Introduction
WebCT is a collection of Web-based Course development Tools. It allows instructors to create secure course content pages, discussion groups, and online quizzes. Since WebCT quizzes give instantaneous feedback and can be set to repeat similar problems until students have mastered them, it is natural to use in settings such as precalculus or calculus in order to drill basic skills.

WebCT instruction can also be effectively used in a variety of other courses where one might expect it to be ineffective in meeting course goals. We will look at examples of these kinds of instruction along with the advantages, limitations and effects on teaching and learning in the classroom.

WebCT Bulletin Board
It is natural to use bulletin board participation as part of a course participation grade since it allows students to communicate their ideas in a manner that is very different from classroom or office hours participation. The instructor can set up various forums for students such as a homework forum, a forum for a specific group of students, or a forum for only the professor and the student. For certain students, posting messages is a great alternative to asking questions in the classroom or in office hours.

WebCT Quizzes
The greatest advantage of WebCT quizzes is that when the students are finished with the quiz, WebCT grades their work and offers instant feedback. Faculty can allow retakes of slightly different versions of each quiz. Quizzes can be set to give a minimal amount of feedback in order to ensure that the process of deciding which answers are correct is a part of the learning process. For this reason, and because it would be easy to cheat on WebCT quiz retakes held outside of class, quizzes counted as part of the course participation grade and complemented standard tests instead of replacing them.

Proof-Writing WebCT Instruction
WebCT instruction was not offered until midway into a first proof-writing class, as this is when the instructor learned how to use WebCT. Previous course work had depended on lecturing, group work, and standard problems sets. Even with problem set revisions,
students were having great difficulty with writing proofs, and so creative WebCT quiz questions focused on developing proof-writing skills (see Figure 1 and Greenwald, 2000).

Notice that in the following statements on the left, the type and order of quantifiers matters very much since switching them around results in a statement that is logically very different than the original.

Match the statement to the proof that either proves or disproves it.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Proof</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. For all $x$ in $\mathbb{R}\setminus{0}$, there exists $y$ in $\mathbb{R}$ s.t. $xy=1$</td>
<td>a. Let $x$ be an arbitrary element of $\mathbb{R}\setminus{0}$. We will produce $y$ in $\mathbb{R}$ s.t. $xy=1$. Take $y=1/x$. Notice that $1/x$ is in $\mathbb{R}$ since $x$ is not 0 by def. Also, $xy=x(1/x)=1$, as desired.</td>
</tr>
<tr>
<td>2. There exists $y$ in $\mathbb{R}$ s.t. for all $x$ in $\mathbb{R}\setminus{0}$, $xy=1$</td>
<td>b. Let $y$ in $\mathbb{R}$ be arbitrary. We will produce $x$ in $\mathbb{R}\setminus{0}$ s.t. $xy$ is not 1. Case 1 $y$ not 0. Take $x=2/y$. Notice that $x$ is in $\mathbb{R}\setminus{0}$ since $y$ is not equal to 0. Also, $xy=2/y(y)=2(y/y)=2(1)=2$. Since 2 is not equal to 1, we have shown that $xy$ is not equal to 1. Case 2 $y=0$. Take $x=3$. Notice that $x$ is in $\mathbb{R}\setminus{0}$ since 3 is in $\mathbb{R}\setminus{0}$. Also, $xy=3(0)=0$. Since 0 is not equal to 1, we have shown that $xy$ is not equal to 1. So, for each $y$ in $\mathbb{R}$, we have produced $x$ in $\mathbb{R}\setminus{0}$ so that $xy$ is not equal to 1, as desired.</td>
</tr>
<tr>
<td>3. There exists $x$ in $\mathbb{R}\setminus{0}$ s.t. for all $y$ in $\mathbb{R}$, $xy=1$</td>
<td>c. We will produce $y$ in $\mathbb{R}$ s.t. for all $x$ in $\mathbb{R}\setminus{0}$, $xy$ is not equal to 1. Take $y=0$. Notice that $y$ is in $\mathbb{R}$. Let $x$ be in $\mathbb{R}\setminus{0}$. We will show that $xy$ is not equal to 1. Notice that $xy=x(0)=0$, by multiplication by zero. Since 0 is not equal to 1, we have shown that $xy$ is not equal to 1, as desired.</td>
</tr>
<tr>
<td>4. For all $y$ in $\mathbb{R}$, there exists $x$ in $\mathbb{R}\setminus{0}$ s.t. $xy=1$</td>
<td>d. Let $x$ be an arbitrary element of $\mathbb{R}\setminus{0}$. We will produce $y$ in $\mathbb{R}$ s.t. $xy$ is not 1. Take $y=0$. Notice that $y$ is in $\mathbb{R}$. Also, $xy=x(0)=0$, by multiplication by 0. Since 0 is not equal to 1, we have shown $xy$ is not equal to 1, as desired.</td>
</tr>
</tbody>
</table>

**Figure 1.** A First Proof-Writing Course WebCT Quiz Question

The WebCT bulletin board was used for more than just answering student questions. While groups of students worked on a demo together in lab, students were asked to individually post their answers to related questions in a bulletin board message. While a number of students had been confused about one part of a proof, they had not asked for clarification during lab from their group partners or the instructor. Yet, instead of just agreeing with other posts, they did bring this up in their newsgroup posting. For some
reason, for certain, often quiet students, posting felt like a safe place for them to share their confusion.

