Agricultural Education in a Virtual World: Assessing a Web-based Multimedia Approach to Greenhouse Education

Emily Rhoades
The Ohio State University

Tracy Irani
University of Florida

Abstract

Although computers have been used in college classrooms for decades, recent advances in online computer technologies have fostered the capability to effectively utilize interactive multimedia in both traditional and non-traditional instructional settings. Where computer technology was formerly used as a primarily presentation or support medium, the advent of web based interactive learning environments that incorporate digital video, image databases, and realistic games/simulators has made possible new interactive learning environments that spur exploration and experimentation by students. Utilizing a competency-based pre/post-test approach, this study assessed the effectiveness of a multimedia-based learning environment utilized in a collaborative project involving five greenhouse agriscience courses. Results showed that this "virtual" approach to using multimedia to simulate students' experience of a real world greenhouse did aid in influencing competency development and added value to the content of courses using this learning environment.

Introduction/Theoretical Framework

Although computers have been used in college classrooms for decades, recent advances in online computer technologies have fostered the capability to effectively utilize interactive multimedia in both traditional and non-traditional instructional settings. Where computer technology was formerly used as a primarily presentation or support medium, the advent of web based interactive learning environments that incorporate digital video, image databases, and realistic games/simulators has made possible new interactive learning environments that spur exploration and experimentation by students (Firth, Jaftha, & Prince, 2004). With 56% of all 2-year and 4-year degree granting institutions in 2001 offering distance education courses, and another 12% reporting they would be adding them in the next three years (U.S. Department of Education, 2003) it is apparent that the trend toward technology based learning is continuing to grow. Roberts and Dyer (2005) reported that this trend is also taking place in departments of agricultural education, with over two-thirds of programs offering courses through distance education.

Students involved in technology based distance education courses report that they appreciate the convenience of online learning when they are place-bound due to responsibilities related to jobs, families, and communities (Kelsey, Linder, & Dooley, 2002). Similarly, on campus students have also discovered the value in the delivery of at least some, if not all, of their course material through online computer technology (Irani & Telg, 2002). Day, Raven, and

Newman (1998) discussed the benefits to students when Internet and computer technology is used in traditional classrooms. The researchers found that the combination of using the World Wide Web with a laboratory aided in achievement and was an effective teaching medium. Day and colleagues (1998) also concluded that the use of technology with traditional classroom teaching improved students' attitude toward the course topic of writing; however, they contended that more studies needed to be conducted in other disciplines.

Online multimedia technology has been shown to be successful when incorporated into on and off campus courses (Bielema, 1997). McGregor, Griffeth, Wheat, & Byrd (2005) reported that students found computer animation to be helpful in learning, by aiding in performance and motivating students to attend to the information more closely. It was also noted that the animation aided in understanding and recall of course information. Firth, Jaftha, and Prince (2004) noted that using computer tutorials as a teaching method was more effective in teaching concepts to students than a traditional lecture. Dunn, Thomas, Green, and Mick (2006) noted that multimedia applications in particular can have a positive affect on educating youth. In a study of high school health education, they noted that incorporating new innovative technology like multimedia applications improved knowledge and intent to change behaviors over the traditional lecture method.

Multimedia technology is unique in its ability to facilitate interactivity, essentially the engagement and interaction of the learner with technology. These capabilities have the potential to be effective tools in education, whether on campus or off campus (Savage & Vogel, 1996). This approach allows a new paradigm in handling and delivering information to students (Gozalez, Cranitch, & Jo, 2000). Multimedia has been noted for having three specific qualities which include: the use of multiple media in providing information; the ability for information access to be immediate and provide large amounts of information; and the interactivity which allows developers and users to create, manipulate, and access information (Savage, & Vogel, 1996). Savage and Vogel (1996) described an evolutionary process of multimedia educational applications in which, as individuals gain experience with these tools, new applications will be developed that take advantage of the strengths offered through computer technologies. This evolution makes it important for researchers and educators to continually monitor new techniques being utilized in academic settings. As technology and communication tools like multimedia grow, new applications will be introduced to on and off campus courses, making it necessary for continual monitoring of education technology.

