Tablet Technology in Math Teaching

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Overview

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• Part 2 – distance students
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  – Synchronous online chats/VoIP/shared applications
• The future of mathematical handwriting
  – Mathematical handwriting recognition
• Future directions
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
- Students will write by hand in assignments – they need to see how this is done
Part 1 – on campus students

How I got involved in tablets

- First year Calculus and Linear Algebra course at the University of Queensland
- 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 (but not both!)
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
  - $2500 (with keyboard)
  - $1000 (without keyboard)
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
  – No vector graphics!

\[ f(x) = \frac{x-1}{x^2-2x+1} \]
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 (joint work with Diane Donovan)
- 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 year
• Engineering and Science
1.3.2 Properties of absolute value

Workbook Solutions 1.6:

(i) \( |a|^{2} = a^{2} \Rightarrow |a| = \sqrt{a^{2}} \) \( \sqrt{(-2)^{2}} = 1 \cdot 2 \cdot 1 = 2 \)

(ii) \( |ab| = |a||b| \) \( |(-3)4| = 1 \cdot 3 \cdot 4 = 3 \cdot 4 = 12 \)

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

(iv) \( |a^{n}| = |a|^{n} \) \( n \in \mathbb{Z}, a \neq 0 \) for negative \( n \)
(\( a^{-2} = \frac{1}{a^{2}} \) \( |(-3)^{2}| = 1 \cdot 3 \cdot 2 \cdot 3 = 9 \))
12.3 Application (area of a triangle)

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

![Diagram of triangle with vectors $v$ and $w$]

Figure 57: Find the area of the triangle $ABC$

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

$= \frac{1}{2} \|v\| \|w\| \sin \theta$  

$= \frac{1}{2} \|v \times w\|$
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

\[
\frac{d}{dx} \frac{f(x)}{g(x)} = \frac{f'(x) g(x) - f(x) g'(x)}{[g(x)]^2}
\]

or

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

\[
h(x) = \frac{f(x)}{g(x)} \Rightarrow h'(x) = \frac{f'(x) g(x) - f(x) g'(x)}{[g(x)]^2}
\]
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 \( \frac{d}{dx} \tan y = \frac{d}{dy} \tan y \cdot \frac{dy}{dx} = \frac{1}{\cos^2 y} \cdot \frac{dy}{dx} = \frac{dx}{dx} = 1 \)

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

\[
\frac{d}{dx} \tan y = \frac{d}{dx} \frac{\sin y}{\cos y} = \frac{d}{dy} \frac{\sin y}{\cos y} \cdot \frac{dy}{dx} = \frac{\cos^2 y}{\cos y} - \sin^2 y \cdot \frac{dy}{dy} \cdot \frac{dy}{dx} = \frac{\cos^2 y}{\cos y} - \sin^2 y \cdot 1 \cdot \frac{1}{1 + \tan^2 y} = \frac{\cos^2 y}{\cos y} \cdot \frac{1}{1 + \tan^2 y} = \frac{\cos^2 y}{\cos^2 y} = 1
\]
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) ✓
## 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
Student comments (course 1)

- 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 gooood
- It’s a good method of teaching, easier to read than whiteboard most times
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?
Part 2 – distance students

Students at USQ

• About 26,000 in total (2004 figures)
• Out of which 2/3 are distance students
• Mature age, part time
Traditional classroom
Distance learning “classroom”
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)
• Integrate in Breeze presentation, keep as separate video, create video podcast, stream as WMV, …
• Watch out for resolution, size, audio quality!
• Example
Distance learning “classroom”
Distance learning “classroom”
The problem with maths communication

\[
\int_0^\infty \frac{\pi}{\sqrt{x^3}} \, dx
\]

Type
\[
\int_0^\infty \pi/(x^3)^{1/2} \, dx
\]

Latex
\[
\int_0^\infty \frac{\pi}{\sqrt{x^3}} \, dx
\]
Another example

Type

\( e^{x^2} \)

\[ e^{x^2} = \left( e^x \right)^2 \]
What did we try?

- **Online tutorial**
  - Synchronous chat with handwriting
  - Type only
  - Offered to all students, on voluntary basis
  - Distance students only
  - For one hour a week
  (joint work with Christine McDonald)
Birgit writes:

Hi Chris, how do you draw the graph of $x^2 + 3$?
First attempts

**Birgit** says: who of you can write?

**Student 1** writes: I can

**Student 2** says: not me

**Student 3** writes: I CAN, NOW

This is not that easy.

**Student 4** says: you showed me before and its not pretty but can be done

**Student 6** writes: YES SORT OF

**Student 4** writes:

**Birgit** writes:

**Student 5** writes:

**Student 3** writes:

**Birgit** says: can anyone see what Student 4, I and Student 5 have written? I can't
Examples

\[
\left(\text{tand}^{\text{m}}\right)^{\text{m}} \lor \left(\text{tand}^{\text{m}}\right)^{\text{m}}
\]

\[
\left(\text{tand}^{\text{m}}\right)^{\text{m}} \lor \left(\text{tand}^{\text{m}}\right)^{\text{m}} = \top
\]

\[
\text{tandlog} \downarrow \text{tandlog}
\]

\[
x \text{ intercepts}
\]
Results from survey

• Discrete Maths:
  – Useful for Venn diagrams, logic sets and relations
  – Talked to others outside tute occasionally, and used hand writing
  – “We were encouraged to answer the questions from other students so this took out the boredom factor”
  – “ensures that at least once a week I’m thinking and looking at maths”
  – Time consuming!!!
Communication with VoIP and shared applications

- **Elluminate** (this morning)
- **Whiteboard** (last week)
Mathematical handwriting recognition

• Infty Project
  http://www.inftyproject.org/
  http://www.caisystem.co.jp/

• MS Equation Writer

• ORCCA project (Western Ontario)

• Issues with recognition
  – Input device
  – Syntax and semantics

The future of mathematical handwriting
Future directions

• Tablet project
  – Distance students (screencast (video), podcast (audio), communication)
  – On campus students (no whiteboard/OHP)
  – Preparation of material outside lecture hours
  – Run at larger scale than before

• Synchronous online chats (distance students)
  – Typed chat
  – Video and audio conferencing
  – Shared applications/documents
Future directions

- **Mobile learning and teaching**
  - **Teaching staff**
    - wireless/bluetooth presentation
    - PDA, pocket PC, tablet PC, light pen, digital notepad
  - **Students**
    - Podcasts (PDA, Pocket PC, Playstation, MM player, iPod)
    - Contribution

- **Currently:** using what’s there, finding out what works
- **Ultimate aim:** implementing new ideas, developing software (maybe hardware)
- **Mathboard**