WeBWorK: An effective online tool for assessment in Mathematics

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Motivation

Issues

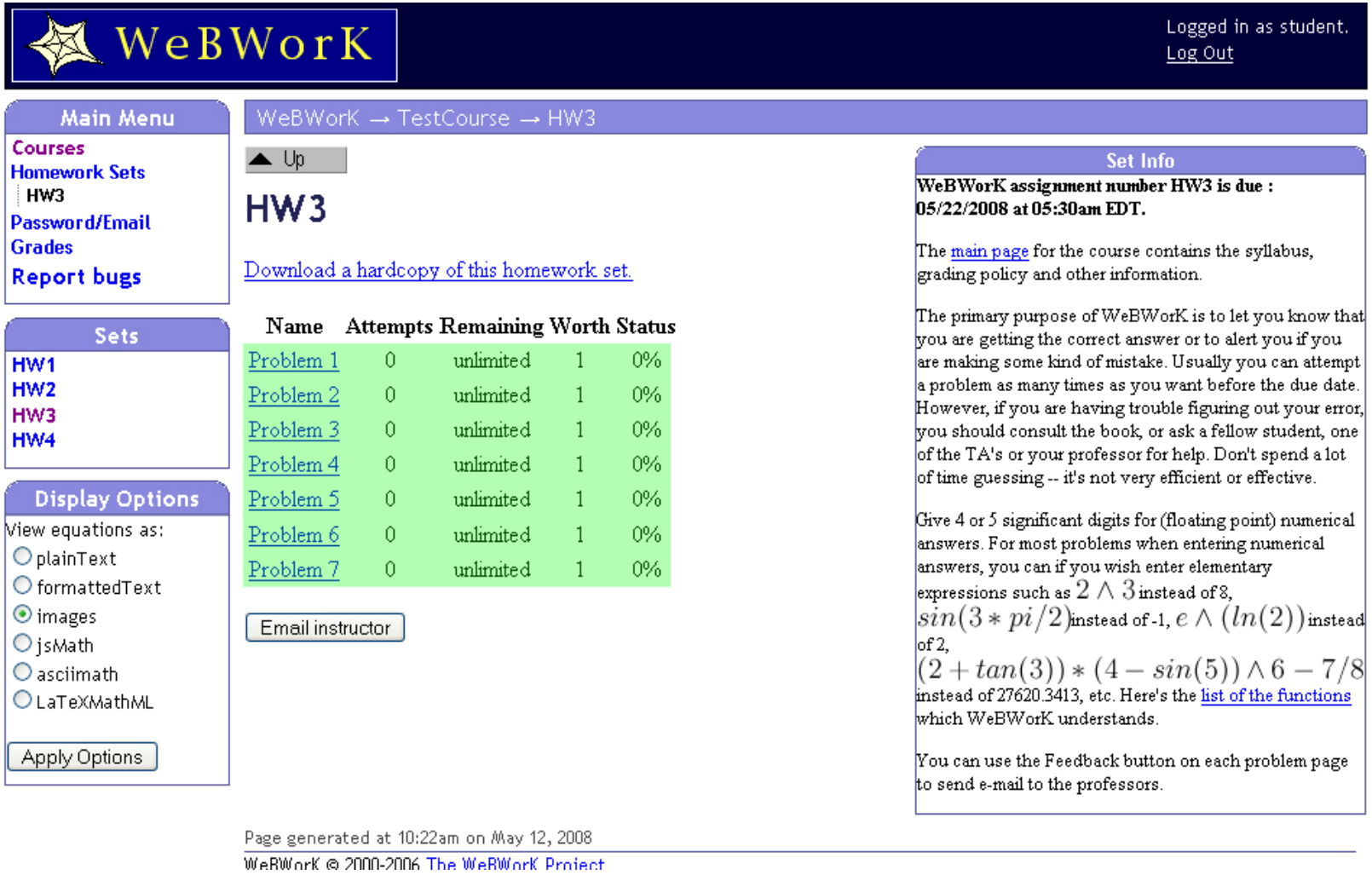
- Free up TA time to use it more effectively and efficiently while continuing to provide feedback on homework.
- Provide faster feedback on homework

Approach

WeBWorK, an open-source online homework system supported by the Mathematical Association of America and the NSF.