Researchers have enlisted frameworks such as the social cognitive theory to better assess how technology is aiding in knowledge and behavioral change (Ho, 2002). Bandura's social cognitive theory stems from his social learning theory which describes that an individual's understanding comes from modeling attitudes, behaviors, and reactions of others when engaging in activities (Bandura, 1971) such as interaction online. Bandura indicates that through the interaction with ones' environment learning can take place. This theory is utilized in media research as it postulates that there is a casual relationship between media and the behavior demonstrated and the followed learning (Baran & Davis, 2003). Banudra (2001) describes that communication systems operate through two methods. Directly, it promotes change by enabling, motivating, informing, and guiding individuals. Socially, the media influences connect with social networks that help to influence change. This can be seen in the classroom when students work with multimedia. They can either experience it on their own which can lead to behavioral change, or they can experience the media on their own and then through classroom discussions on the experience will face behavior change.

The theory states that personal determinants, behavioral determinants, and environmental determinants all come into play (Bandura, 2001). Personal factors include cognitive events such as those found in a classroom setting; while the student's behavioral pattern could include their current usage of the technology or media being used. With 79% of college students reporting using the internet to enhance their college academic experience (Jones & Madden, 2002) it can be assumed students enrolled in college courses already have an established behavioral pattern online. The part that is changing in this dynamic is the environmental determinant or the environment in which the learning is taking place.

One way in which to measure student outcomes with respect to technology like multimedia is through competency models (Dooley, & Linder, 2002). Competencies, according to Buford and Lindner (2002), are a group of related knowledge, skills, and abilities that affect a key part of an activity. Competency models are described by Rothwell and Linholm (1999) as a narrative description of specific competencies for a job or occupation that describes the key characteristics used in identifying top performers of those skills. Such competency models have been noted to be successfully used as an assessment tool, a career development tool, or as a behavioral benchmarking tool (Dooley, Linder, Dooley, & Algeera, 2004; Dooley & Lindner, 2002; Yeung, Woolcock, & Sullivan, 1996). Within agricultural education, competencies have been utilized to a large extent as a tool designed to measure acquisition and application of knowledge in the form of skills among students, teachers, producers and practitioners (Moore & Rudd, 2005). Moore & Rudd advocate taking a systems approach to competency development based on steps or stages. Stone (1997) proposed a five stage approach that included identifying potential competency areas, followed by identification of target audiences, collection of competency data, building of models and communicating the verified competencies to external audiences.

Competency modeling has both a theoretical base and a practical application. Theoretically, competency models are developed and tested in an attempt to link together relevant skill attributes and inform the learning process (Stone, 1997). Educators have utilized competency models as way to link educational curriculum and workplace skills which are needed by students (Rothwell & Linholm, 1999). Researchers in agricultural and science education have called for more integration of these competency models when using distance education and technology rich education, such as multimedia (Dooley, et al., 2005). Dooley and colleagues (2004) have also noted that evidence of learned competencies can be provided through self-assessments. These assessments not only help identification of growth at the end of a course, but can provide learners with an understanding of their prior competencies in an area before a course starts (Dooley, et al., 2005). Within agri-science education, greenhouse management and operations lends itself to the competency based approach. In greenhouse education, much foundational work has been done on competency approaches that have been utilized to develop curriculum to insure that students get experience in the technical and commercial aspects of running a greenhouse (Gowdy, 1990; Wells, J.A., et al, 1990; and Lamberth, 1983). Limited research exists, however, as to the ability to extend competence approaches delivered in the live classroom setting to an online interactive multimedia environment where course objects can be shared by a variety of instructors and a wider range of students can be reached.

Purpose(s)/Objective(s)

At least 84 courses covering some aspect of greenhouse agri-science are taught at land grant institutions across the U.S., and the majority of those courses are taught in colleges of agriculture or engineering. Greenhouse education is highly visual in nature and focuses on understanding how plants grow and develop under a variety of conditions. Traditionally, this is done through hands-on application in the field and in greenhouses, which can be expensive to maintain. As such, collaborators on a multi-institutional project determined it to be an area well suited to multimedia based instruction in which visual image databases could be created and simulation of the greenhouse environment utilized by students to replicate the conditions in an actual greenhouse environment (Tignor et al., 2004). But what effect could such a "virtual" multimedia environment have on student competencies? Most studies that have looked at the effect of computer technology on student learning outcomes have focused on limited application tools like presentation software, animation and video; limited evidence existed as to how virtual simulation based technologies might influence agriscience students' learned competency development.

For this study, collaborators at five land grant universities across the U.S. utilized a multimedia interactive approach when developing an online learning environment to be used in a greenhouse science course taught at each institution in 2005-6. Over three hours of individual video-based modules on nine topics covering everything from computers, structure, plant life cycle, to labor were filmed in Arizona, Vermont, Ohio, and Florida were developed. The videos as well as a searchable digital repository of materials and images for educational use were integrated into a specially designed online learning environment. Also included was a simulated greenhouse environment created in Macromedia Flash. The simulator modeled greenhouse environments based on climate data from each of the four locations shown in the videos. Students in the courses utilized the virtual simulator as part of the instructional material, practicing and completing assignments much as they would in a "real" greenhouse. Videos and other materials from the digital repository were integrated in various ways within individual courses.

