
Integrating Web-Based Teaching Tools into Large University Physics Courses



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Outline

- **Overview**
- **Introductory Physics: Multiple Course Goals and Challenges**
- **Our Online Math and Homework Quiz Systems**
- **Incorporating them into the course**
- **Results and Thoughts**

Overview

- Using web-based instruction in Introductory Physics courses is nothing new
- Studies show simply turning in homework online is no better than properly graded pen & paper homework
- What does appear to matter is the content and HOW online activities are structured

This talk:

- New tools
- How to incorporate them

What is Physics 218?

- Large, introductory course
- Typical enrollment is 1,500 for Fall and 750 for Spring
- Split up into lecture "sections"
 - 120 students/lecture
 - Single professor per section
- Common syllabus, instructor dependent lectures, exams & grades

More on the course

- Course style is known in the literature as “Traditional”
 - Lecture (x2/week)
 - Recitation and lab (x1/week)
 - Graduate student leader to solve problems
- Designed for first-year Engineering majors
 - Preparation for engineering curriculum
- Calculus is a co-requisite
 - This is problematic (more later)

Primary Goals

Create Good

PROBLEM SOLVERS

What does this mean?

Being a good “problem solver” means many things to many different people

• Here I mean:

- Understanding the concepts in the problem
- Turning the physical quantities into symbolic variables
- Translating the problem into the language of Mathematics (symbolic notation)
- “Turning the crank” on the math to find a “Closed Form” solution and a numerical solution

A Silly Example

Your car can drive at 60 miles/hour. How far can you travel in 0.7 hours?

- Speed = $S = 60$ mi/hr
- Time = $t = 0.7$ hours

• Symbolic answer: **Distance = $S \times t$**

• Numeric Answer: Distance = 60
mi/hr \times 0.7 hr = 42 mi

Want student to be able to do both

The Teaching Challenges

- Many students have very poor math and problem solving skills
- Great variation between the best and the weakest students
- Most students aren't taught to use variables
 - High school: *"Get good at plugging in the numbers into the equations we give you"*

Other Challenges

- We have VERY limited human resources for grading feedback or tutoring time
- When this program began (2001) there were:
 - No web-based instruction or tools
 - No math remediation materials
 - Homework was not collected or graded
 - No feedback other than exams and easy weekly recitation quizzes

Yet more challenges...

Many don't know how to study at the college level

- Often the smartest kid in their school, didn't have to spend too much time studying or do many problems
- Don't know what to study. *"I looked over the homework before the exam, like I did in high school; everything kinda made sense..."*
- Don't know how to tell if they've gotten the problem right

Big Picture Solution

Create "*Teaching-while-quizzing*" tools and deliver them with WebCT

Two Separate Issues:

1. The Quiz Tools Themselves

- Nothing terribly new or complicated

2. New ways of incorporating them into the course as a whole

Design with both in mind

System Goals

- Remediate math deficiencies
- Level the playing field without biasing the grades in favor of the better-prepared
- Automate homework grading and provide quick feedback
- Guide study time towards problem solving
- Teach students how to check their own work
- Make it REALLY EASY for other instructors to incorporate the tools into their courses

Combine Elements of Good Teaching

- **Explicit Goals**
- **Immediate and Constant Feedback**
- **Balance between skill-level and Challenge**
- **Improve “time-on-task”**
- **High expectations**
- **Motivation for performance**
- **The Opportunity to “Repeat Until Mastery”**

Overview of the Tools

Three Separate Quizzing Tools

1. The Automated Mathematics Evaluation System (AMES)
2. The Computerized Homework Assignment Grading System (CHAGS)
3. After-homework Quizzes Intended to Consolidate Knowledge (QUICK)

Why WebCT?

All tools implemented with WebCT, but in principle could have used other formats

- Quiz tools readily available
- Design once, reuse indefinitely/easily for all instructors
- Students can use anywhere
- Class rosters automatically added
- Neo account security
- TA's can enter in grades
- Huge server capacity
 - We're a HUGE hog of resources
- Great support from ITS!!! (Thanks Rhonda!)

