Notes

Multi-institutional Cooperation to Develop Digital Media for Interactive Greenhouse Education

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Russell (1999) compiled a large bibliography of research demonstrating that there is not a significant difference between standard and distance education learning. Yet rapid advances in the use of technology for the discipline of horticulture have been shown to improve student learning outcomes, increase student enrollment, and foster better teachers (Mason, 2005). As society moves more toward worldwide web-based education or distant learning, plant scientists are using more creative lecture delivery methods.

For example, Wilson and Danielson (2005) created an interactive virtual plant identification and use instrument for a native landscaping course, in which students can walk virtually through a botanical garden and self-select plants to learn more about. Similarly, Wilson and Thetford (2003) animated the complete life cycle of an angiosperm for a web-based plant propagation course. Both of these projects were course-specific, but their applications are widespread. There are nearly 30,000 acres of horticultural crops produced under protected environments in the United States (U.S. Dept. of Agriculture, 2002). More than 84 greenhouse-related courses are offered by instructors at land-grant institutions to teach greenhouse production and management concepts (Tignor et al., 2005). Nationwide, greenhouse industries are significantly diverse in terms of climate, systems, and crops, creating both educational challenges and opportunities to provide learning materials that share common conceptual issues of controlled plant environments (energy conservation, environmental safety, labor efficiency, plant response manipulation). Guzmán et al. (2005) developed a virtual laboratory for teaching greenhouse climatic control in which users have access to a full greenhouse climate model with specific control options. Faust (2005) developed greenhouse crop simulation software that allows the user to grow several crops online with different growing techniques, environments, and plant growth regulators. Evans et al. (2006) developed 15 virtual field trips that demonstrate various technologies and management strategies used in greenhouse management and controlled environment agriculture. Although these educational advancements are innovative and useful, their applications can be limited by crop specificity, complexity, or electronic accessibility and were not designed to consider geographic distinctions within the simulation model. The overall objective of this project was to develop a web-based multimedia instrument for greenhouse education to facilitate student learning and comprehension of greenhouse production and environmental control among diverse geographies, climates, and business practices. Specific objectives were to 1) produce greenhouse videos in Arizona, Vermont, Ohio, and Florida that emphasize state-specific

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
0.4536	lb	kg	2.2046
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

production, environmental control, labor, and marketing issues; 2) develop an interactive greenhouse environment simulator that allows users to model greenhouse environments based on climate data from each of the four video locations; 3) implement a searchable digital repository containing hundreds of useful greenhouse images, videos, and lectures; and 4) develop a web-based method for instructors to evaluate perceived student learning of greenhouse concepts.

Greenhouse DVD

In an effort to demonstrate varying greenhouse production practices among states, a video producer was contracted and sent to Vermont, Arizona, Ohio, and Florida for filming. All videos were recorded using a digital Sony PD-150 (Sony Corp., Tokyo) with similar subject content, shooting style, and interview length. Two to 3 h of original video at each location were edited using a Sony D-1000 deck and fire-wired into a G3 Mac computer using Final Cut Pro software (Apple Computer, Cupertino, Calif.). Videos from each location were organized by topic into 55 smaller 1- to 8-min segments, including introduction to the state industry, introduction to a specific business, greenhouse structure, sample crop cycle, crop nutrition, pest control practices, and computer use. These clips were created to be "standalone" and can be viewed on their own or compared and contrasted with each other. A DVD menu was designed to facilitate instructor and student access and use. Also, each video was transcribed so that the text can be viewed and printed. The DVD was engineered for a standalone player connected to a television or use in a computer. The video clips were also placed on a streaming server and archived in a digital repository, thus increasing user accessibility.