Based on the above, the purpose of this study was to understand how effective a multimedia approach to greenhouse agriscience might be with respect to student competency development, as well as course perceptions and satisfaction. The following research objectives guided this study:

1. To describe the students enrolled in the courses utilizing the greenhouse multimedia materials in terms of demographics and their course expectations.
2. To describe pre/post change in a set of student competencies related to course concepts and

verified via authentic verification narratives.
3. To describe students' perceptions and satisfaction with course content and delivery methods.

Methodology

The research design for this study was ex post facto in nature, using a pretest/posttest design. Courses utilizing the materials developed through the greenhouse education initiative were assessed through an online inventory utilizing the competency based approach developed by Dooley and Lindner (2002). Instructors collaborated on development and utilization of the multimedia based learning environment in their courses, and also directed students in their courses to fill out the pre and post instrumentation online.

Derived from the competency-based behaviorally anchored instrument developed by Dooley and Linder (2002), the 23 item instrument used in this study assessed student gain through authentic verification measures in 10 investigator-developed competencies (Figure 1). Dooley and Linder (2002) described this competency model as an effective benchmarking tool to evaluate student proficiency and growth. Those competencies included: greenhouse structures and glazing materials, greenhouse environment impacts on plant growth and development, IPM, BMPs/environmental impact of greenhouse production, plant life cycles, root substrates, plant nutrition, irrigation, packing and post harvest operations, regional/national/international industry differences. Students were prompted with a behavioral anchor, asked to rank themselves between novice and expert, and then asked to verify their response through a qualitative narrative. Pre and post test versions of the instrument also included course expectancies, evaluation of the course materials, and demographics. Face and content validity was established through an expert panel of university faculty. A Cronbach's Alpha reliability of .84 was calculated for the pre-test and .78 for the post test instrument.

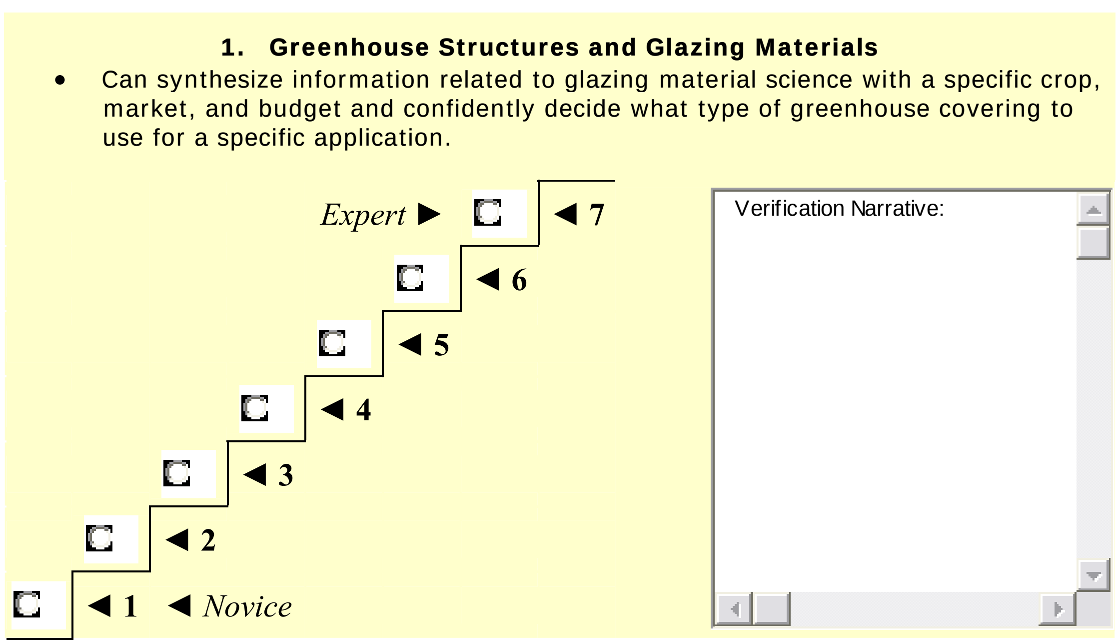

Fig.1. *Example of greenhouse structures and glazing materials core competency self-assessment.*

Course instructors were contacted before their courses started and given directions to implement the pre-test portion of the online instrument with their students. For the post test, researchers prompted instructors to facilitate their students' completion of the same assessment during the final week of their course, as well as provide an answer to the open ended question, "where did your growth occur." Students' pre and post test answers were matched based on an arbitrary identification number that students reported on both instruments. To assess course effect, means for students in each course were first calculated and visually inspected for outliers, then averaged. Correlational statistics were run between course and the main variables studied and no relationships were found. Narratives were also examined based on course to look for any trends that were not course specific. No course specific trends were analyzed.