More on Theory

We use some of the ideas in the (non-physics) education literature in new ways

- **Mastery Learning**

- Repetition until achieving a certain score

- **Precision Teaching**

- Repetition until achieving a predetermined number of correct answers per unit time

The Deal

- For ALL quizzes: Passing requires a 100% score, within the allotted time
- If they fail:
 - Indicate the correct answers
 - Unlimited number of attempts (without penalty)
 - Change the problem (slightly) on each attempt
- Passing required to move on to next quiz
- Required to pass all quizzes to pass the course

Notes

- Forcing 100% combats the temptation to just do easy problems
- Multiple topics and difficulty level incorporated into each quiz
 - Encourages learning material as a whole
- Students motivated by getting 100% for part of their grade

Note: Yes, this means that everyone gets a 100% for their homework grade. All this does is "shift the mean grade in the course." (Students don't understand this...). In practice: Giving harder exams (lower mean scores) and making the homework only worth about 15% of the grade.

The Sequence

The sequencing of the quizzes is also important

- Course begins with the AMES (math) quizzes and they must get ten 100%'s
- THEN, they can move on to CHAGS Homework 1 problems (break the assignment into 3 parts)
- When they get 100% on all three, THEN they can move to QUICK for a homework 1 quiz
- When they finish that, THEN they can move on the Homework 2 etc.

More Carrots

- The first in-class paper-and-pencil exam covers the three Chapters of the text book
- When the students have a 100% on all the AMES, CHAGS and QUICK materials they EARN the right to get a mini-practice exam to study for the in-class exam
 - **Further incentive:** if they get a 100% on this mini-practice exam BEFORE the in-class exam, I give them 5 bonus points on the exam

AMES (Math)

- Strictly limited to the relevant pre/co-requisite math topics for the course
- Goal: “remind” students of the tools they should already be really good at, and have them practice until they (re)gain facility
- Studies (elsewhere, but confirmed here) show that students who cannot do well on these quizzes are very unlikely to succeed in the course
 - Encourage them to drop or get other remediation

AMES Continued

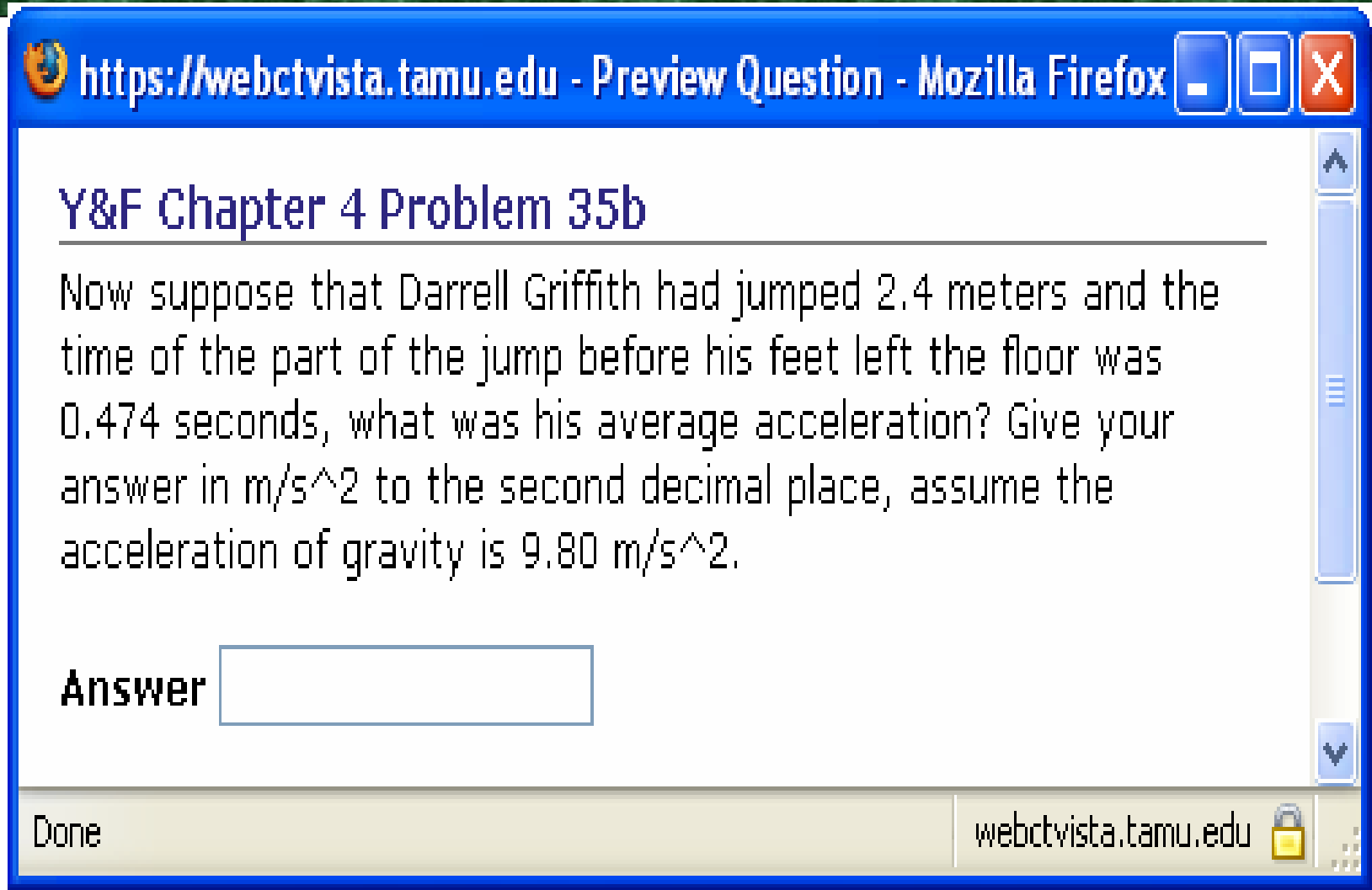
- Each quiz is ten multiple-choice problems
- Have one problem from each of seven areas
 - fractions, geometry, trigonometry etc.
- Allow ten minutes to complete the quiz
 - Well-prepared students take about 4 minutes, they finish all ten quickly
- Benefits:
 - Effects remediation at the beginning, levels the playing field
 - Learn all topics as a whole
 - Doesn't penalize the less prepared students
 - Establishes high standards: *No whining in class!*

