Implementing E-Learning in the Teaching of Calculus

Colloquium
Mathematics and Statistics Department
University of Maine

Thomas Prellberg

Queen Mary, University of London
Libra Visiting Professor of Diversity, University of Maine

November 20, 2008
Introduction

- E-learning for Calculus I: a web-based platform for
  - self-paced student learning,
  - on-line assessment, and
  - immediate feedback.

- A practitioner’s view
Introduction

E-learning for Calculus I: a web-based platform for
  - self-paced student learning,
  - on-line assessment, and
  - immediate feedback.

A practitioner’s view

Implementing assessment mechanisms in e-learning
  - summative assessment
  - formative assessment
Restructuring First-Year Mathematics

General restructuring of first-year mathematics due to
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- dropping A-level standards

(A-levels: national standardized subject tests)
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- rapid increase of student numbers

- stable graduate student numbers: stretching of resources
First-Year Mathematics

- First-Year Syllabus (of Three-Year BSc Study Programme)

Essential Mathematical Skills

Semester 1
- Calculus I
- Probability I
- Geometry I
- Mathematical Computing

Semester 2
- Calculus II
- Introduction to Statistics
- Differential Equations
- Introduction to Algebra
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Suitable for e-learning: Calculus I and Calculus II
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Suitable for e-learning: Calculus I and Calculus II
besides, Calculus had not been updated for some 20 years...
Choice of Platform

Selection of Thomas’ Calculus together with CourseCompass / MyMathLab (Pearson Education)
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Similar products: Maple T.A., WileyPLUS with Webassign, . . .
Interlude: Maths vs Math

British terms and US equivalent

- Maths: math
Interlude: Maths vs Math

British terms and US equivalent

- Maths: math
- Trapezium:
Interlude: Maths vs Math

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- Invigilator: Proctor
- Countless others such as Titbit: tidbit, etc.
CourseCompass

E-Learning and Calculus

Features

All the usual features (like in e.g. WebCT)
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All the usual features (like in e.g. WebCT) plus plenty of online content (too much?):
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- Video lectures
- Java-based animations
- Powerpoint slides
- Maple/Mathematica worksheets
- Revision help: flashcards/reviewcards
- ...
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But more importantly

- Exercises with integrated support/feedback
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- Exercises with integrated support/feedback
- Several environments: homework/quiz/test
- Personalized study plan
Features of Exercises

- Intelligent, Mathematica-based engine: more than multiple-choice questions!
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- Algorithmic questions (randomized numbers)
- Question pooling possible for more randomness
- More than 2000 exercises available
- Fully integrated help available
- You can also design your own questions
Homework environment: sample problem

Find the value or values of c that satisfy the equation \( \frac{f(b) - f(a)}{b - a} = f'(c) \) in the conclusion of the Mean Value Theorem for the following function and interval.

\[
f(x) = 2x^2 + 5x - 3, \quad [-1, 1]
\]

The value(s) of c that satisfy the equation are \(0\).

Enter any number or expression in the blue-outlined box, then click Check Answer.
Exercise-specific support and help

- “Help Me Solve This”: a step-by-step guide through the solution requiring the student to provide the result of intermediate calculations
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- “Help Me Solve This”: a step-by-step guide through the solution requiring the student to provide the result of intermediate calculations
- “View an Example”: shows the full solution of a sample problem
Homework environment

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- “Animation”: leads to a java-based applet for hands-on experimentation
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- “Textbook Pages”: leads to the relevant section in the textbook
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- “Textbook Pages”: leads to the relevant section in the textbook
- “Ask my Instructor”: enables the student to email the lecturer
Demonstration
Find the value or values of c that satisfy the equation \( \frac{f(b) - f(a)}{b-a} = f'(c) \) in the conclusion of the Mean Value Theorem for the following function and interval.

\[ f(x) = 4x^2 + 4x - 3, \quad [-3, 3] \]

The value(s) of c that satisfy the equation \( \frac{f(b) - f(a)}{b-a} = f'(c) \) is/are \( 1 \).

