural Resource Modules or "iFARM" (Unruh

Figure 1. Plant breeding iFARM Module Screenshot. In the top left part, a female breeder is introducing how to breed corn and in the bottom are the essential tools to perform the crosses. Top right is the bottom to view the video again and an indication of the season where the process is carried out.



Snyder et al., 2009) to introduce the practical techniques and "hands-on" skills of plant breeding in the field (www.ifarmlearning.com). The iFARM modules reflect real-life situations that can potentially enhance students' skills and experiences.

The design of this study was non-experimental, pre-test-post-test descriptive and comparative, which involved the use of general knowledge instrument to gather measuring differences (Dimitrov and Rumrill 2003). The module was developed using Flash Professional CS5.5 establishing a field scenario for a plant breeder and the foundations of this profession such as crossing the crop plant, climate condition and tools used. The plant breeding modular unit consists of the introduction of different cross systems in two important commodities, corn (*Zea mays*) and sorghum (*Sorghum bicolor*). For each crop, the module explains the process of crossing and selection of plants carrying the desirable traits needed to enhance food production. After the students watch the explanation of the process, they have similar scenarios with all the tools necessary to perform their own crosses (Figure 1). The students were required to watch the two videos imbedded into the module of actual plant breeders doing the same procedures in the field.

Demography

This investigation was a descriptive census (all members of the class) study (Patton, 2002) and the target population was undergraduate students in the College of Agriculture. The target population consisted of 133 undergraduate students from two different agronomy courses during the Fall and Spring semester of 2010 and the Spring semester of 2011. Although the participants were not selected randomly because the investigation was a census study, students who completed the pre-test and post-test were considered to be representative of undergraduates who would have enrolled in these courses in previous semesters or will enroll thereafter (Oliver and Hinkle, 1982). These students represented five colleges with the majority from the College of Agriculture.

Assessment and Data Collection

Approval was obtained from the university's Institutional Review Board and no identifying information was used in the data analysis. The pre-test consisted of five multiple-choice questions and yes or no questions that were provided before the iFARM plant breeding activity. On the pre-test they were also asked the following perception questions: (1) Are you familiar with the concepts with plant breeding? (yes or no); (2) Do you have any previous experience with plant breeding? (if yes provide details); (3) I think learning about plant breeding will benefit my career objectives? (Strongly agree, agree, neutral, disagree, strongly disagree, and no opinion). Students spent 5 minutes on the pre-test, 30 minutes completing the worksheet, which contained several short answer questions based on previous experiences and learning (Table 2) and 10 minutes on the post-test. The post-test and pre-test consisted of five questions covering the same concepts formulated differently. The post-test also included the following perception questions and responses: (1) Do you believe that you have a better understanding of plant breeding after this module? (yes or no); (2) Did you find the directions easy to navigate? (yes or no); (3) Overall, did you find this activity useful in your learning? (yes or no and why); (4) I think learning about plant breeding will benefit my career objectives (Strongly agree, agree, neutral, disagree, strongly disagree, and no opinion)

All these exercises were graded and the answers were recorded in Microsoft Excel® to run statistics. Basic statistics and graphics were performed in Microsoft Excel® and t-test analysis was completed using GraphPad Prism version 5.00 for Mac OS X (GraphPad Software, San Diego California USA,www.graphpad.com.)

Results and Discussion

R1) What were the students' levels of pre course and post course knowledge regarding plant breeding subject content?

The pre-test and post-test had five questions covering plant breeding such as plant breeding general concept, cross pollination, backcrossing, crop desirable characteristics and plant reproduction systems. In both the pre-test and the post-test the minimum points obtained by the participants was zero, a maximum points obtained was six and median was four points. We observed a slight decrease in the students' scores from pre-test to post-test with the group averages of 4.06 (SD=0.899) to 3.43 (SD=1.579), respectively (Table 1). There was no statistical significance found after completing independent t tests of both the pre-test and post-test (Table 1). According to these results, we need to make modifications to our pre-test, post-test questions because post-test questions were more difficult following the module, because our expectations were higher.

Table 1. Independent T-Test of the Pre-test and Post-test (N = 131)

	Mean	SD	T-test	Sig. (2-tailed)
Plant Breeding Pre-test	4.06	0.89	50.32	.000
Plant Breeding Post-test	3.43	1.57	24.84	.000

Note. The pre-test and post-test scores were based upon a total of six points.

R2) What relationships existed between student's previous backgrounds enrolled in the courses and plant breeding competence (i.e., knowledge)?

Since we had a very diverse population with regard to plant breeding knowledge and experience, years in college and majors' careers, we wanted to classify the population and verify if the possible sub-groups and backgrounds could influence our results for this study. Based on our pre-test questions about familiarity with plant breeding, 43.8% of the students stated that they were familiar with plant breeding concept and 19.6% mentioned that they had previous experiences in plant breeding (Table 2). Another interesting fact for us to know was the students' interest in plant breeding relative to their potential careers, to understand the possible perception and attitude about this field of study. Therefore, we asked if they thought that learning about plant breeding would be beneficial for their career and 80.2% of the students strongly agreed and agreed that learning plant breeding would benefit their career (Table 3). Unfortunately, this question was not part of the assessments prior to the 2011 Spring semester. However, the responses from that class indicated to us that the majority of the students agreed that the plant breeding module could be beneficial to their professional goals. It supports how helpful a plant breeding module like ours could help students in their career development.