CHAGS Homework System

The CHAGS quiz system is different than what most people are used to

- Common syllabus has homework problems from each chapter for the student to solve
- For each problem the students are must it on paper using variables (previous example) BEFORE going online
- Same problem is presented on WebCT, but with different numeric parameters
- Short time to quickly type the new numbers into a calculator (using their equations on paper), and plug new number into WebCT

Example using WebCT



The screenshot shows a Mozilla Firefox browser window with the address bar displaying <https://webctvista.tamu.edu> - Preview Question - Mozilla Firefox. The main content area displays the following text:

Y&F Chapter 4 Problem 35b

Now suppose that Darrell Griffith had jumped 2.4 meters and the time of the part of the jump before his feet left the floor was 0.474 seconds, what was his average acceleration? Give your answer in m/s^2 to the second decimal place, assume the acceleration of gravity is 9.80 m/s^2 .

Answer

The browser's status bar at the bottom shows "Done" on the left, "webctvista.tamu.edu" in the center, and a lock icon on the right.

Force the student to have their equations ready to go!

QUICK (After Homework)

- **AFTER** a 100% on the homework
- Two or three quick multiple-choice problems they haven't seen before
 - Use a standard textbook test bank
- **Ten Minutes**
 - Have to pick short enough problems
- **New problems for each attempt**

QUICK Mini-Practice

- For each exams a mini-practice exam is made from the QUICK questions
 - 20 minutes, four problems
- 5 bonus points for a 100% BEFORE the in-class exam
- Encourages time-on-task problem solving preparation for the exam
- Reinforces keeping up with the course content, learning material as a whole

