ENHANCED LEARNING AND ASSESSMENT OF CALCULUS THROUGH ONLINE QUIZZES

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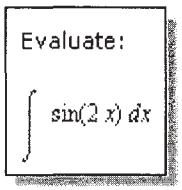


Assessment, both formative and summative, is one of the most important components of any course. Frequent quizzes are an important component of mathematics courses, since they allow for repetition of important concepts, keep the students on task throughout the semester, and provide timely feedback to the students as well as the instructor. Online quizzes save class time, and can be given more often than in-class quizzes. Further, since in most universities, simultaneous sections of calculus run at the same time, online quizzes provide an efficient way to homogenize the learning outcomes in different sections.

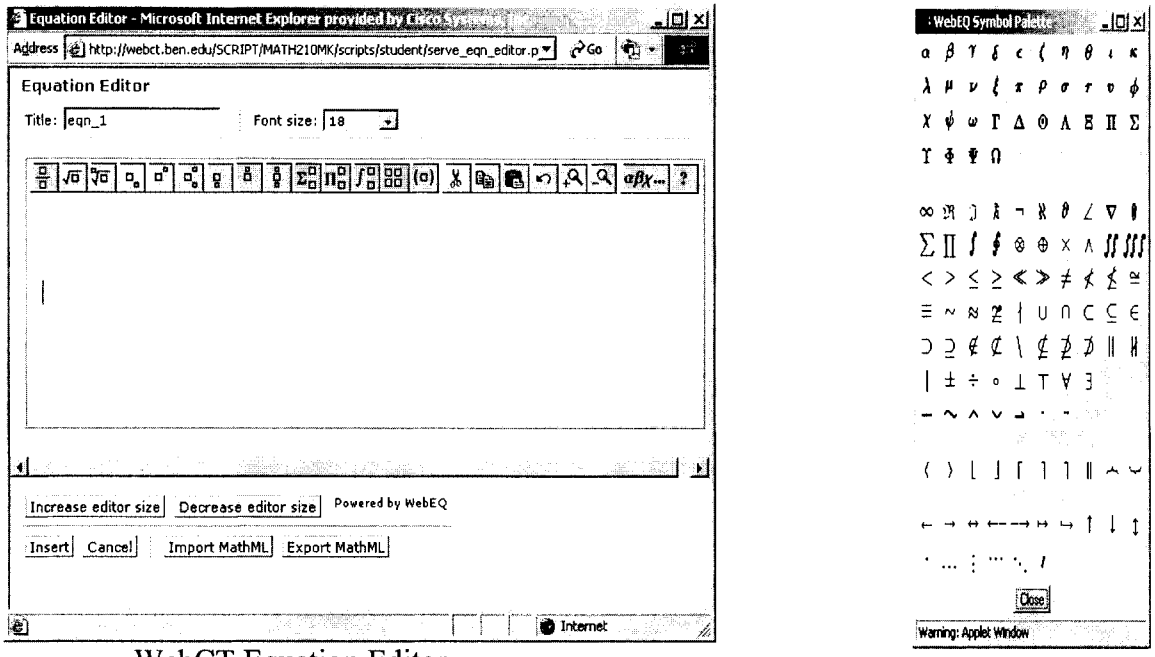
Online distance learning seems to be the reality of higher education in the years to come. Many universities across the world are presently using web based course management systems like Blackboard and WebCT. Many people have experimented with online assessment in mathematics. Some textbooks are packaged with electronic test banks, but they usually are not easily modifiable. Interestingly, most mathematicians use tools like WebWork (developed initially at the University of Rochester), or AiM (developed initially at the University of Birmingham). WebWork requires a Unix server, and AiM requires maple software on student computers. So these may not be very efficient and cost-effective in most small schools.

In a recent article in *The College Mathematics Journal* (Vol. 34, No. 4, September 2003), G. Donald Allen says, "Within every course management package, such as Blackboard and WebCT, there are extensive tools for online exam creation and online grading. However, all are unsuited to the mathematics environment." This is due to several reasons. One, type-setting mathematical symbols requires specialized software, which usually is not available in its full capacity in these course management systems. Two, different mathematical entities may be identical, for example, $(a+b)(a-b) = a^2 - b^2$. So assessing mathematics quizzes may require software that understands mathematical manipulations. Three, it is desirable that we create multiple problems about the same concept and having the same level of difficulty. This allows us to maximize student learning by using some problems for practice tests, and we can offer different problems to different students to minimize cheating. So ideally, mathematics problems should be generated algorithmically.

In the year 2003-2004, I received release time to create electronic quizzes for my calculus students. I decided to use WebCT (which was already available on campus) to create and

administer these quizzes. These quizzes are online, and the students only need a web browser to access them. The WebCT support on campus takes care of the administering issues, and I do not need to maintain a server.

