Progressive Teaching with Tablet Technology

Birgit Loch
Mathematics & Computing
lochb@usq.edu.au
Overview

- Handwriting in mathematics teaching
- How did I get involved in tablets?
- Hardware and software configurations
- Details of the study
- Examples
- Student/instructor attitude
- Application to distance education
- Future directions and alternative hardware setups
Townsley (2002)

One reason we all use blackboards to write down mathematics is the symbols with which mathematics is communicated. Writing the symbols down gives the student a chance to read what has been spoken and thus access the content via several senses.
Loomes et al. (2002)

*Students need to learn mathematical explanation*
Handwriting in mathematics teaching

- Students part of development process, can contribute, comment, be shown alternate paths, spontaneously develop in real time -> student directed learning
- Interactive, dynamic, flexible learning process
- Engages students, builds on their abilities
- Can draw additional graphs, pose further problems
- Increases my motivation and engagement
- Passive lecture modes are tiring, tendency to cover material too fast
How did I get involved in tablets

- First year Calculus and Linear Algebra course at UQ
- 320 students
- Three lectures each week
- On campus students only
- Lecture material as workbook (PDF or for sale in print)
- Relevant material and blank boxes
The lecture theatre

- Standard set up:
  - Data projector and OHP until end of S1, 2004
- S2, 2004:
  - Either data projector or OHP
Hardware configurations

- **Graphics tablet**
  - About $100
  - Various sizes
  - Wacom market leader

- **Tablet PC**
  - Windows XP Tablet Edition
  - Additional ink functions in MS Office
  - Handwriting recognition
  - $3000+
Software configurations

- Adobe Acrobat Standard
  - Natural conversion from LaTeX to PDF
  - Commenting function allows electronic ink
  - “printed” to standard format PDF file to allow viewing with Acrobat Reader
  - Can add images, typed comments, audio, record audio comment

- BUT:
  - Smoothening of handwriting
  - Writing near previous comment
Software configurations

- **Powerpoint**
  - Equation editor sometimes awkward to handle
  - Use LaTeX to generate formula, then take screenshot and include this in slide
  - Or write formula by hand while preparing slide
  - Need latest version of MS Office to save

\[ f(x) = \frac{x-1}{x^2-2x+1} \]
Details of the study

- Over four consecutive semesters
- Four different mathematics courses – three first year and one second year
- Two courses with graphics tablet, two with tablet PC
- Two lecturers
- Three courses at UQ, one at USQ
- “workbook” for organizational structure of lecture
Details of the study

- S2, 2004. UQ
  - Calculus and Linear Algebra I (all)
  - 320 students, 1st year
  - Engineering and Science

- S2, 2005. UQ
  - Discrete Mathematics (part)
  - 120 students, 1st year
  - IT, Science, Electrical Engineering

- S1, 2005. UQ
  - Calculus and Linear Algebra II (LA only)
  - 600 students, 2nd year
  - Engineering and Science

- S1, 2006. USQ
  - Algebra and Calculus I (Calculus only)
  - 120 ONC, 110 EXT, 1st
  - Engineering and Science
Details of the study – course 1

<table>
<thead>
<tr>
<th>Details</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2, 2004. UQ</td>
<td>One lecturer</td>
</tr>
<tr>
<td>Calculus and Linear Algebra I (all)</td>
<td>Initially OHP and computer</td>
</tr>
<tr>
<td>320 students</td>
<td>Graphics tablet (A6)</td>
</tr>
<tr>
<td>Engineering and Science</td>
<td>PDF</td>
</tr>
<tr>
<td></td>
<td>No technical problems</td>
</tr>
<tr>
<td></td>
<td>Notes made available on website afterwards</td>
</tr>
</tbody>
</table>

Birgit
## Details of the study – course 2

<table>
<thead>
<tr>
<th>Two lecturers</th>
<th>S1, 2005. UQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Algebra taught</td>
<td>Calculus and Linear Algebra II (LA only)</td>
</tr>
<tr>
<td>with graphics tablet (A3)</td>
<td>600 students</td>
</tr>
<tr>
<td>Calculus taught writing on</td>
<td>Engineering and Science</td>
</tr>
<tr>
<td>OHP</td>
<td></td>
</tr>
<tr>
<td>PDF</td>
<td></td>
</tr>
<tr>
<td>Major technical problems</td>
<td>Diane</td>
</tr>
<tr>
<td>No notes made available</td>
<td></td>
</tr>
</tbody>
</table>
Details of the study – course 3

- S2, 2005. UQ
- Discrete Mathematics (part)
- 120 students, 1st year
- IT, Science, Electrical Engineering