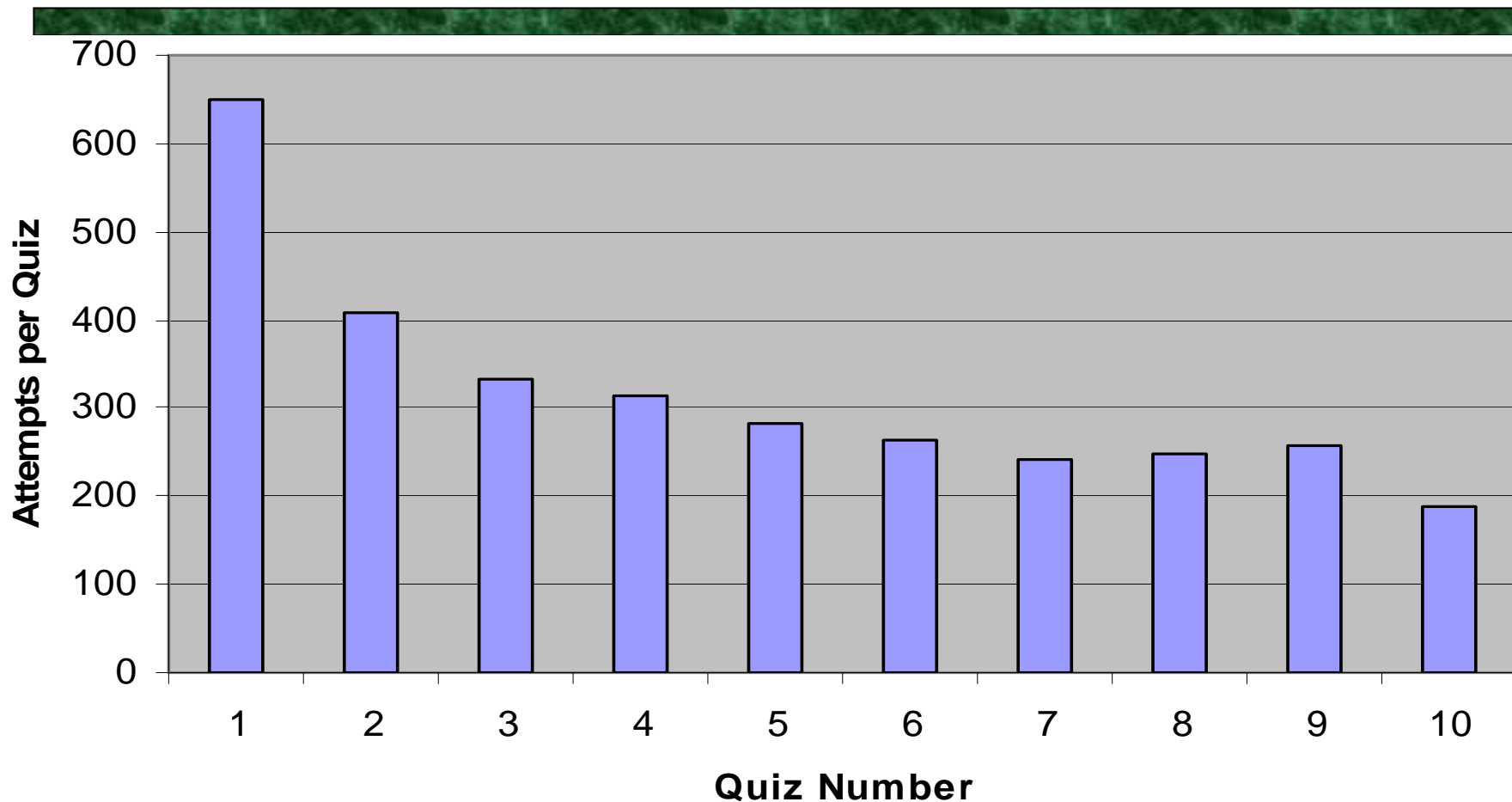
Discussion & Results

History: In 2001 there was no web-based learning in the Department

Now:

- 13 Homeworks at ~10 problems/HW, QUICK for each, Math quizzes & MPE
 - Tens of thousands of quizzes per section
- Most of the tools are now widely adopted by most instructors to some degree
 - Easy to incorporate, high likelihood of adoption
- Other courses already created