WebCT really helped the students in this course. They loved being drilled on WebCT quizzes, and felt in evaluations that they learned a lot from this process. It revitalized the class, which had been tired from working hard to learn proof-writing skills via standard problems sets, classroom presentations and group work. This newfound energy helped the class continue to work hard and eventually succeed at proofs. See Greenwald (2000) for the complete list of WebCT quizzes used in this class.

Liberal Arts Mathematics WebCT Instruction
In a liberal arts mathematics class, WebCT quizzes were used to reinforce the material (see Figure 2).

Do this question without a calculator, ie use your math common sense!

The math common sense dictates that your answer to the problem
PROBLEM: 1% of what number is

99999999999999999999999999999999?

would be...

1. smaller than
   999999999999999999999999999999999

2. bigger than
   999999999999999999999999999999999

3. equal to
   999999999999999999999999999999999

Figure 2. Liberal Arts Mathematics WebCT Quiz Question

One of the problems that arose in WebCT instruction was the inappropriate use of the bulletin board by students. Some students posted personal messages to the entire class that were meant for only the instructor. In order to correct this problem, during the next semester, professional web posting rules were highlighted. In addition, the default newsgroup was set as a locked bulletin board from which they could read messages from the instructor, but could not post messages. In order to post messages, students needed to choose a forum in order to decide whether a message should go to the entire class or only to the instructor. Setting up all of these different forums was time consuming for the instructor, but it was well worth the effort, as it took care of the inappropriate posting problems.

Another problem that arose in WebCT instruction was that the instructor added quizzes to this course, but did not remove anything else from the class. This resulted in an increased
workload for the students. For the next semester, the instructor reorganized and decreased the number of WebCT quizzes. In addition, other aspects of the class were also changed to allow for a more balanced workload for the students.

WebCT quizzes reinforced the material and allowed the professor to communicate and highlight important skills and understanding that were needed for success. In evaluations, students reported that WebCT quizzes were useful and enjoyable.

**Linear Algebra WebCT Instruction**
Because of its limited calculation and formatting capabilities and less than ideal interface, it might seem ineffective to use WebCT in a linear algebra course. Yet, with some creative maneuvering, this can be highly effective. One can create matrices in another program and upload them as images as in the following quiz question (see Figure 3).

Which of the following are true for the augmented matrix L below representing a system with variables x and y? (Solve the system by hand first.)

\[
L = \begin{bmatrix}
1 & 2 & 0 \\
1 & 1 & 6 \\
3 & -2 & 8 \\
\end{bmatrix}
\]

- 1. The system is inconsistent.
- 2. The system has infinitely many solutions.
- 3. This system has exactly 1 solution.
- 4. There is a solution with x = 2.
- 5. There is a solution with y = -6.

![Figure 3. Linear Algebra WebCT Quiz Question](image)

Quizzes were used to ensure that students developed basic linear algebra skills. Since the instructor set a time limit on completion of the quizzes, the questions also provided students with a guideline for the length of time in which they should be able to complete problems.

**Women and Minorities in Mathematics WebCT Instruction**
WebCT instruction can be used in all levels of classes, including a senior level women and minorities in mathematics seminar (Greenwald, 2001a). WebCT quizzes and tests (see Figure 5 and Greenwald, 2001a) supplemented student presentations and replaced standard tests. They were used throughout the class in order to ensure that students understood the mathematics and ideas in the assigned readings and in other students’ presentations. They served as a way for the instructor to highlight certain material and to tie together mathematics and themes in a relatively non-stressful testing situation.
Recall that the Mental Rotations Test has shown gender differences in the past. We discussed the 1990 study (Sex differences in visual-spatial ability: The role of performance factors, Goldstein, Haldane and Mitchell, Memory and Cognition, 1990, 18 (5) 546-550) showing that ratio scores showed less of a gender difference on the MRT, and that untimed MRT exams also showed less of a gender difference. We then talked about a 1993 study (Performance factors and gender-related differences in spatial ability: Another assessment, Stumpf, Memory and Cognition, 1993, 21 (6) 828-836) analyzing data from 15 different visual-spatial tests. They were able to duplicate the MRT results, but found that increased time / ratios did not reduce gender differences in the other 14 tests.

Here is an example of mental rotation intellectual task **examine figure on left; which two of the 4 alternatives (label the alternatives a, b, c and d going from left to right) match it?**

![Figure 5. Women and Minorities in Mathematics WebCT Quiz Question](image)

See Greenwald (2001a) for the complete list of WebCT questions used in this course.

**Conclusion**

WebCT instruction can be a great way to reinforce material and encourage participation. Some students who are quiet in class feel more comfortable using bulletin boards in order to ask questions. While one must be careful to weigh the benefits of WebCT instruction with the time constraints of both the professor and the students, creative quiz questions (see Greenwald, 2000; Greenwald, 2001a; and Greenwald 2001b) can be used to highlight and reinforce material.

**References**


