

# Teaching Methods

## An Online Study Tool for Reviewing Plant Propagation Terms and Concepts

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**ADDITIONAL INDEX WORDS.** distance education, active learning, web technology, seed propagation, vegetative propagation, micropropagation

**SUMMARY.** Interactive web-based questions were developed for students to review subject matter learned in an online plant propagation course. Articulate Storyline software was used to build nearly 250 review questions with five different testing styles to ascertain proficiency in subject areas, including the biology of propagation, the propagation environment, seed propagation, vegetative propagation, micropropagation, and cell culture. Questions were arranged to correspond to the supporting textbook chapters in *Hartmann and Kester's Plant propagation: Principles and practices*, ninth edition. These are open access and available to instructors and students worldwide. Users received immediate feedback for each question answered correctly or incorrectly. The system remembers where one leaves off, which enables starting and stopping multiple times within a chapter. Means of pre- and posttest responses to nine content knowledge items showed that students perceived a significant content knowledge gain in the course. These online interactive reviews can be adapted easily to other courses in a variety of fields, including horticulture, botany, systematics, and biology. They can also be expanded to overlay multiple objects and trigger events based on user response. Since inception, the website hosting these online reviews averaged 156 unique visitors per month. Students have reported this to be a useful tool to prepare them for course exams.

Distance education enrollments have increased for the 14th straight year. Currently, 31.6%

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of all higher education students are taking at least one distance education course (Seaman et al., 2018). With 42% of faculty reportedly teaching a fully online course for credit (Jaschik and Lederman, 2017), distance education was found comparable or even superior to traditional classroom teaching (Driscoll et al., 2012; Means et al., 2010).

Many instructors struggle with keeping students engaged, motivated, and challenged in an online classroom (Bigatel and Edel-Malizia, 2018). Although learning outcomes can be equivalent among traditional in-class vs. hybrid distance education courses, greater student satisfaction is still often correlated with live instruction (Hoch

and Dougher, 2011; Rieger et al., 2011). When asked to compare the efficacy of online vs. in-person courses on a range of objectives, an overwhelming majority of professors (86%) said they believed online courses were less effective for interacting with students (Jaschik and Lederman, 2017).

With the rapid advances in distance education technologies, new approaches are continually sought to facilitate learning in an online environment. Online innovations not only serve to reinforce important subject knowledge but help meet a critical need when shifting from traditional, entirely synchronous instruction (hands-on live learning) to a hybrid or fully online approach with asynchronous components. Increasingly, technology offers opportunities to create powerful learning tools, regardless of the learning platform (Pitler et al., 2012). More and more, instructors who are teaching in person are also using courseware learning management platforms such as Blackboard Learn (Blackboard, Washington, DC) and Canvas (Instructure, Salt Lake City, UT) to deliver content resulting in a flipped classroom approach (Heyborne and Perrett, 2016).

A majority of students (72%) feel their grades would improve if faculty used more technology in the classroom (Seaman et al., 2018). Likewise, instructors report the adequacy and availability of multimedia tools were limiting (Wright et al., 2010). Effective online formats use a variety of instructional strategies to enhance interactive learning, ensure critical thinking, and provide immediate feedback (Campbell et al., 2011; Schroeder-Moreno, 2010; Tignor et al., 2007; Wilson and Flory, 2012; Wilson and Thetford, 2003).

Described as “the purposeful act of reproducing plants,” plant propagation has been practiced for at least 12,500 years and is considered a fundamental occupation of humankind (Davies et al., 2018). To meet the 70% increased demand in food production that will occur by the year 2050, it is crucial that we develop students who can think critically and have access to the latest propagation and production technologies that they can then adapt to local situations. Video making, dynamic electronic presentations, interactive learning, and other teaching methods in plant propagation available universally in

Table 1. Subject content within 18 chapters of a plant propagation textbook (Davies et al., 2018). Storyline software (Articulate Global, New York, NY) was used to create online self-reviews that can be found on the course website (University of Florida, 2018). Mixed style questions were multiple choice, true or false, matching, and proper sequence.