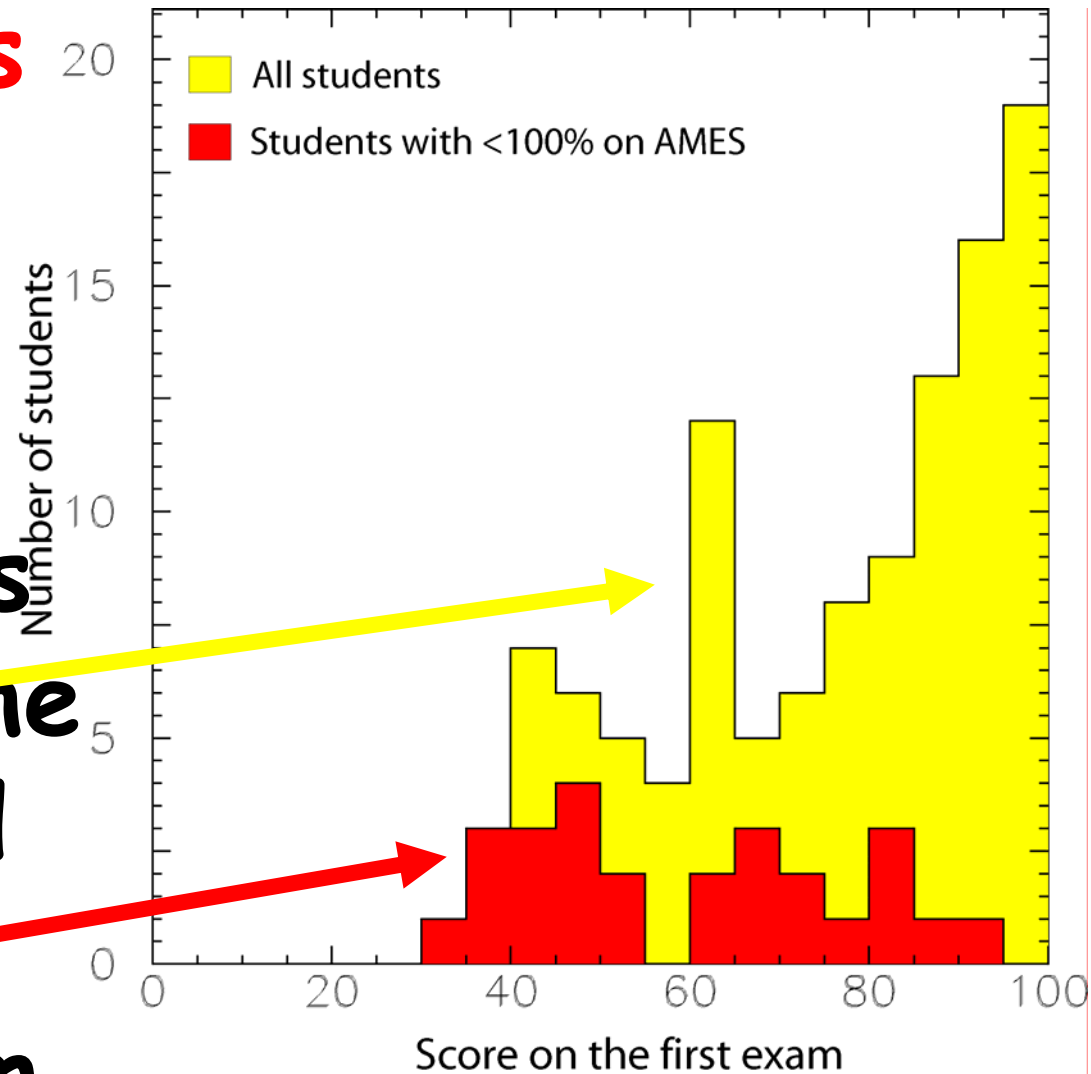
Other Results



- Students are clearly getting better at the math
- More than 3,000 math quizzes for 120 students, or ~300 math problems/student
- Average score for each quiz jumps by ~10%