What is WeBWorK?

An open-source online homework tool . . .



*Locally maintained by CTLT

WeBWorK offers:

- Variety of answer formats
  - Numbers (with specified error tolerance)
  - Mathematical expressions (symbolic)
  - Words
  - Multiple Choice
  - Essay (unmarked)
- Randomized parameters: can generate unique numbers and graphs for each student
- Specified number of attempts, with instant feedback
- Large existing problem database of math problems
- Quiz mode for limited-time assignments

How we use WeBWorK

Courses:

- Differential Calculus (MATH 100, 102, 104, 110, 180, 184)
- Integral Calculus (MATH 101, 103, 105)
- Multivariable Calculus (MATH 200, 253)
- Vector Calculus (MATH 264)
- Linear Algebra (MATH 152, 221)

Total of 9673 students in 2012/13

Implementation:

- Weekly assignments worth up to 10% of final grade
- Randomized numbers for each student
- Multiple attempts
- Common assignments to all sections in most courses
- Diagnostics/review assignment at start of term
- Pre-reading quizzes

How students use WeBWorK:
(first year courses, self-reported)

Productive Habits

Rework a problem to correct errors either on your own or by searching for hints in your notes/textbook.

Never	Occasionally	Often	Very Often
7%	28%	38%	28%

Ask Instructor/TAs or other students for help to solve problems.

Never	Occasionally	Often	Very Often
36%	31%	21%	13%

Unproductive Habits

Use Wolfram Alpha or similar resources to obtain the solution to a problem.

Never	Occasionally	Often	Very Often
29%	41%	16%	13%

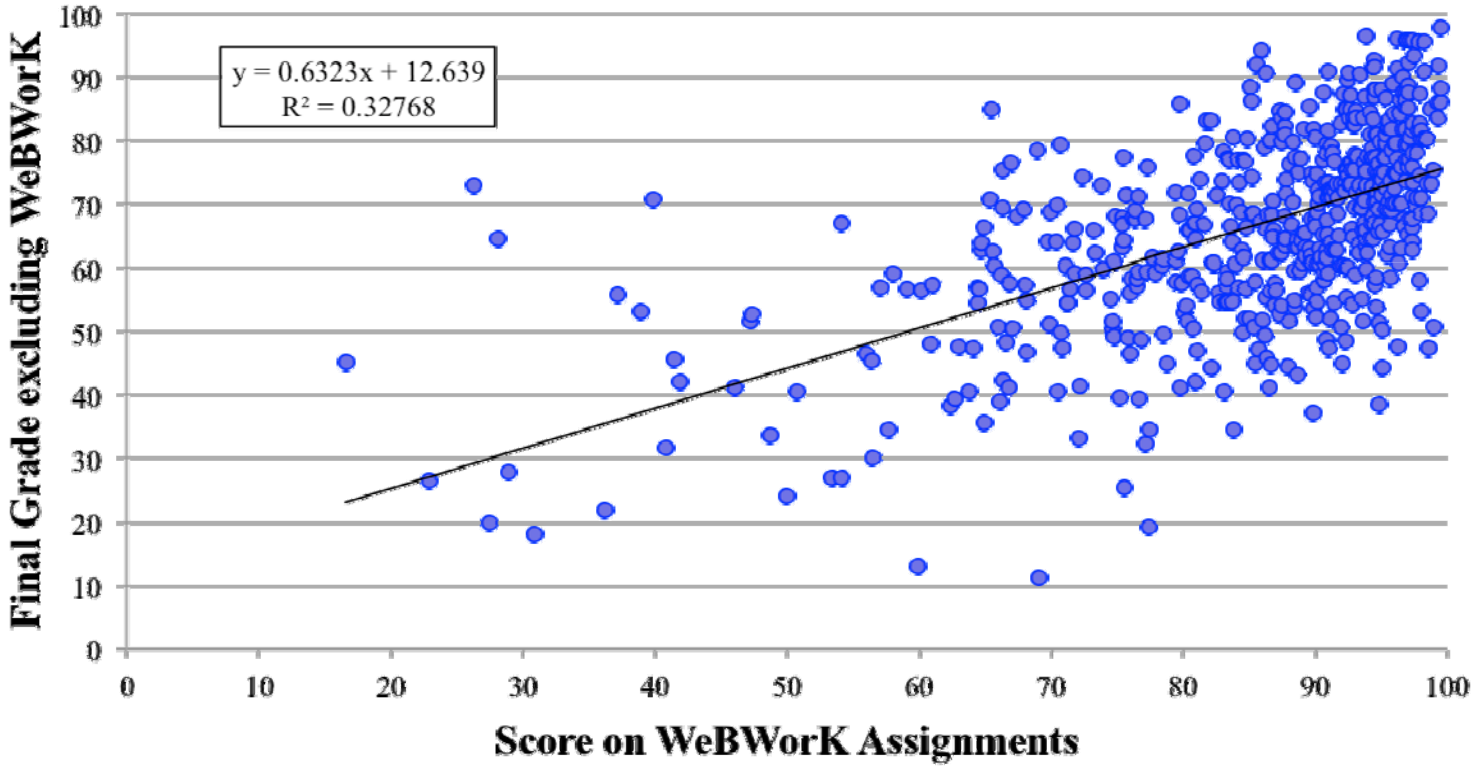
Guess the answer to a question.

