Building Retentive Understanding of Biology By Using a "Hybrid" Format With an Interactive Website and Active-Learning Exercises

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Abstract

Introductory Biology at North Carolina State University is a freshman course taught in large lecture halls using a standard, lecture-based format. We are experimenting with a hybrid course that utilizes a multimedia, interactive course website to replace lectures and allows classroom time to be utilized for application of knowledge and active-learning exercises. The results from the first semester of the new course are promising, but suggest several ways in which the hybrid format can be improved.

Introduction

Freshman biology at North Carolina State University is currently taught in a standard lecture-based format in classrooms of ~200 students. Lectures, in concert with "recognition" multiple-choice exams, encourage students to memorize and regurgitate isolated facts. Students then do not develop a true understanding of the material, and often retain little of what was taught. We are experimenting with a hybrid format that replaces the standard lecture with a multimedia, interactive course website. During their website exploration, students interact with learning objects and discover information through videos, animations, and images with audio and scrolling text. This enriched website initiates the building of retentive understanding that is refined in small classroom sessions in which an instructor and students engage in review, problem solving, and application of concepts. To assure that students study the website material prior to class, they are required to submit an on-line quiz at the end of each week.

The "hybrid" approach to education, sometimes called blended learning, is gaining acceptance as a way to accommodate students in small sections without using class time for lectures. In some schools it provides a way to teach more students in a limited amount of space by reducing the number of classroom hours. Our motive, however, is to increase the quality of student learning without imposing a greater burden on faculty. Instead of taking notes during lecture, students acquire the basic biological facts and concepts from an enriched website, and classroom time then can be used for higher-order learning experiences. In Fall 2006, we taught two sections of the hybrid format with two weekly meetings of 75 min for each section of 30 students. Students also attended a weekly laboratory; the same as students in the standard class sections.

The Course Website

The interactive website was created specifically for our Introductory Biology class by Dr. Black with the assistance of an undergraduate Biology major and consultation with a staff member from the University's Learning Technology Service. The website includes an outline of each weekly topic with links to specific content. Some links access popup windows that contain an image, brief slide show, or

short video clip with audio narration by Dr. Black (Figure 1). Scrolling text can be accessed by clicking on a text symbol in the popup window. The text is a script of the audio and is included to meet accessibility criteria and to provide for alternative learning styles. Other links from the outline lead to interactive learning objects of various types. Many of these were designed by Dr. Black in QuickTime movie format (Figure 2), while others are Flash animations obtained from a variety of outside sources. We included short interactive reviews at the end of a few topics (Figure 3) and plan to add more of these as time permits. As the course progressed, we realized that many students were not learning the material as well as expected, so we added a list of "concept checks" at the end of each subtopic. These consist of a list of things that the students should be able to do based on concepts learned from that section of the website.

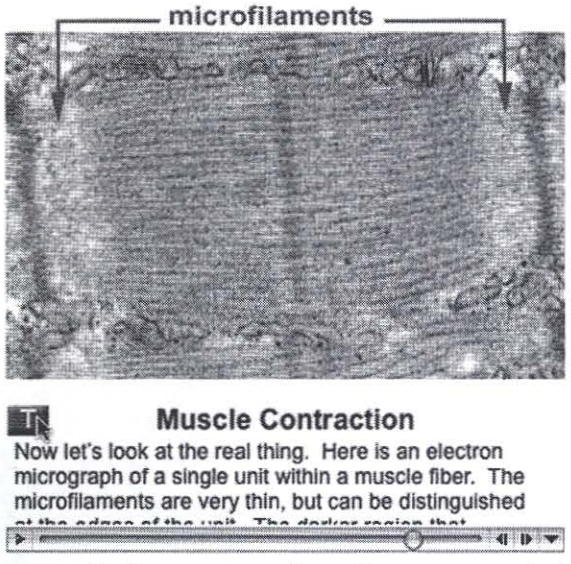


Figure 1. Popup page from the course website. The Scrolling text option has been selected.