Module	Chapter	Subject	Articulate online interactions
General aspects of propagation	1	How plant propagation evolved in human society	Seven mixed style questions and corresponding images review the history of agriculture and the plant propagation industry in North America.
	2	Biology of plant propagation	Fifteen mixed style questions and corresponding images review propagation biology concepts such as the life cycles of different kinds of plants, mitosis, plant hormones and their effects, and cell types and structures.
Seed propagation	3	The propagation environment	Eighteen mixed style questions and corresponding images review the propagation environment, including greenhouse types, environmental controls, container types, and management practices.
	4	Seed development	Nine mixed style questions and pictures review topics pertaining to seed development such as the basics of seed production, propagation and fertilization, and the various fruit types.
	5	Principles and practices of seed selection	Fifteen mixed style questions and pictures review topics of breeding systems, pollination, and seed certification.
	6	Techniques of seed production and handling	Fourteen mixed style questions and pictures review topics pertaining to seed quality, conditioning, and storage.
	7	Principles of propagation from seeds	Nineteen mixed style questions review methods for measuring germination and types of seed dormancy.
	8	Techniques of propagation by seed	Sixteen mixed style questions review the procedures for seedling production in the field and in protected culture. Scarification and stratification practices are reviewed.
	9	Principles and practices of clonal selection	Sixteen mixed style questions review the causes and patterns of variation within clones.
	10	Principles of propagation by cuttings	Thirteen mixed style questions review the factors involved in adventitious root and shoot formation, including phytohormone interactions.
	11	Techniques of propagation by cuttings	Twenty-four mixed style questions review eight different types of cuttings and their management.
	12	Principles of grafting and budding	Four mixed style questions review the correct sequence for graft union formation.
	13	Techniques of grafting	Four mixed style questions review the different types of grafting and management practices.
	14	Techniques of budding	Seventeen mixed style questions review the different types of budding and management practices.
	15	Layering and its natural modifications	Thirteen mixed style questions review the different types of layering and their management.
	16	Propagation by specialized stems and roots	Fourteen mixed style questions review propagation systems for seven types of geophytes and their growth patterns.
	17	Principles and techniques of micropropagation	Twelve mixed style questions and images review the topic of micropropagation, including various techniques, processes, and terminology. The stages of micropropagation are reviewed through multiple-choice exercises. Propagation terminology is reviewed through drag-and-drop exercises.
	18	Principles and techniques of plant tissue culture	Nineteen mixed style questions and images review the topic of tissue culture from nonmeristematic tissue of adventitious origin. Regeneration methods and techniques for callus, somatic embryos, seedlings, and adventitious shoots are reviewed.

both the developing and developed world are critical in overcoming learning barriers.

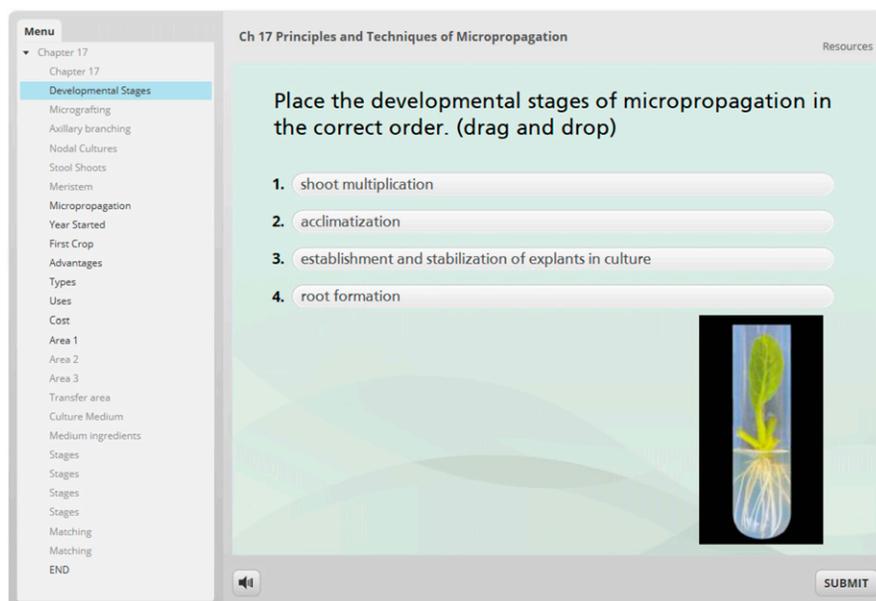
The purpose of this project was to 1) develop interactive, online quizzes for students to self-evaluate their understanding of concepts and terms introduced in an online plant propagation course, 2) make this available universally as a resource for all instructors and students, and 3) evaluate students' perceived content knowledge gain from using this teaching tool.