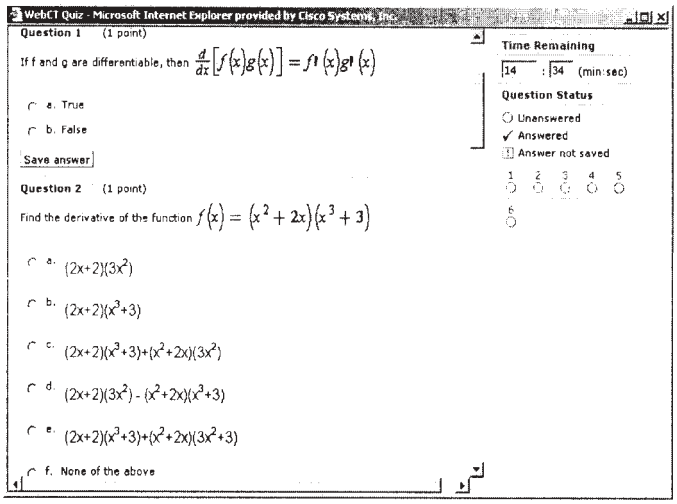
WebCT has an in-built quiz tool. It has an in-built equation editor, supplemented by a symbol palette that allows us to type many (but not all) mathematical characters in the question.

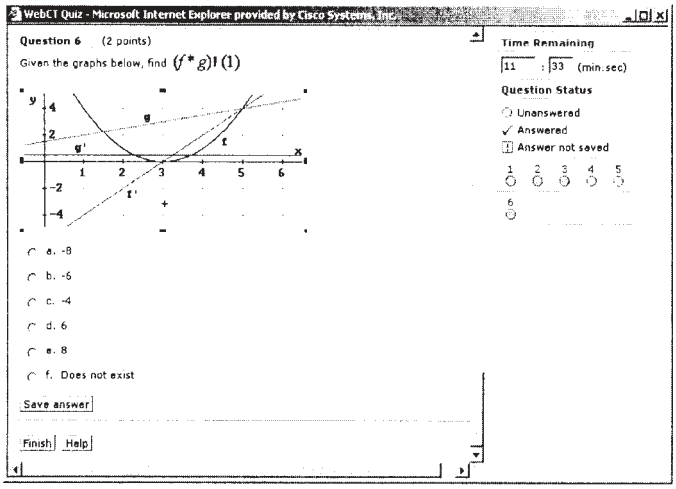


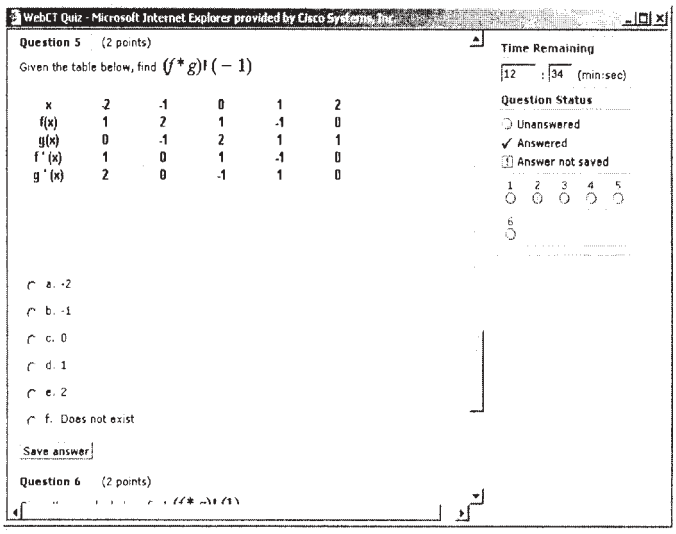
WebCT Equation Editor

However, the WebCT equation editor does not allow us to create graphs. Further, the equation editor is not available in the answer choices. The first problem can be solved by creating the graphs in another software, and bringing the picture into the quiz problem using a simple HTML code. The second problem can be solved either by buying a partner software that allows us to type equations in the answer choices, or typesetting the equation in another software, and then using HTML to bring the equation into the problem.

On the following page, we have some examples of problems that were created this way.



