Design and Implementation of a Web Based System for the Learning and Testing of Image Based Knowledge

Subject/Problem:

The study and mastery of image based information has been central to many biological disciplines, and yet has always been logistically difficult to manage. As the instructor in charge of our Developmental Biology course I have faced this problem repeatedly. What is the most effective way to present images to students for study? How can students evaluate the level of their mastery of the material? What is the most efficient way for the instructor to test that mastery?

The traditional answers to these questions have been to provide students with slide boxes containing a large number of serially sectioned embryos at various stages and an annotated atlas, and then to set up an array of microscopes with slides containing structures to be identified for the exam. These methods present many problems, both to the student and the instructor. It is difficult for students to measure their progress and to pace their study through the semester. The images are only available in the classroom as we do not allow slide boxes to be borrowed. Many students find too much new material remaining as the semester winds down. During the exam students must move in lockstep from microscope to microscope, regardless of how difficult or easy the current question happens to be for them. And, of course, if one of the slides is accidentally (or not!) moved on the stage of one microscope, everyone from that point on is identifying the wrong structure.

To alleviate the last mentioned problem, I moved from microscopes to overhead projection slides some years ago. The lack of flexibility in the sequence of questions and limited accessibility to the images remained as problems, however.

Design or Procedure:

The problem of accessibility was addressed first with the development of a internet based system for organizing and displaying images in a web browser (Gepner, 2009). In this system a web page was divided into two sections (frames) that display different content. The frame at the left shows a column of small images (thumbnails), each of which is a clickable link. Clicking on one of these small images brings up a large version of the same image in the frame at the right. There are many sources for these images – I made use of an image library provided by the publisher of the atlas used in the course.

For testing purposes, the large image can be annotated with an image editing program to add numbered arrows indicating the structures to be identified. Initially, students wrote their answers on paper. In a later version that added a form to the web page and connecting it to a database they were able to enter the answers online.

We worried that some students might be able to recognize a structure if given the name, but unable to recall the name. To measure student learning more exactly we decided to change the

design such that students are given the names of structures to be identified and need only point to those structures.

How is the pointing process performed? There is more than one possibility, but the most natural way for a student to point is by using a device with which they are intimately familiar – the mouse. A technique used by web authors to allow users to click on a predefined area within an image, called a hotspot, in order to jump to a relevant page was utilized to accomplish this. When the mouse is clicked a red dot is placed on the image at the position of the mouse cursor as feedback for the student, and the coordinates of the dot are saved by the system. Students can change their mind and re-click on a new spot any time before submitting the test. The program can compute whether these coordinates are inside the boundaries of the hotspot, so the test is self-grading. Completed questions are marked by a check symbol in a red square next to the structure name, so that students can recognize which questions they have completed.

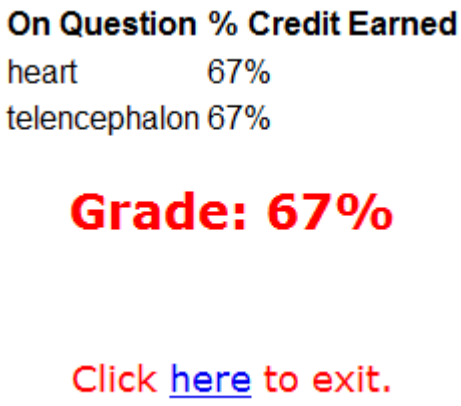
The current system has incorporated many improvements during its evolution. Instructors have an image library at their disposal, to which they can add or delete images. Images in the library can be used to prepare practice or actual tests. Individual images can be used one or more times in the same test. When adding an image the test author traces the outline of the target structure with mouse clicks to define the 'hotspot'. Each question consists of an image with one defined hotspot. Any number of questions can be added and the order of questions can be controlled. The system can also accommodate multiple sections of a course. Tests can be moved between active and practice status. Only one test can be designated as the active (actual) test, but any number of tests can be set as practice tests.

The interface for the actual slide test appears as in the following screen capture:

Besides controlling the image library and the preparation of tests, the image manager also manages student access to practice and actual tests. A data table with student names and password provides user authentication individually for each test. The student data table can be populated automatically if a text file in the correct format (csv) is available from the registrar's office or added individually through the interface. Once students are in the system, they can be added to or removed from individual tests. This system also insures that students can only submit results from a real test once.

Once tests have been completed, the test manager produces reports on final student grades by test and by section. If a student questions the accuracy of a recorded incorrect answer the instructor can call up the image with the hotspot and the student's red dot showing on the screen to demonstrate that the click was not in the correct area.

