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ABSTRACT

Technology is helping undergraduate biology instructors re-define their pedagogical “toolboxes” for the 21st century classroom. Indeed, new multimedia learning tools are evolving to fill the niche to assist student transition from simple inquiry-based learning (textbooks, less student responsibility) to professional science practice (research, more student responsibility). Moreover, these tools are creating interactive classrooms, empowering instructors to be facilitators of learning, and helping to excite the next generation of researchers and good citizens. This article will review what is meant by multimedia learning and multimedia instruction; present one example of a new type of multimedia learning tool, “research module,” that is being used in American high school and undergraduate classrooms; describe research-based parameters to follow when creating a research-based pedagogical activity; and highlight evidentiary support for the benefits and success of these multimedia modules.

Keywords: Environmental Education, Inquiry, Inquiry-Based, Learning Outcomes, Multimedia Design, Multimedia Instruction, Multimedia Learning, On-Line Curriculum, Simulations

INTRODUCTION

Multimedia Learning and Multimedia Instruction

As textbook-only coursework has declined in appreciation among educators and their students, a wide variety of technologies are helping undergraduate biology instructors redefine their “pedagogical toolboxes” for the 21st Century Classroom. These multimedia learning tools are evolving and, through their evolution, are allowing instructors to re-imagine possibilities for teaching in innovative and exciting ways. Moreover, these technologies are making classrooms interactive and empowering instructors to be facilitators of learning, and helping them to excite the next generation of researchers and good citizens. To assist science educators in harnessing the best interactive methods this article begins by reviewing some basic pedagogical terms, including multimedia learning and multimedia instruction.
One of the most influential researchers in the area of multimedia learning, Richard E. Mayer and his associates at the University of California, Santa Barbara, have conducted research for years aimed at pinpointing research-based principles for the design of multimedia methods and materials. As a result, Mayer and Moreno (2005) have proposed a “Cognitive Theory of Multimedia Learning” to explain how the mind works in multimedia learning.

According to Mayer, *multimedia learning* takes place when students build mental representations from exposure to words and pictures. Thus, *multimedia instruction* is the presentation of words and pictures that are intended to foster learning. However, beyond this simple union of words and graphics lie two contrasting views of multimedia learning: *multimedia learning as information acquisition* and *multimedia learning as knowledge construction*. Only one of these views, however, provides a solid foundation for creating effective instructional multimedia design.

Basically, if one views multimedia learning as information acquisition, then multimedia is merely an *information delivery system* (analogous to a parcel delivery person). According to this viewpoint, learning is a series of deposits to a student’s memory bank. This view entails assumptions such as: learning is based on information; the student’s “job” is to receive information and, therefore, he or she is a passive recipient of information and stores it in his or her memory. The role as the teacher is merely to present information using the media. By contrast, if one views multimedia learning as knowledge construction, then multimedia is a *cognitive aid*. According to this view, multimedia learning is a sense-making activity in which the learner seeks to build a coherent mental representation from the presented material. Unlike information, which is an objective commodity that can be transferred from one mind to another, knowledge is personally constructed by the learner and cannot be transferred exactly from one mind to another. This view assumes that the student’s role is to make sense of the presented material, actively organizing and integrating the material into a coherent mental representation. In this view, the teacher’s role is to assist the student in the sense-making process. As Mayer himself puts it, the teacher becomes “an aid to knowledge construction.”

Mayer’s knowledge construction perspective is most plausible, because it is more aligned with established research on how people learn (Bradsford et al., 1999). Indeed, constructivist learning theory holds that “learning consists less in recording information than in interpreting it. To interpret what is received and is attended to, the learner must personally construct meaning for it” (Wubbels & Girgus, 1997).

**Module Creation**

**Research-Based Parameters**

The knowledge construction view of multimedia learning is consistent with the goal of effective multimedia in the classroom: to help students develop a genuine understanding of the presented material rather than simply exposing students to, and overloading them with, vast quantities of information. If one is an advocate of this knowledge construction view, the goal is to create and use interactive media that fosters this specific type of learning. The following are five keys steps to creating an effective multimedia, research-based activity or “research module.”

**Think of Students as Research Scientists**

Scientific inquiry exists on a continuum—from a pure verification experience in a classroom or laboratory (textbook/lab manual) to a full-fledged research immersion in a real-world laboratory (Weaver et al., 2008). The levels of intellectual ownership and responsibility increase along this gradient, in that students transition from simple confirmation of details to engaging in full-fledged professional science practice itself. A widely used approach to undergraduate education involves direct mentoring by a scientist, such that an undergraduate works in the lab to perform hands-on research alongside experienced scientists. Using this approach, students engage in many of the activities and
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