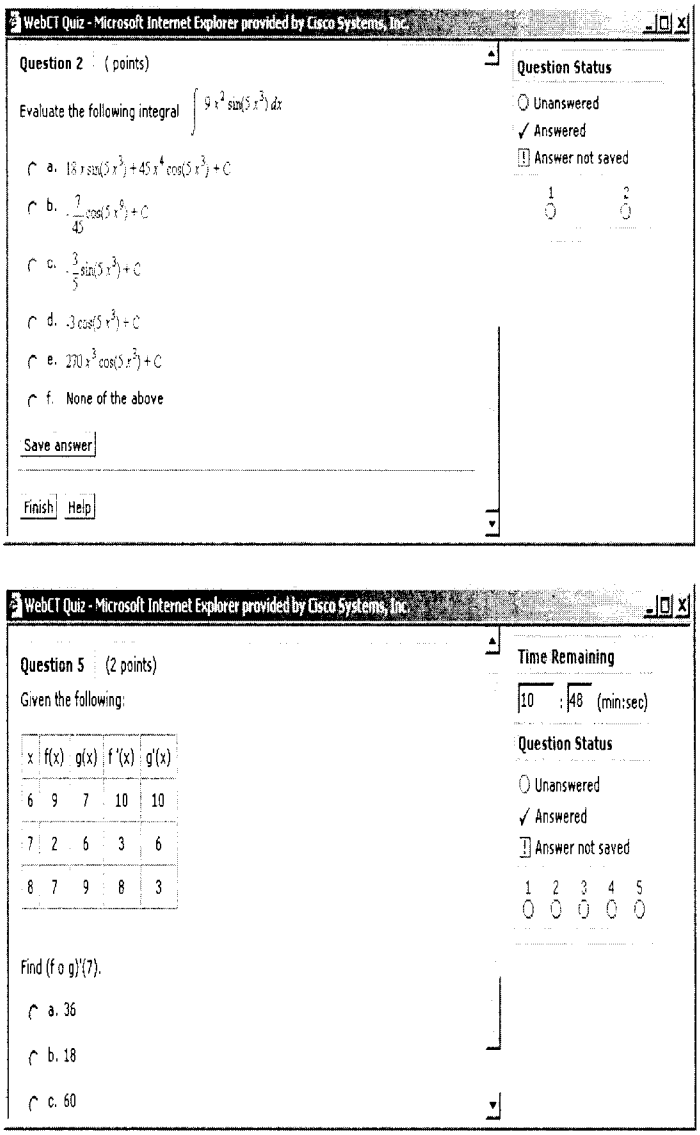




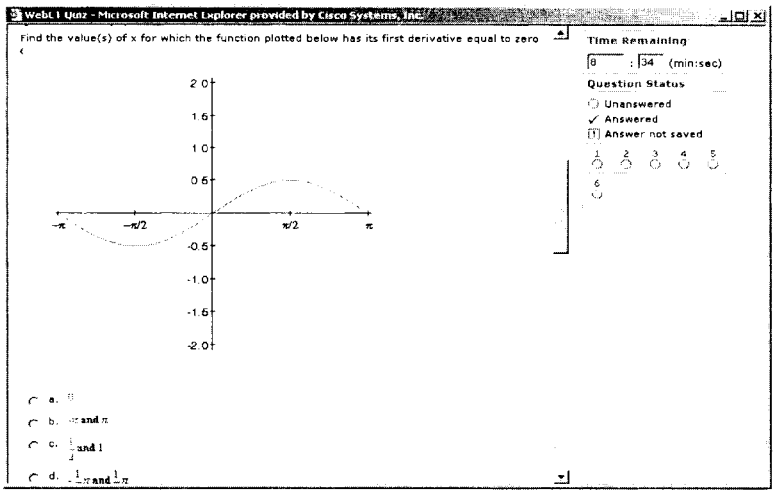
Some sample problems

These problems encompass the four ways to understand each concept: graphically, numerically, algebraically, and verbally. I have included lots of problems that involve graphs and tables, and test the student's understanding of the basic concepts. Most of these problems are multiple choice, however, I do have some short answer ones. The answer choices are usually functions or graphs, and not numbers.

In order to create multiple problems of the same type, I use maple software to generate a text file that can upload the questions into WebCT at one go. This simplifies the typesetting problems, it is easier to find incorrect answer choices, but most of all, it is time-efficient. We require maple only on one computer, and no servers need to be maintained. Further, these files are easy to modify. Here are some examples of algorithmically generated problems.



Algorithmically generated problems



An algorithmically generated graph problem

Most of the students who were administered these quizzes had no experience with online tests. Here are some student comments about whether the online quizzes helped them understand the course material and perform better in the exams:

- It forces me to study
- They help you know what you really have to work on
- They are good practice problems for the exam
- The mistakes I had on the quiz help me understand why I made the particular mistakes
- The two correlate
- Somewhat…I never really paid attention to their effect on my exam grades
- Somewhat b/c it is extra practice
- No, I do not think so. Exam questions are more difficult than the quiz ones

In conclusion, quizzes are a useful component of mathematics courses, but creating electronic quiz problems can be tedious. In small schools where Windows is the most commonly used platform, and course management systems like WebCT are already available, using a mathematically intelligent software to create them algorithmically is both economical and time-efficient.