Results

The greenhouse multimedia learning environment was utilized in five introductory level courses at the University of Vermont, University of Arizona, and The Ohio State University during fall 2005 and spring 2006. Courses included "Introduction to Hydroponics," "Physiology of Plant Production Under Controlled Environments," "Greenhouse Crop Production," and "Greenhouse Operations and Management." Instructors indicated that all 10 competencies were addressed in their courses, and they worked together to insure that competency based material was utilized similarly.

Objective 1: To describe the students enrolled in the courses utilizing the greenhouse multimedia materials in terms of demographics and course expectations.

A total of 51 students were enrolled in the courses utilized for the study. The majority of student respondents were male (68%, n=35), and were undergraduate students (73.5%, n=36). A total of 20.4% (n=10) reported being a master's student and 6.1% (n=3) were working on a doctorate while taking the course. Students participating were in majors ranging from plant and soil science to business and agriculture education.

Students were asked to indicate the reasons they were enrolled in the course. Responses ranged from "I am writing a thesis on aquaponics and it environmental and economic potential" to "To Learn how to maximize plant growth in a commercial setting" to "It fulfills a major requirement."

Respondents were in agreement that they expected to interact with students at the beginning of the course (98.0%, n=50). The majority (29.4%, n=15) felt at the onset of the course that they would spend 3-4 hours on the course each week, while 25.5% (n=13) felt they would spend only 2-3 hours each week on the course. Students were also asked to rank their overall computer skill on a one to five scale (1= very poor to 5= excellent). A mean of 3.51 (SD=. 97) was calculated indicating a medium skill level in computer usage.

Objective 2: To describe pre/post change in a set of student competencies related to course concepts and verified via authentic verification narratives

Results indicated significant growth from pre to post test in all competency areas (Table 1). Students' reported pre-course competencies averaged from 2.09 to 3.43 on a seven-point scale, while post-course competencies averaged from 4.38 to 5.15 in the 10 areas.

Table 1
Competency Knowledge Growth Based on Pre and Post-Test Means

Competency	Pre-test Mean	Post-test Mean	t	Sig.
Greenhouse Structure and glazing materials	2.09	4.66	9.07	.000
Greenhouse Environmental impact on Plant Growth and Development	2.40	5.03	11.62	.000
IPM	2.53	4.38	7.36	.000
BMP/Environmental Impact of Greenhouse Production	2.77	4.44	6.32	.000
Plant Life Cycle	3.06	5.15	8.31	.000
Root Substrates	3.43	4.88	6.71	.000
Plant Nutrition	3.03	5.06	9.56	.000
Irrigation	2.97	4.94	9.86	.000
Packing and Post Harvest Operation	2.09	4.41	9.62	.000
Regional/National/International Industry Differences	2.20	4.06	7.33	.000

Verification narratives recorded during the pre-test included statements such as:

- "I have very little experience working with plants in the greenhouse."
- "I don't know very much about greenhouse production yet, but I do have some experience in dealing with structures and the economics of them."
- "While I have seen others do it and am learning more about it as time goes on, I still don't know what the heck I'm doing."
- "I already have done this on the family farm as it relates to production ag."
- "Again, I know more about corn, soybeans and wheat than with greenhouse crops."

Verification narratives recorded during the post-test included statements such as:

- "I came in with nothing so I feel I learned a lot. This course was more challenging than I expected and was a good base of knowledge."
- "I have now gained the skills necessary to calculate what the heating and cooling requirements will be for an array of materials."
- "I feel I could develop a BMP fairly well to fit with my greenhouse needs."
- "This is one of the most important aspects in commercial greenhouse production. Special care must be taken, and it is crop specific. I would be able to do this for sure."
- "I would know how to use irrigation for dry down but could not use it to its max potential."