Quiz questions were generated from subject content found in the universal textbook used by most institutions, *Hartmann and Kester's plant propagation: Principles and practices* (Davies et al., 2018). This textbook is now in its ninth edition, with more 100,000 copies in print in several languages. The ninth edition consists of 18 chapters as described in Table 1 (Davies et al., 2018).

Storyline 3 software (Articulate Global, New York, NY) was chosen to build interactive review questions for each of the 18 chapters (Table 1) (Davies et al., 2018). Four different response styles were used, including multiple choice, true/false, proper sequence, and matching. Attractive features of the software are that it is readily available, easy to use, allows for multidevice interactive e-learning, and provides an intuitive user-friendly interphase. Video and audio can be incorporated easily into later versions.

A new open-access website page was created to host these Storyline interactions (University of Florida, 2018). Corresponding images from the chapters were included to enhance the overall visual appeal when appropriate. Users can drag and drop the correct term that matches a description and receive immediate feedback for each question answered correctly or incorrectly (Fig. 1). After all questions are answered, a final grade percentage appears on the screen. By selecting from a database of nearly 250 questions specific to the art and science of plant propagation, users can practice their propagation knowledge virtually anywhere and at any time.

All Storyline interactive online quizzes were made available at the course website (University of Florida, 2018) and assigned weekly through the course management system, along with the corresponding reading assignments. A pre- and posttest assessment



**Fig. 1.** Screenshot of an example self-review quiz question built using Storyline 3 software (Articulate Global, New York, NY). The student is asked to drag and drop the stages of micropropagation in proper order (University of Florida, 2018). After the SUBMIT button is clicked, the question is graded for immediate feedback. The menu to the left outlines all the questions associated with this chapter for a quick reference.

**Table 2.** Students' perceived pre- and posttest content knowledge means, difference, and significance ( $n = 19$ ) in a plant propagation course that used interactive online self-review quizzes. Knowledge items used a Likert scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree); means were compared using a matched  $t$  test.

Knowledge item	Premean	Postmean	Difference	$t$ test	Significance
Genes	3.28	4.11	0.83	0.27	0.012
Sexual vs. asexual propagation	4.06	4.50	0.44	0.03	0.190
Plant life cycles	3.56	4.33	0.78	0.04	0.009
Seed development and germination	3.44	4.33	0.89	0.23	0.001
Plant hormones	3.17	4.44	1.28	0.09	0.002
Adventitious roots	2.78	4.24	1.46	0.18	<0.0001
Grafting and budding	2.72	4.50	1.78	0.42	<0.0001
Plant clone variation	2.28	3.78	1.50	0.15	<0.0001
Micropropagation	2.65	4.50	1.85	0.45	<0.0001

instrument was developed that included nine knowledge items designed to assess perceived knowledge change/gain in plant propagation concepts. The resulting questionnaire was administered via the web course management system ( $n = 19$ ). Items used a Likert-type scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). Means were calculated for both pre- and posttest responses to nine content knowledge items and then compared using a matched pairs  $t$  test at  $P = 0.05$  using JMP Pro (version 14.1.0; SAS Institute, Cary, NC).

Results showed that on every level, except in their ability to differentiate between sexual and asexual propagation, students perceived a significant content knowledge gain from this course (Table 2). The greatest gain in perceived content knowledge was in micropropagation followed by grafting and budding. Verbal feedback from students who have used this tool has been positive. During the end-of-semester discussion session between the instructor and students, one student commented, "The online interactions were a fun way for me to test my knowledge of plant propagation

before and after the course, and help me review for the final exam.”

For instructors, additional test bank resources are available from the publisher (Pearson Education, New York, NY). Authors have created 422 test questions with answers that may be useful for creating exams. PowerPoint slides for each of the 679 figures in the textbook are also available. To register for an instructor access code, visit the Pearson website (Pearson Education, Inc., 2018).

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