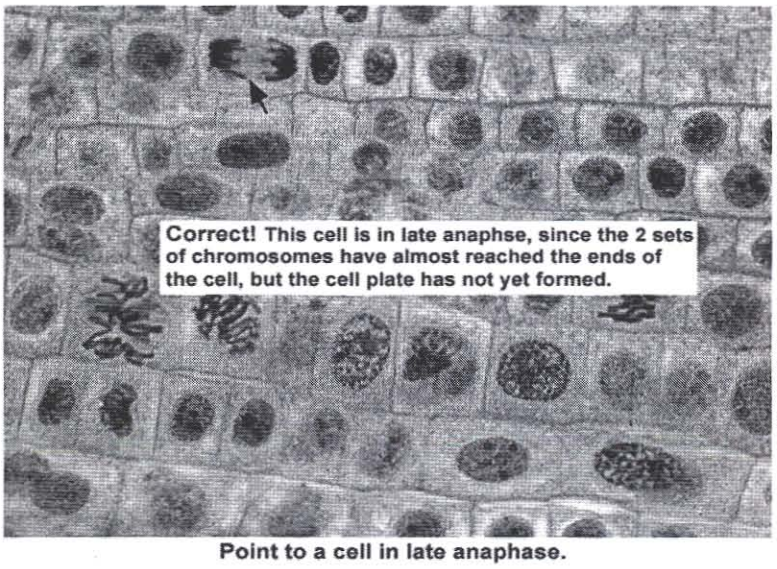


Figure 2. Interactive learning object from the course website.

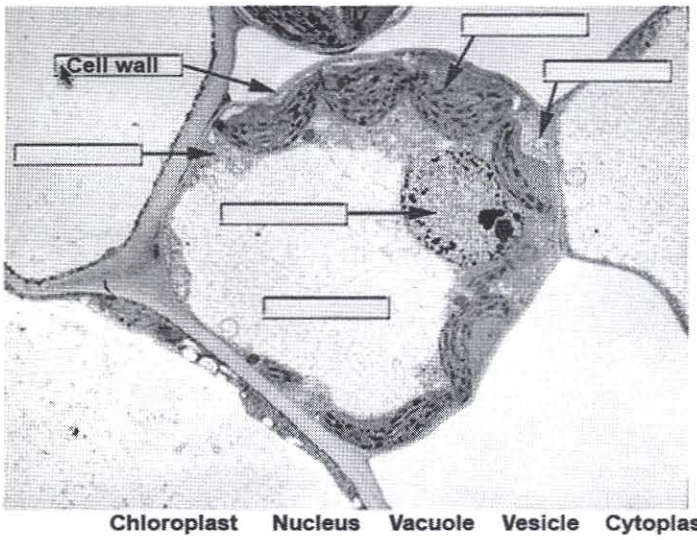


Figure 3. An interactive review of plant cell structure from the course website.

The course website also contains icons that link to required and optional reading assignments for each topic. All readings are available via the Internet and many of them were correlated with upcoming classroom activities. Additional icons link to definitions of terms utilized in the topic under study, to a list of the interactive pages within the topic, and to a list of scripts for all audio in the popup windows. The latter feature was requested by students and added half way through the semester. The current course website may be viewed at http://courses.ncsu.edu/bio181/common/Black/. Much of the site may be viewed by the public, but access to specific content requires a University password since some of the material is copyrighted. Due to a rearrangement of content between the two semesters of Introductory Biology, the website no longer contains material on ecology or evolution. In some semesters, the website is utilized for a distance education section of Introductory Biology, rather than as part of a hybrid course.

Classroom Sessions

Classroom sessions for the hybrid course were utilized primarily for building understanding and applying concepts, but did include some review of material learned from the course website. For example, during the week when eukaryotic cells were under study, students were required to come to the white board and fill in an outline of an animal or plant cell by drawing an organelle, naming a organelle drawn by a previous student, or assigning a function to an organelle drawn and named by other students. Each student also had the option of correcting a mistake if they thought that one had been made. Students also labeled diagrams of chloroplasts and mitochondria, indicating where different steps of photosynthesis and respiration occurred.

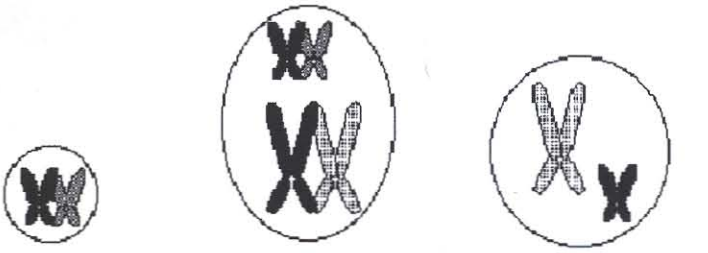
Student-directed, active-learning exercises were the main focus of the classroom sessions. These activities were developed by Drs. Niedlek-Feaver and Grubb, who were also the classroom instructors. Examples of classroom exercises from the Ecology and Cell Division topics follow:

Ecology: Students were provided with examples of species descriptions. They were then given pictures of imaginary organisms and asked to prepare species descriptions compatible with each picture and its accompanying list of facts. The descriptions had to include important terms and concepts. For example, the students were asked to consider what possible agents could be controlling population numbers (disease, predators) and how these influences would result in either a logistic or exponential growth curve for the population of their species. Students were then asked to defend their descriptions to their peers after which the class as a whole constructed a viable "community" using these descriptions, but also adding other species as necessary. Each group that added a new species was required to justify its niche to the class.