(Type a simplified fraction. Use a comma to separate answers as needed.)
Quiz/test environment

Help switched off, several options

- limit total time allowed
Quiz/test environment

Help switched off, several options

- limit total time allowed
- limit number of attempts
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Help switched off, several options

- limit total time allowed
- limit number of attempts
- block other features
Quiz/test environment

Help switched off, several options

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- allow/disallow review
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- allow/disallow review
- password protection (proctor mode)
Quiz/test environment

Help switched off, several options

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- limit number of attempts
- block other features
- allow/disallow review
- password protection (proctor mode)
- scramble question order
Demonstration
Study Plan

Students get their personal study plan generated:
Study Plan

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- Start by taking a sample test or assigned test
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- Start by taking a sample test or assigned test
- Now the study plan indicates areas that need more practice...
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- ... and offers specific practice questions
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- Take another test to check if material is mastered
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Students can monitor their own progress
Study Plan

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Students can monitor their own progress (and so can the lecturer)
Introduction  Background  Platform  Features  Implementation  Feedback for The Lecturer  Evaluation  Calculus and Beyond

MAS115 QMUL 2007/8 [325]  >  Back to Gradebook

Previous Student

Study Plan

Click a chapter below to start practicing, or follow these steps to create a personalized study plan.

1. Take a sample test or an assigned test or quiz. Then return to this page.
2. Practice the topics you need to study ( ).
3. To prove mastery( ), take another sample test or an assigned test or quiz.

Show All  Show What I Need to Study

Jump to where I worked last

<table>
<thead>
<tr>
<th>Book Contents for All Topics</th>
<th>Correct</th>
<th>Worked</th>
<th>Available Exercises</th>
<th>Time Spent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch 1: Preliminaries</td>
<td>31</td>
<td>31</td>
<td>79</td>
<td>4h 16m 27s</td>
</tr>
<tr>
<td>Ch 2: Limits and Continuity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Rates of Change and Limits</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>10m 20s</td>
</tr>
<tr>
<td>2.2 Calculating Limits Using the Limit Laws</td>
<td>16</td>
<td>16</td>
<td>18</td>
<td>48m 19s</td>
</tr>
<tr>
<td>2.3 The Precise Definition of a Limit</td>
<td>7</td>
<td>8</td>
<td>13</td>
<td>56m 31s</td>
</tr>
<tr>
<td>2.4 One-Sided Limits and Limits at Infinity</td>
<td>2</td>
<td>2</td>
<td>18</td>
<td>20m 27s</td>
</tr>
<tr>
<td>2.5 Infinite Limits and Vertical Asymptotes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6 Continuity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Implementation

Central question:

“How do we get students to embrace this new technology to maximize their learning?”
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- First, students are given unassessed exercise problems in homework mode.
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- Assessed coursework consists of problems in quiz mode.
- To encourage practice, multiple coursework submissions are allowed.
- Only the final submission counts.
Implementation

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  - Students work on exercises with tutors present
  - Tutor-to-student ratio 1:10
- Assessment
  - 10% ten courseworks
  - 10% two in-term tests
  - 80% final exam
## Item Analysis - Thomas Prellberg - Windows Internet Explorer