Never	Occasionally	Often	Very Often
34%	47%	14%	5%

Correlation with marks

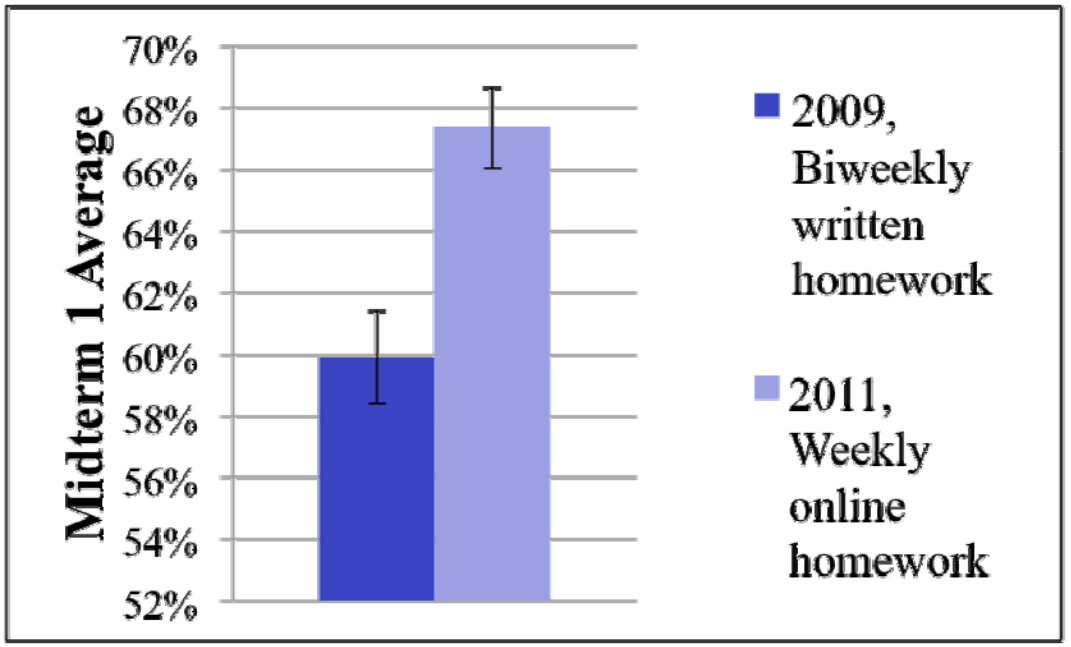
(MATH 102)

- WeBWorK consists of weekly homework and pre-lecture quizzes
- Average WeBWorK score 85.2%
- Median WeBWorK score 89.9%