- Two lecturers
- One part taught with tablet PC
- Second part taught writing on OHP
- PDF
- Minor technical problems, fixed quickly
- No notes made available
Details of the study – course 4

- Two lecturers
- Calculus taught with tablet PC
- Powerpoint
- Minor technical problems, fixed quickly
- Notes made available on website afterwards

- S1, 2006. USQ
- Algebra and Calculus I (Calculus only)
- 120 ONC, 110 EXT, 1st
- Engineering and Science

Birgit
1.3.2 Properties of absolute value

Workbook Solutions 1.6:

(i) \( |a|^2 = a^2 \implies |a| = \sqrt{a^2} \quad (\sqrt{2^2} = 1 \cdot 2 \cdot 2) \)

(ii) \( |ab| = |a| \cdot |b| \quad (|(-3)(4)| = |-3| \cdot |4| = 3 \cdot 4 = 12) \)

\( 1 \cdot 2 \cdot 2 = 12 \)

(iii) \( |a + b| \leq |a| + |b| \)

(triangle inequality)

(iv) \( |a^n| = |a|^n \quad , \quad n \in \mathbb{Z} \), \( a \neq 0 \) for negative \( n \)

\( a^{-2} = \frac{1}{a^2} \), \( |(-3)^2| = |-3|^2 = 3^2 = 9 \)
12.3 Application (area of a triangle)

Find area of the \( \Delta ABC \) with vectors \( v, w \) along edges as shown in figure 57.

\[ \text{area} = \frac{1}{2} \text{base} \cdot \text{height} \]

- \( \text{area} = \frac{1}{2} ||v|| ||w|| \sin \theta \)
- \( \text{area} = \frac{1}{2} ||v \times w|| \)

Figure 57: Find the area of the triangle \( ABC \)
Areas Between Curves

How do we find the area between two curves defined by \( y = f(x) \) and \( y = g(x) \)?

\[
\int_a^b f(x) \, dx - \int_a^b g(x) \, dx
\]

\[
= \int_a^b (f(x) - g(x)) \, dx
\]

Area = \( \int_a^b (f(x) - g(x)) \, dx \), so long as \( f \) is above \( g \) over the domain \([a, b]\).
The Quotient Rule

\[ \frac{d}{dx} \left( \frac{u}{v} \right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} = \frac{\frac{du}{dx} v - u \frac{dv}{dx}}{v^2} \]

or

\[ \left( \frac{u}{v} \right)' = \frac{u'v - uv'}{v^2} = \frac{\frac{u}{v} v' - u v'}{v^2} \]

\[ h(x) = \frac{f(x)}{g(x)} \Rightarrow h'(x) = \frac{f'(x)g(x) - g'(x)f(x)}{(g(x))^2} \]
Inverse trigonometric functions

\[ \frac{d}{dx} \arctan x = \frac{1}{1 + x^2} \]

Why?

Let \( y = \arctan x \)

Then \( \tan y = \tan(\arctan x) = x \)

and \( \frac{d}{dx} \tan y = \frac{d}{dy} \tan y \cdot \frac{dy}{dx} = \frac{1}{\cos^2 y} \cdot \frac{dy}{dx} = \frac{dx}{dy} \cdot \frac{dy}{dx} = 1 \)

\[ \Rightarrow \frac{dy}{dx} = \cos^2 y = \frac{1}{\sec^2 x} = \frac{1}{1 + \tan^2 x} \]

\[ \Rightarrow \frac{d}{dx} \tan y = \frac{d}{dx} \frac{\sin y}{\cos y} = \frac{d}{dy} \frac{\sin y}{\cos y} \cdot \frac{dy}{dx} = \frac{\cos y \cdot \cos y + \sin y \cdot \sin y}{\cos^2 y} \cdot \frac{dy}{dx} = \frac{\cos^2 y}{\cos^2 y} \cdot \frac{dy}{dx} = \frac{dy}{dx} \cdot \frac{dy}{dx} = 1 \]

\[ \Rightarrow y = \arctan x = \frac{1}{1 + \tan^2 y} = \frac{\cos^2 y}{\cos y \cdot \cos y} = y \left( \frac{\cos^2 y + \sin^2 y}{\cos^2 y} \right) = y \left( 1 + \tan^2 y \right) = 1 \]
## Student attitude