Students were asked on the post-test to describe where their growth in knowledge occurred during the course. Students' responses included statements such as:

- "I feel my growth in knowledge occurred mostly the areas of light, temperature and heating controls within the greenhouse. Understanding the importance and knowing how much to use is what I have gotten better."
- "The exercises in the modules really helped me apply the information learned in class and online lectures to real situations. The lab also was a good hands-on experience with different aspects of greenhouse management."
- "Mostly with hands on stuff in labs, I learned the most when it was an active in-class class, learning from slides on the internet just doesn't do it for me, the better labs were also with the instructor who had a lot of experience and went far into depth."

Note: Students' comments re labs in post test verifications are referring to virtual multimedia greenhouse environment.

Objective 3: To describe students' perceptions and satisfactions with course content and delivery methods.

Students were asked to indicate on a scale of one to five (1= strongly disagree to 5= strongly disagree) their attitudes toward the content in the course. Students mostly agreed that the content was stimulating (M=4.45, SD =.54), was useful (M=4.51, SD =.70), and related to future professional work (M=4.26, SD =.94). They agreed that they would recommend this course to others (M=4.47, SD = .83). Respondents were more neutral in their feelings of looking forward to each lesson (M=3.88, SD =1.07). (See Table 2.)

Table 2
*Students' Agreement/Disagreement with the Benefits of the Course and Its Content.**

	n	M	S.D.
The content in the course was useful	51	4.51	.70
The content in the course was stimulating	51	4.45	.54
I would recommend this course to others	51	4.47	.83
The content presented in the course relates to my future professional work	51	4.26	.94
I will use what I learned in the course in my job	50	4.20	1.10
I looked forward to beginning each lesson	51	3.88	1.07

*Scores based on a 1-5 scale (1= strongly disagree to 5= strongly agree).

The majority of students (94%, n=47) were very satisfied to satisfied with the content in the course. They also were very satisfied to satisfied with the delivery methods used in the course (70%, n=35). A majority of students (86%, n=43) reported reviewing the course materials online more than once during the semester/quarter they were enrolled.

Conclusions/Recommendations

Findings indicated that enrollment in the courses utilizing the multimedia learning environment was slightly male dominated and represented mostly undergraduate students in a variety of majors. Students' reasoning for participating in the course ranged from requirements to personal interest, a finding that could be expected for many courses across college campuses. Students studied reported having average levels of computer skills. With respect to the multimedia aspects of the learning environment under study, an implication of this finding is that greater skill levels may lead to higher growth in competencies and success in using the multimedia materials.

Based on this study, it appears that the multimedia greenhouse science materials utilized in the courses studied did aid in influencing the level of competencies gained by students. Although students started the courses lower in most of the competency areas, the post test competency means increased significantly after exposure to the course materials in each of the 10 instructor identified areas. Further, text based verification narratives based on standardized behavioral anchors included in each competency assessment supported these findings in terms of recognition of competencies gained as a result of taking the course.

Overall, students were satisfied with the course content and delivery methods. The majority reported utilizing the variety of materials in the course including the online multimedia materials, verifying consistency of exposure to the multimedia components. Similar to the findings of Day, Raven, and Newman (1998), students reported positive attitudes toward the course content and its usefulness to their future professions.

While this study is limited in analysis of other extraneous variables that could have aided in the competency increase and positive attitude toward the course delivery, the researchers believe that since students did indicated usage of the materials during their course experience, it thus had some influence. Further research must be conducted to determine how much that influence was. This study is also limited with a small population. Due to the small number of students enrolled in these courses and the course affect itself; further data analysis was not completed.

As reported by Dunn, Thomas, Green, and Mick (2006), these results provide support for the value and effectiveness of using multimedia materials to teach greenhouse concepts in a virtual environment that can be readily accessed by students no matter where they may be. Future courses should continue to incorporate new teaching technology to engage students with the materials.

Findings of this study are specific to these materials and the specific course in which they were used and are not further generalizable. Further studies should be conducted utilizing interactive multimedia and simulations of real life agricultural environments in a variety of disciplines to determine the true effectiveness of multimedia approaches in the context of agricultural education. Extraneous variables such as other instructional methods involved in the course, human-technological aspects, and technology comfort levels should be addressed in future studies looking at similar multimedia-rich courses. Future research should continue to evaluate the effectiveness of not only multimedia but also other computer and communication technologies in the agricultural classroom. While the competency based approach utilized in this study proved to be an effective method in evaluating course materials, further research should continue to test this instrumentation. The technologies utilized in study are continually being added to and future research needs to be conducted to further assess these technologies as they are utilized. Studies should also compare courses using these technologies with courses using more traditional approaches to hands on agriscience instruction. Instructor perceptions of multimedia learning environments should also be evaluated.

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