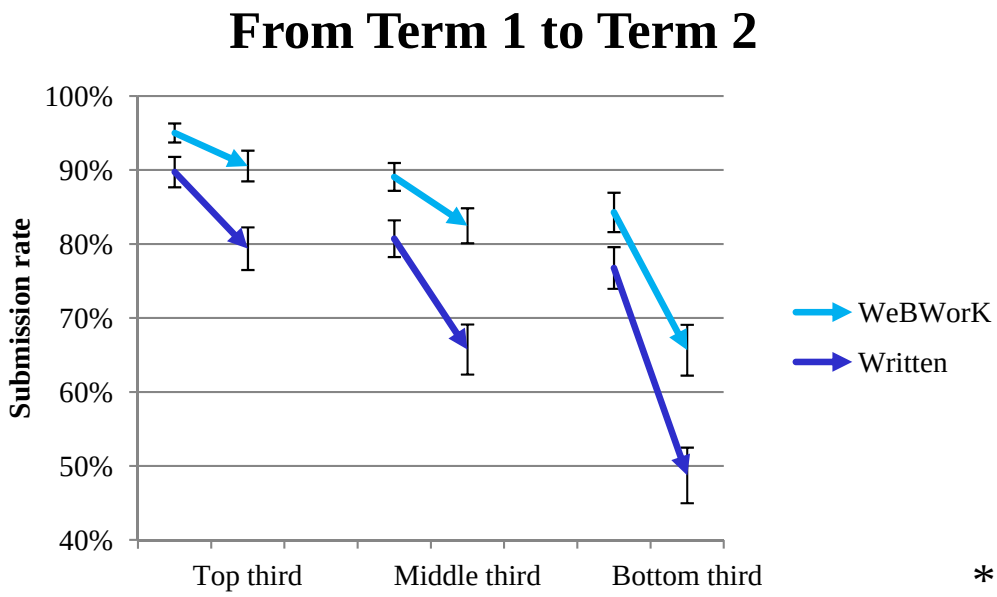
Improved exam performance
(MATH 101: Written vs. online homework)

- 2009: Biweekly written assignments and in-class quizzes
- 2011: Weekly online assignments and in-class quizzes
- Same instructor



Persistence in assignment submission

(MATH 110 – A two term course)



Number of students: 238

Grouped by final exam grades:

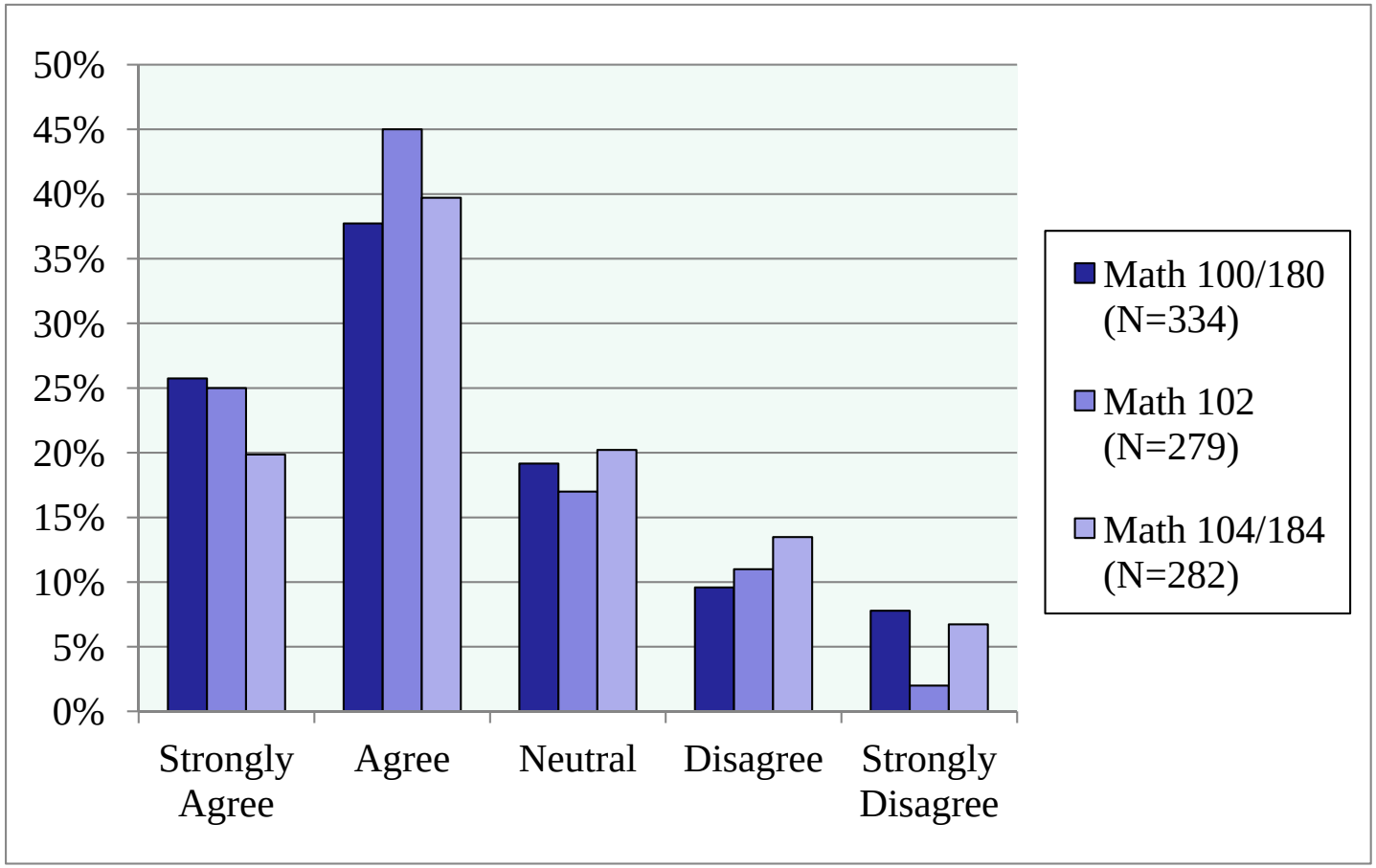
- Top third: > 59%
- Middle third: 44% to 59%
- Bottom third: < 44%