Once the testing system was in place, we realized that it would not be difficult to use the same interface to produce a system that will monitor the progress of student learning and motivate the student to improve their mastery of the slides. Thus was born the practice test. How does a practice test differ from an actual test? As in an actual test, the student is given a series of structure names and asked to point to the correct place in an image. In the practice test, however, the student is given immediate feedback as to whether his/her response is correct or not. If incorrect, they are given another try. The instructor can set each practice test to a desired number of tries and students receive decreasing point values for each additional attempt they require. The awarding of points is designed to motivate student learning, as it simulates game playing scenarios with which the student may be familiar. After submitting a practice test the student can see their individual point values and total point values displayed.

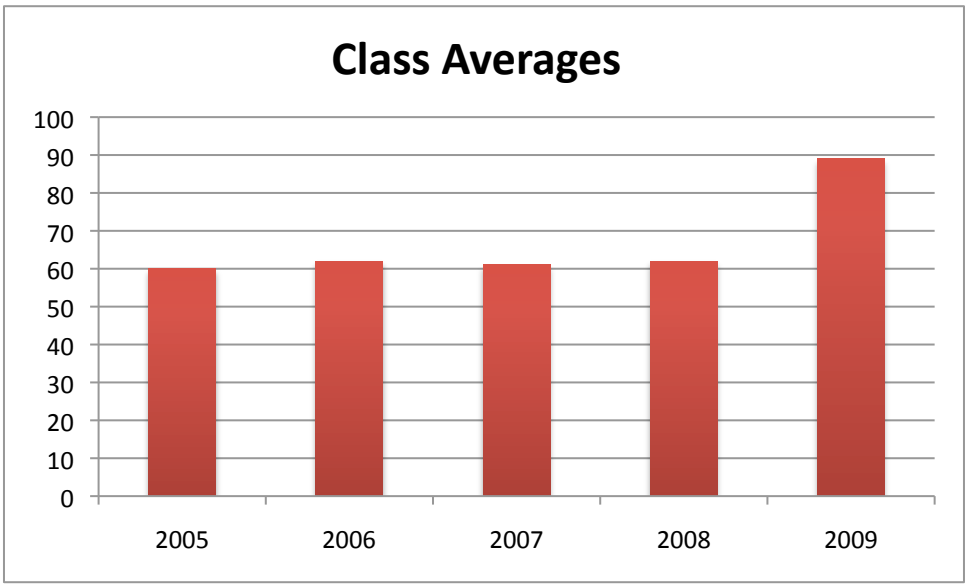


Analyses and Findings:

The web based test systemhas been in use for the past four years. The instructor has benefited from avoiding the chore of setting up a microscope based test and from the automated grading capability of the new exam format. Student responses to the test format have been recorded through questionnaires that were administered immediately after completion of the exam. Student comments indicate that they appreciate the ability to answer questions in preferred order and to allocate time differently to individual questions. Another advantage from the student perspective is the instant reporting of their grade at the conclusion of the exam.

The practice test system was only completed in the fall of 2008 and used for the first time in the spring 2009 semester. The system retains data on the number of times that each student has accessed the system, so it will be possible to test a correlation between the number of practice sessions and the grade on the exam when sufficient data points are available. What is clear,

however, is that the class average on the 2009 exam, where the practice test was available (average = 82) increased significantly over past years when it was not (average in the low 60's).



Part of this improvement may be due to the student's increased familiarity with the test system interface, or to the novelty of the practice system that might wane over time. I believe these are minor factors.

Rather, I would argue that this improvement is consistent with the current educational paradigm that students learn best when actively engaged with the material rather than passively observing a slide with a microscope (Wood, 2009). Working with a screen and a mouse is second nature to current undergraduates. They focus their attention to the screen to a degree that would be difficult to maintain through the tube of a microscope.

Similarly, educational research has shown repeatedly that returning one or a few graded exams has little benefit on student learning (summative assessment). Conversely, providing frequent and responsive feedback on student performance (formative assessment) leads to greater learning. The practice test provides this type of formative assessment, and provides motivation by assigning point scores as in gaming systems.

Contribution:

The test manager system has the ability to author and administer both practice and actual test instruments, and adds flexibility and organization to any evaluation system based on the ability to recognize structural details inside of images. The practice test system provides fulltime access to the image collection to the students, gives them motivation to learn the material, and allows them to monitor their progress.

General Interest:

This system will be of interest to any teacher who utilizes images as a component of course content. As recognition of structure is such an integral component of biology courses across the spectrum, I anticipate that it will be useful to many components of a typical biology curriculum.

References:

Gepner, I. (2009) Frame Your Images: Making Digital Images Accessible for Study and Testing. *The American Biology Teacher*, 71,42-48.

Wood, W. (2009) Innovations in Teaching Undergraduate Biology and Why We Need Them. *Annu. Rev. Cell Dev. Biol*. 2009. 25:5.1–5.

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