Cell Division: Students worked in groups to fill in the chart below, then discussed their results.

Below are cells from various stages of mitosis and meiosis from a mother cell that has four DNA helixes ("chromosomes") before replication of the DNA. The diploid (2N) chromosome number is four, as shown in the diagram. Decide whether the following diagrams show (1) stages in mitosis, meiosis I, meiosis II, or do not apply to cell division in this cell. For each cell, indicate (2) the phase of mitosis or meiosis. (3) Justify your answers.

Mother cell



A 1 _____

2 _____

3: _____

B 1 _____

2 _____

3: _____

C 1 _____

2 _____

3: _____

D 1 _____

2 _____

3: _____

E 1 _____

2 _____

3: _____

F 1 _____

2 _____

3: _____

Evaluation and Student Perceptions

Students filled out lengthy evaluation forms at the end of the semester. The evaluations were completed outside of class and returned anonymously during the final exam. Student perceptions of the course website were mainly positive, although some students thought that too much "clicking" was required and others wanted a search option for rapid location of specific pieces of information. Regarding the popup windows, comments were largely positive; surprisingly, many students preferred the scrolling text to audio narration. Students appreciated the addition of concept checks. In the two sections of the course, 74-85% of students thought that this feature helped crystallize the objectives for each topic. The interactive features and animations were the website's most popular feature; 75-92% of students agreed with the statement that the learning objects helped build an understanding of concepts. Some specific student comments are listed in Table 1.

Table 1. Student comments on website animations and interactive features

"They aided greatly my understanding of the material."
"I am a visual learner, so of course it helped."
"They helped to get the user involved and brought more understanding to the section."
"The interactive parts where we were actually able to do things helped a great deal to show what we know and don't know."

Exams in the course were composed of short answer and essay questions. Comparisons were made between questions based on factual information versus application exercises similar to those performed during class. As shown in Table 2, students did as well or better on the application questions as compared to the more factual ones, even though the application questions required a higher order of thinking. We also compared the grade distribution for the hybrid sections to that of the standard, lecture-based sections of Introductory Biology. Final grade distributions were similar, but the hybrid sections did have a higher percentage of B grades and a somewhat lower percentage of C grades than the lecture-based sections (Table 3).

Table 2. Student responses to factual vs. application-based questions (percent of possible points earned for each question type)

Topic	Factual questions	Application questions
Photosynthesis	62%	73%
Cell metabolism	78%	74%
Molecular genetics	70%	78%
Comprehensive	NA	82%

Table 3. Grade distribution in hybrid vs. lecture-based sections

Grade	Hybrid course	Lecture-based course
A	24%	28%
B	58%	34%
C	11%	23%
D+F	7%	12%

We judge the hybrid course experiment a success, but have learned ways to improve it. Based on student comments, the website has been simplified by removing one level of navigation (less "clicking" required). We plan to make the first classroom meeting optional and utilize it to focus on the website concept checks while eliciting student discussion and responding to questions. Students will be strongly encouraged to prepare answers to the concept checks and bring them to class. The weekly quiz will be based on the concept checks and due before the second class meeting to further encourage students to learn the relevant web-based material early in the week. The second (required) class meeting will be devoted entirely to active-learning exercises as previously described. With these changes, we hope to provide a model for future hybrid courses in the discipline of Biology.

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About the Authors

Betty L Black received her Ph.D. from Washington University (St. Louis). She conducts research on development of embryonic intestine in birds and mammals, and teaches a course in Developmental Anatomy plus distance education courses in Histology and Animal Diversity. She has received two University awards for "Innovative Excellence in Teaching and Learning with Technology."

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Brenda Grubb received a B.S. degree in Biology from East Carolina University, a Ph.D. in Genetics from George Washington University (Washington D.C.), and did post doctoral training at UCLA. She is currently an Assistant Professor of Zoology. She conducts research on embryonic development and teaches courses in Developmental Biology, Experimental Embryology, and Introductory Biology.