**Name:** Midterm Test  
**Date Due:** 11/09/06 5:10pm

**Results View:** All Scores  
Results submitted by an instructor are not included in this data.

<table>
<thead>
<tr>
<th>#</th>
<th>Question ID</th>
<th>Objective</th>
<th>Correct</th>
<th>Partial Credit</th>
<th>Incorrect</th>
<th>Incomplete</th>
<th>Avg Time Spent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2.31</td>
<td>Find the limit.</td>
<td>234</td>
<td>0</td>
<td>45</td>
<td>9</td>
<td>3m 14s</td>
</tr>
<tr>
<td>2</td>
<td>2.3.11</td>
<td>Find delta.</td>
<td>242</td>
<td>0</td>
<td>36</td>
<td>10</td>
<td>1m 55s</td>
</tr>
<tr>
<td>3</td>
<td>2.4.29</td>
<td>Find the limit involving (sin x)/x.</td>
<td>249</td>
<td>0</td>
<td>24</td>
<td>15</td>
<td>2m 7s</td>
</tr>
<tr>
<td>4</td>
<td>2.4.61</td>
<td>Find the limit with noninteger or negative powers.</td>
<td>215</td>
<td>0</td>
<td>62</td>
<td>11</td>
<td>2m 30s</td>
</tr>
<tr>
<td>5</td>
<td>2.5.33</td>
<td>Find the equations of the asymptotes. Then graph the rational function.</td>
<td>185</td>
<td>92</td>
<td>5</td>
<td>6</td>
<td>4m 3s</td>
</tr>
<tr>
<td>6</td>
<td>2.6.21</td>
<td>Determine where a function is continuous.</td>
<td>215</td>
<td>0</td>
<td>61</td>
<td>12</td>
<td>1m 46s</td>
</tr>
<tr>
<td>7</td>
<td>3.1.33</td>
<td>Solve applications.</td>
<td>243</td>
<td>0</td>
<td>44</td>
<td>1</td>
<td>1m 11s</td>
</tr>
<tr>
<td>8</td>
<td>3.2.29</td>
<td>Find the derivative of all orders of the function.</td>
<td>227</td>
<td>59</td>
<td>1</td>
<td>1</td>
<td>3m 45s</td>
</tr>
<tr>
<td>9</td>
<td>3.6.13</td>
<td>Find the derivatives of rational powers.</td>
<td>178</td>
<td>0</td>
<td>105</td>
<td>5</td>
<td>5m 29s</td>
</tr>
<tr>
<td>10</td>
<td>3.6.45</td>
<td>Find the slope, the tangent line, or the normal line at the given point.</td>
<td>230</td>
<td>0</td>
<td>45</td>
<td>13</td>
<td>3m 51s</td>
</tr>
<tr>
<td>11</td>
<td>4.2.1</td>
<td>Find the values of c that satisfy the conclusion of the Mean Value Theorem.</td>
<td>188</td>
<td>0</td>
<td>88</td>
<td>12</td>
<td>4m 50s</td>
</tr>
<tr>
<td>12</td>
<td>4.2.33</td>
<td>Find the function from a given derivative whose graph passes through a given point.</td>
<td>241</td>
<td>0</td>
<td>41</td>
<td>6</td>
<td>2m 32s</td>
</tr>
</tbody>
</table>

Legend:
- # of students submitted: 288  
- total # of attempts: 288

[Export class summary]
Data on Student Performance

Two types of data available:

- Statistical data on performance, broken down by individual problems
  - very useful to monitor student learning in a timely way
  - ability to identify and respond to specific difficulties
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  - very useful to monitor student learning in a timely way
  - ability to identify and respond to specific difficulties

- **Individual data on performance for each student**
  - ability to see precisely when and for how long a student has been online: “Big brother is watching”
Demonstration
Looking Back

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  - >10% gave MyMathLab 0/5 rating
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  but we’ve just updated to Windows XP...
Student Performance

- The level of the exam paper had been increased
Student Performance

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- Calculus I exam results correlated well with other exams
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Calculus I exam results correlated well with other exams
Improvement across module boundaries:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>2004/5</td>
<td>8.5</td>
<td>34.1</td>
<td>57.9</td>
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<td>95.7</td>
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<td>14.1</td>
<td>25.6</td>
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<tr>
<td>2006/7</td>
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<td>32.2</td>
<td>73.1</td>
<td>88.6</td>
<td>97.0</td>
<td>97.7</td>
<td>98.1</td>
</tr>
</tbody>
</table>

Cumulative pass rate in Essential Mathematics

“Essential Mathematics” achieved record pass-rates!
Calculus and Beyond

The use of MyMathLab for Calculus has been a success.

- Usefulness of MyMathLab for e.g. Engineering Mathematics?
- Similar environments, e.g. MyStatLab for statistics modules?
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Ongoing development with little established consensus. One year ago, the American Mathematical Society started to solicit comments about online grading:

http://firstyearmathematics.blogspot.com