*Submitted means received a mark of >20%

The drop of submission rate from Term 1 to Term 2 is smaller for WeBWorK than for written assignments, regardless of student performance.

Students' attitudes about immediate feedback

"The immediate responses I got from WeBWorK helped me learn the course material." (online survey)



Students' attitudes about online vs. paper-based homework

"If you were to take a similar course again, which homework program would you prefer ?"

(online survey, N = 618 respondents)

Online survey options	% responses
Only WeBWorK assignments	**31%**
Only hand-in assignments	8%
Only in-class quizzes based on a list of suggested problems	5%
A combination of WeBWorK and short hand-in assignments	**25%**
A combination of WeBWorK and short in-class quizzes	**29%**

Sources of students' frustration in WeBWorK

Students are often

- confused by the answer format required by WeBWorK
- frustrated by the particular syntax required by WeBWorK

Guessing behaviour on true/false questions (MATH 221, Two sections)

Many multiple true-false questions were given throughout the course:

- One section: Unlimited attempts: 7 true-false statements in a question
- Another section: Limited (7) attempts: 5 true-false statements

No indications on correct answers until all are correct.

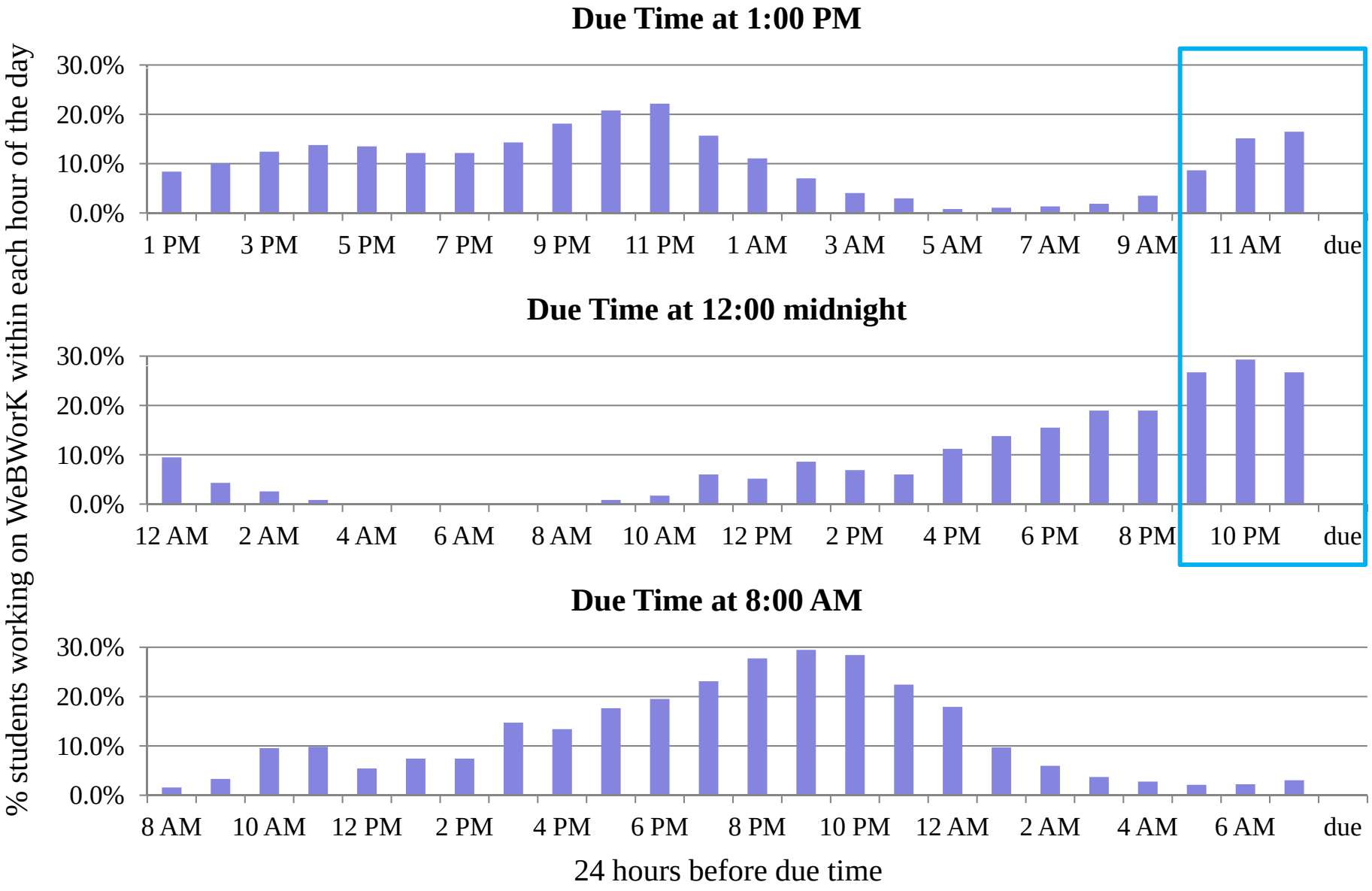
	Unlimited attempts	Limited attempts
Avg % students who got full mark in true/false questions	75.3%	79.5%
Avg % students who exhibit “guessing behaviour” when doing questions (“guessing behaviour” = 4 submissions within 30 seconds)	47.4%	9.7%

Who guessed? Both high- and low-performing students did.

	% students who exhibited “guessing behaviour”
Top third (final grade > 77)	40.4%
Middle third (final grade from 64 to 77)	52.8%
Bottom third (final grade < 64)	51.4%

Due time and last-minute working trend

(3 different first/second year course)



Summary

- WeBWorK has now been implemented in most of our large undergraduate math courses.
- Students report in surveys that they:
  - find the immediate feedback provided to be helpful for learning
  - prefer a homework structure that includes some WeBWorK over one that consists only of traditional written assignments
  - use the system primarily in ways that are productive for learning
- Evidence that WeBWorK is an effective online assessment tool:
  - performance on WeBWorK assignments correlates well with overall course performance
  - submission rates are higher and decrease more slowly over the term than with written homework.
  - there are indications that exam performance increases with the introduction of WeBWorK

Future work

- Analyse types of errors (i.e. guessing vs. syntax/format errors)
- Improve specific assignments and problems to reduce student frustration with syntax and answer formats.
- Develop custom remedial assignments based on diagnostic results