First Exam Scores after Math

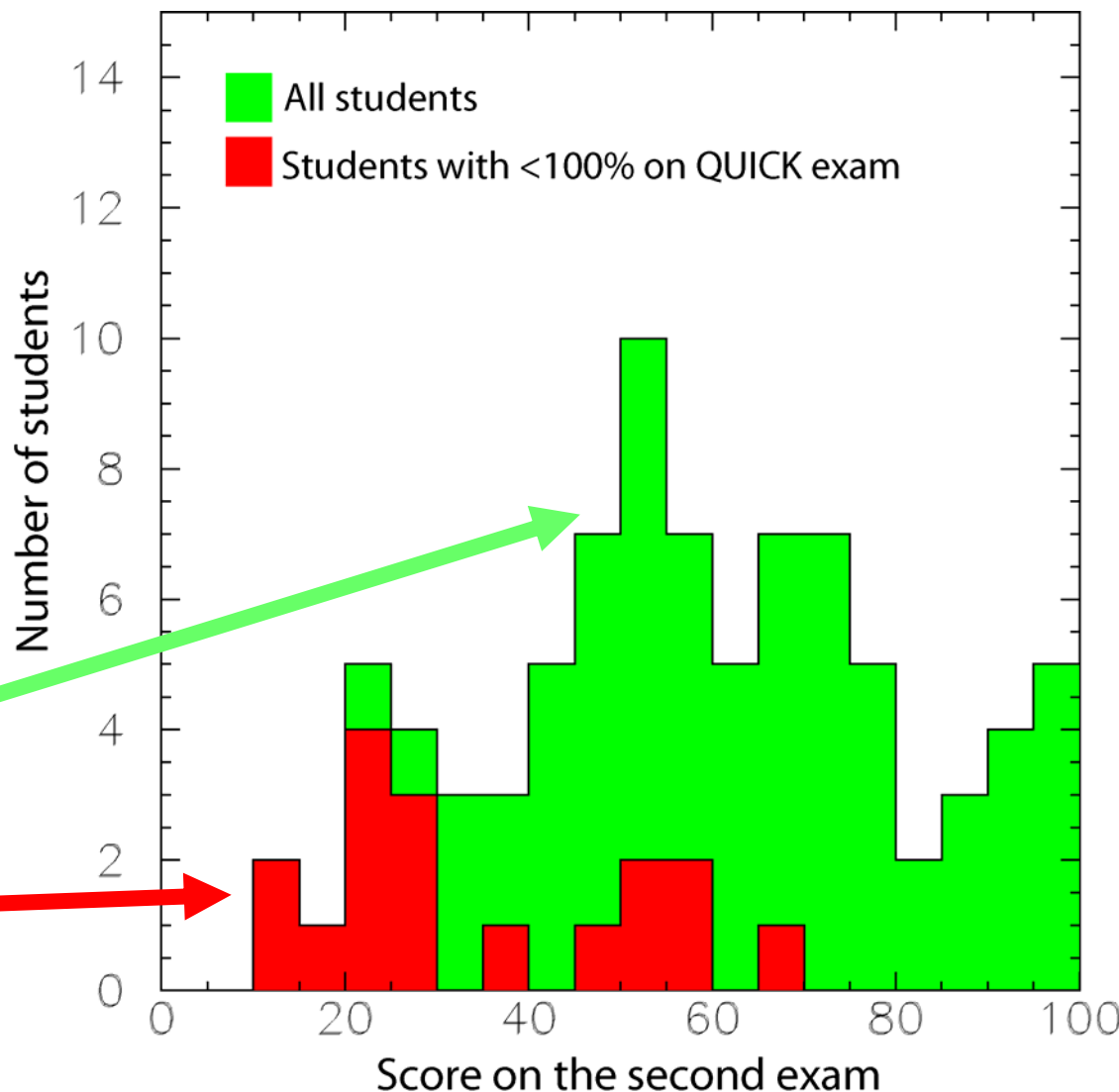
- The math quizzes pre-date the mini-practice exams
- Compare students who completed the math quizzes and those who didn't on the first exam



Mini-practice Exams

Study after incorporating QUICK mini-practice exams

- In my course about 60% of the students take the mini-practice exam
- Compare students those who did with those who didn't



What we CAN'T claim

None of these results prove learning

- High degree of correlation between good students and likelihood of taking the mini-practice exam in the first place

But...

BUT, it does provide a really nice graph to show the students! → Effective motivation

- *"You want to do well on the exam? Do what the good students do and get a 100% on the practice exam"*
- *"You want to know if you're ready for the exam BEFORE the exam (while you can still do something about it)? WebCT will TELL YOU if you are ready, and if not which problems you need to study"*
- Gives them something to DO


Other Observations

- **Surveys results:** More time spent on problem solving, not memorization & book reading
- **Many Instructors/Teaching Assistants note:**
 - Clear shift among weaker students to use symbol based problem solving methods and self-checking
 - Marked decrease of student complaints about difficulty following simple math steps
- **Personal Note for my class:** The 2005 End-of-Semester Challenge exam:
 - 127 of 581 in my course (22%)
 - 23 took Challenge Exam, 12 from my class (52%)
 - Seven of Top-10 scores, Eleven of Top-15

All are consistent with expectations from the literature

Conclusions

- A combined program of integrating Web-based tools into Introductory physics courses:
 - Develops math skills
 - Cheaply checks homework with quick feedback
 - Offers LOTS practice problem feedback
- Pervasively adopted
 - Thousands of quizzes taken
 - Incorporated into the other large courses
- Appears to have real benefit to students, and is readily implemented by new instructors



"Integrating Web-Based Teaching Tools into Large University Physics Courses,"
David Toback, Andreas Mershin and
Irina Novikova, *The Physics Teacher*,
Vol 43, P. 594 (December 2005)

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