<table>
<thead>
<tr>
<th>Question</th>
<th>1 (65)</th>
<th>2 (160)</th>
<th>3 (38)</th>
<th>4 (54)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I prefer if lecturer writes on computer</td>
<td>80%</td>
<td>12%</td>
<td>24%</td>
<td>75%</td>
</tr>
<tr>
<td>I prefer if lecturer writes on OHP</td>
<td>3%</td>
<td>60%</td>
<td>42%</td>
<td>2%</td>
</tr>
<tr>
<td>Writing during lectures helps my understanding</td>
<td>89%</td>
<td>65%</td>
<td>95%</td>
<td>98%</td>
</tr>
<tr>
<td>It is not easy to read</td>
<td>12%</td>
<td>38%</td>
<td>11%</td>
<td>6%</td>
</tr>
<tr>
<td>It is easy to read</td>
<td>79%</td>
<td>30%</td>
<td>71%</td>
<td>80%</td>
</tr>
<tr>
<td>Lecturer appeared comfortable with technology</td>
<td></td>
<td></td>
<td>73%</td>
<td>93%</td>
</tr>
</tbody>
</table>
Influences on student attitude

- Direct comparison with other modes of delivery
- Technical problems wasting time
- Competence using the stylus
- Publication of notes on Web
What changed student attitude from course 2 to course 3?

- Interviewed focus group - two students enrolled in course 2 and 3
- Student perception of tablet technology improved because of:
  - Size of tablet/tablet PC
  - Lecturer more confident
  - No distraction (“everyone was frustrated”)
  - Material seemed to be covered more quickly
- Tablet technology is not just a teaching tool, it improved their learning (made understanding easier)
Perfect lecture set up. Perfect course for that matter, I’ve really enjoyed this subject, each maths subject should have this setup

- Keeps me awake in lectures
- We work through problems together
- It is an incentive to come to lectures, you can learn more by writing it down
- The graphics pad is easier to see than the OHP
- Love the graphics pad! Very useful and modern, 1000x better than OHT
Student comments (course 4)

- Keep up the writing on the computer because it is easily accessible and easily readable
- It stores electronically what would normally be rubbed off the white board
- Quick and easy (no turning lights on and off)
- Yeah, it goes well. Love your work Birgit!
- Good use of technology, don’t stop now
- Is gooooood
- It’s a good method of teaching, easier to read than whiteboard most times
More comments (course 4)

○ Several students said
  ● Printing takes too much paper
  ● Need more space

○ Some students write notes only, and get the lot afterwards
  ● Concentrate on understanding
Instructor view

Benefits:
- Respond to student question
  - Investigate alternate path to solution
- Active student contribution. Student may find their answer or question recorded on the slide
- Refer back to previous material
- Keep exact high quality record
- Can modify/refine/add to later
- One medium only, no need to swap
Instructor view

○ Dangers:
  ● “A risk inherent in using new technology in the classroom is that the technology becomes a distraction rather than a complement”. (Anderson et al., 2005)
  ● Things can go seriously wrong, and can lead to frustration
  ● ONC student attendance reduced if notes posted on web?
Successful teaching tool

○ Key factors
  ● Added benefit to students (web delivery, easier to see, understand)
  ● Lecturer’s competency and dexterity
  ● Technical problems/reliability of equipment (waste of time)
    ○ Can outweigh all benefits!

○ Hardware
  ● Graphics tablet or tablet PC are fine, as long as the lecturer can handle!
Lecture delivery at a distance

- Can record any movement on the screen and produce video (including audio)
- Software:
  - Camtasia (AVI, flash, MOV, WMV, any codecs)
  - Captivate
- Integrate in Breeze presentation, keep as separate video, create video podcast, stream as WMV, ...
- Watch out for resolution, size, audio quality!
- Example
  ([http://www.sci.usq.edu.au/staff/lochb/talks/MAT1102_calc_l1_wk1_1_talk/MAT1102_calc_l1_wk1_1_talk-3.avi](http://www.sci.usq.edu.au/staff/lochb/talks/MAT1102_calc_l1_wk1_1_talk/MAT1102_calc_l1_wk1_1_talk-3.avi))
  ([MAT1102_calc_l1_wk1_1_talk-3.avi](MAT1102_calc_l1_wk1_1_talk-3.avi))
Future directions

- Podcasting of lectures (MP4/DivX)
- Create interactive lectures with flash?
Alternative hardware setups

- Promethean ACTIVpanel, 15” LCD display
- Interactive Whiteboard
- ACTIVslate wireless tablet (needs whiteboard)
Alternative software setup

○ Classroom Presenter
  ● Requires two computers?
  ● Instructor and presenter version
  ● Anderson et al.

○ Windows Journal
Examples – Powerpoint

Functions (3)

Example

- You may get an exam question like this!

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>50</td>
<td>=IF(B2&gt;30,B2-30,A2)</td>
</tr>
</tbody>
</table>

- What value will appear in cell C3?
Quiz (6)

Which of the following expressions will compute the average of the column of length 10 starting in A2?

a. =Average(A2:A10)
c. =Count(A2:A12)/10
d. =Average(A2:A11) ✓