Greenhouse environment simulator ('a plant's day in the life of a greenhouse')

An interactive greenhouse environment simulator was developed by integrating mathematical models created for this application and an animation interface (Flash MX Pro 2004; Macromedia, San Francisco) for demonstrating environmental control principles with emphasis on cooling, heating, ventilation, and glazing materials. The greenhouse mathematical model, based on energy balance of the greenhouse component systems, is a set of differential equations that are solved numerically using the fourth-order Runge-Kutta (RK4) method (Chapra and Canale, 2002). The model was programmed using ActionScript 2.0 (Adobe Systems, San Jose, Calif.) and tied to the climate data from each location and the Flash graphic interface. The solution provides the dynamic response of the greenhouse moist air properties to outside climate conditions for a particular greenhouse design. A user can complete a range of simulations from a simple nonventilated greenhouse with no environmental control, demonstrating the true "greenhouse effect" to a greenhouse with ventilation, shadecloth, heating, and cooling set points. Multiple user-selected control options combine to provide a comparison of more than 32,000 possible design scenarios. Option selections include: geographic location (Arizona, Ohio, Florida, or Vermont), season (winter, spring, summer, or fall), structure type (A-frame, arch, or Quonset), glazing (glass, polyethylene, or polycarbonate with single layer or double layer), ventilation (absent, natural, or forced at half or full capacity with the vented option), cooling (absent and wet pads at half or full capacity), heating (absent, half capacity, or full capacity), plant biomass/evapotranspiration (absent, small, or large), and set points for air temperature [no control or temperature set points (day 24 °C, night 18 °C)]. After each design is created by the user, an internal environmental response is simulated by providing realistic graphics of a visual image of solar radiation, air temperature, and air humidity changes within the greenhouse in response to a 1-d cycle of external climate conditions (Fig. 1).

Digital repository

A web-based, searchable repository site was developed within DSpace (Massachusetts Institute of Technology and Hewlett-Packard Co., 2002) to house original greenhouse-related lectures, videos, and images from all over the world. Our DSpace site currently has 774 high-resolution greenhouse images

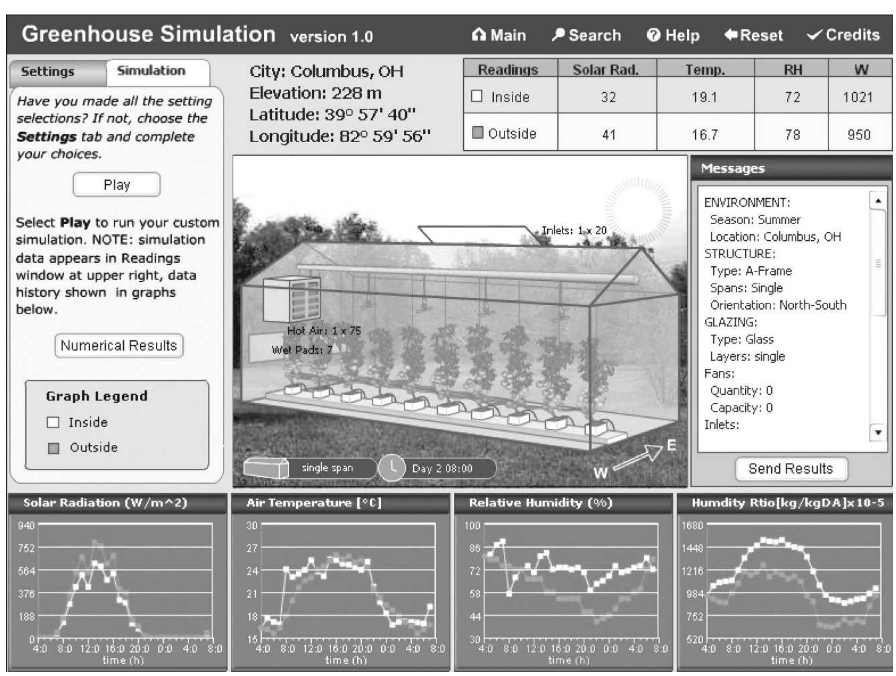

Fig. 1. Screen capture of a greenhouse simulation [with solar radiation (Solar Rad.), temperature (Temp.), and relative humidity (RH) outputs] after environment, structure, glazing, ventilation, and cooling options were selected (Tignor, 2005); W = watts, W/m² = W·m⁻², Rtio = ratio, kg/kgDA = kg·kg⁻¹ dry air, 1 m = 3.2808 ft (1.8 × °C) + 32 = °F, 1 m² = 10.7639 ft², 1 kg = 2.2046 lb.