Table 2. Plant Breeding Opinion Question Responses Pre-Test (N = 133)

Question	Percentage
Are you familiar with the concepts of plant breeding?	
Yes	41.4
Somewhat	2.4
No	49.7
Do you have any experience with plant breeding?	
Yes	19.6
No	73.0

Table 3. Students' Response to Whether the Module will be Beneficial to their Potential Career (N = 76)

Scale	f	Percent
Strongly Agree	28	36.8
Agree	33	43.4
Neutral	10	13.2
Disagree	5	6.6
Strongly Disagree	0	0.0

Based upon student responses on the final evaluation, the majority of the participants found the plant breeding module to their liking (51.8%) with a mean of 2.17, liked much, and only 15.1% did not like the plant breeding module (Table 4). In general, the majority of the students understood the general concepts of plant breeding with 80.5% of the students responding that they believed they had a better understanding of plant breeding following the module (Table 5). Students also responded that they found the directions easy to navigate (84.2%) and the module useful to their learning (75.9%).

Table 4. Plant Breeding Final Evaluation Question (N = 133)

How well did you like the Plant Breeding Module?	Percentage
Liked Very Little	4.3
Liked Little	10.8
Neutral	31.7
Liked Much	28.1
Liked Very Much	23.7
Mean	**2.17**

Note. Score: 1 = Liked Very Much, 2 = Liked Much, 3 = Neutral, 4 = Liked Little, 5 = Liked Very Little

Table 5. Plant Breeding Opinion Question Responses Post-Test (N = 133)

Question	Percentage
Do you believe that you have a better understanding of plant breeding after this module?	
Yes	80.5
No	5.3
Did you find the directions easy to navigate?	
Yes	84.2
No	3.1
Overall, did you find this activity useful in your learning?	
Yes	75.9
No	9.8

R3) What were the students' perceived learning experiences using the plant breeding module?

Following the post-test, we wanted to obtain the opinion of the students about their experience with this instrument. Eighty-eight percent of the students felt that this module was useful based upon qualitative responses and had a positive comment to report, falling into one of three categories: learned about plant breeding, different form of learning/hands-on and easy to follow and understand (Table 6). While only 11.8% of the students said that they did not find the module useful either because it was too simplistic for the age group or because they were frustrated with the technology. Some of the reasons for the usefulness of the module that the students provided were the following: Student 1["Learned basics of plant breeding"], Student 2 ["the activity is different to the usual class exercise, the exercise makes it easy to remember"], and Student 3["the activity created a visual aid of the process of pollination"] (Table 6).

Overall, the students demonstrated an interest in understanding the plant breeding concepts and in its potential ability to help with a potential career. Regrettably, after the introduction of the module, the participants showed a lack of improvement in their test scores. On the other hand, most of the students indicated that the module helped them to understand the technical practices of plant breeding in the field.

Summary

In general, students reported that they could successfully navigate the module and categorized it as good to introduce knowledge on plant breeding. Although, the scores decreased slightly on the post-test students still felt that the module was valuable for

Table 6. Themes Regarding Students' Perceived Usefulness of the Plant Breeding Module

Theme	Frequency (N=101)	Example Quotations
Yes		
Learned about plant breeding	51.5% (n = 52)	(P1) "I learned some basics of plant breeding." (P2) "It taught me how plant breeding is done." (P3) "Learned basics of plant breeding." (P4) "Made me have a general idea of plant pollination, awesome." (P5) "I learned a lot more about breeding and the steps to do it." (P6) "Taught me the techniques used in plant breeding." (P7) "I now know the techniques different farmers use to pollinate crops." (P8) "The activity is different to the usual class exercise, the exercise makes it easy to remember."
Different form of learning (ex: Hands-on)	22.8% (n=23)	(P9) "Different type of learning." (P10) "It was hands on." (P11) "Because it was easy to follow and hands on." (P12) "It's about as hands-on as it can be for the season."
Easy to follow and understand	13.9% (n = 14)	(P13) "Step by step processes were helpful." (P14) "The video gave me a step by step walk through of the process (which was great)." (P15) "Was very informational and easy to follow and understand." (P16) "It was very simple to follow and understand." (P17) "It explained step by step how to cross plants."
No		
It was too simplistic for our age.	5.9% (n = 6)	(P18) "Very elementary." (P19) "It seemed not geared towards college students."
Frustrated with the technology	5.9% (n = 6)	(P20) "The inability to go back or stop the movie was frustrating." (P21) "You are unable to navigate video. It also plays voice if you exit and it is playing and you must exit iFarm to restart." (P22) "iFarm quit working so I couldn't even finish the worksheet, when I went back later it finally worked."

their future. Students at all schools could benefit from STEM education which could lend to more real-world experiences that enhance their basic abilities to develop or enhance their decision making and critical thinking skills. By developing a tool that brings this experience to the classroom, students potentially learn about plant breeding. This was observed on the significant tests based on the one-paired t-tests analysis. Plant science education needs to encompass online resources that are available to integrate real world situations as described within this paper. In this study, we had the opportunity to evaluate the impact of this module on college students as a method to inspire them to pursue a graduate school degree in plant breeding. Further work would involve visualizing the importance and need of professionals within the field of plant science. We would like to also modify and introduce this module to K-12 students as a method to introduce plant breeding careers as an alternative option for those student interested in science.

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