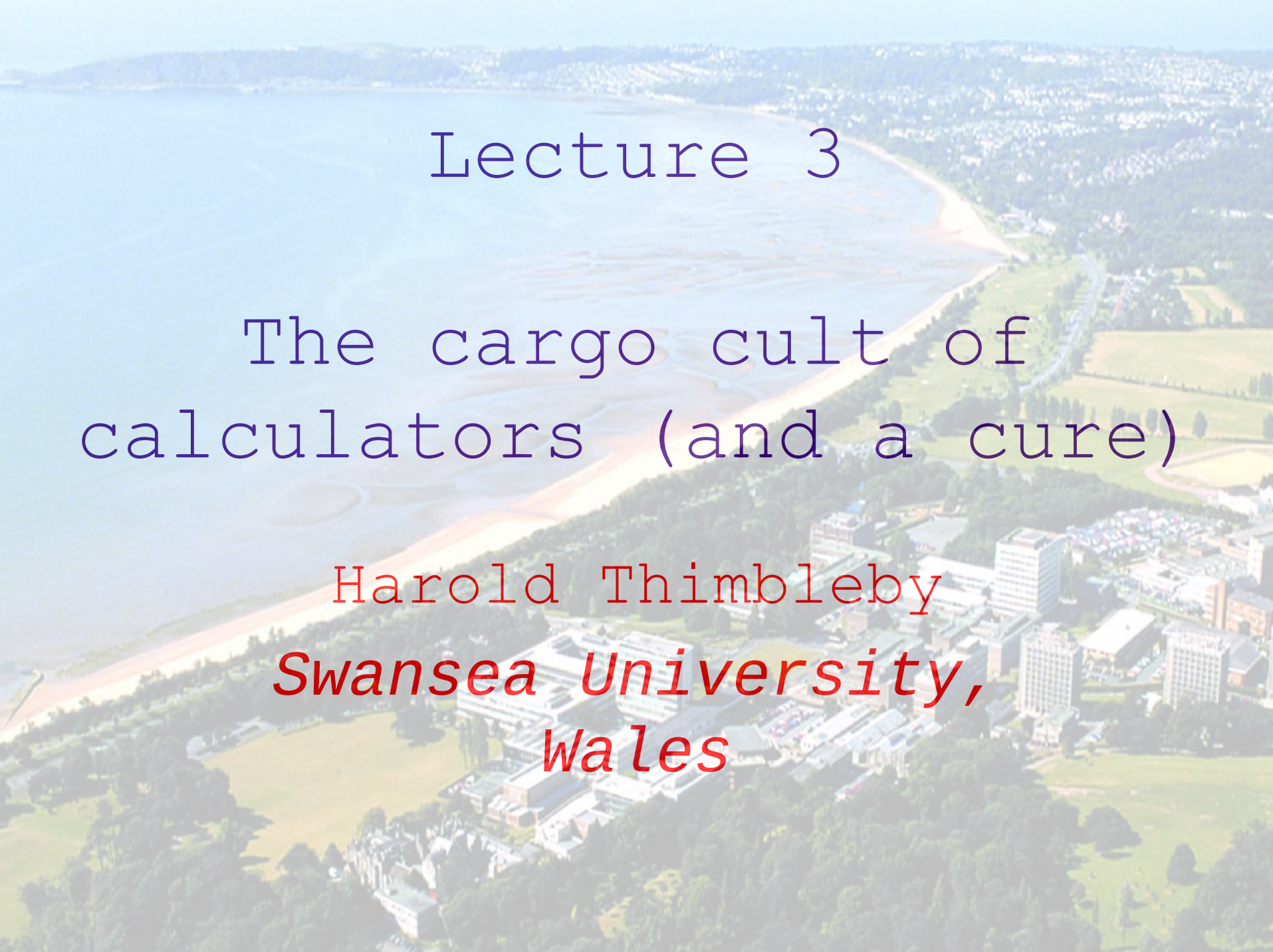


Lecture 3

The cargo cult of calculators (and a cure)

Harold Thimbleby

Swansea University, Wales

Talk structure

- **Part 1**
  - Nothing works
  - Why not?
- **Part 2**
  - A new approach
  - Demos
  - Evaluation

Part 1

Casio *fx-83WA*

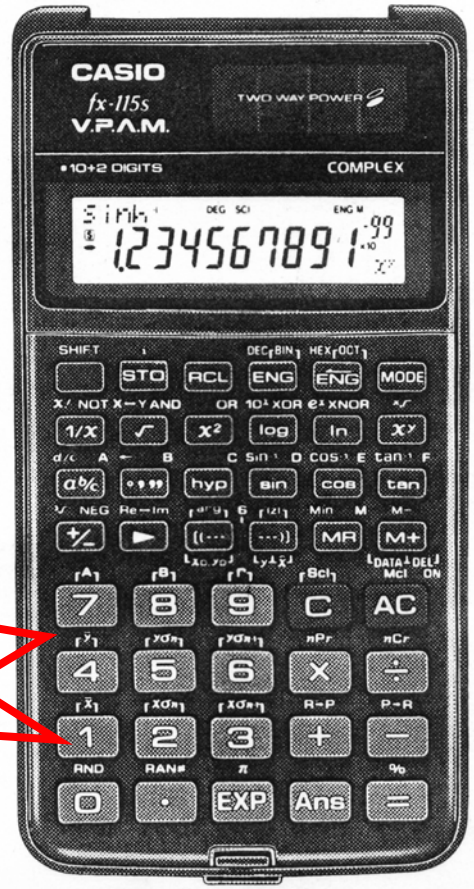
FOR COMPLICATED CALCULATIONS.

UNCOMPLICATED CALCULATORS.

VPAM

Thanks to VPAM (Visually Perfect Algebraic Method) calculations have become a lot easier. It may sound confusing, but all it means is that the scientific calculators in the Casio VPAM range perform calculations exactly as you would write them or read them in a text book.

For example, using the FX115s illustrated here, you would enter the calculation 5x2+sin30=10.5 exactly as you would write it. You can also see the intermediate values of a calculation as you go along and calculations



symbols are clearly visible on screen.

This all adds up to a VPAM calculator being very easy to use. No other range of scientific calculators has VPAM - it is unique to Casio.

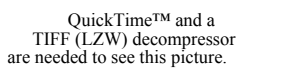
The FX115s contains all the features needed for study up to and including key stage 4 and is just one of six in the Casio Scientific VPAM range listed below.

CASIO®

For education, we're in a class of our own

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Store in memory?



Optimal solutions

- M+ – MRC M+ MRC
- = – MRC M+ MRC
- ***if*** … 2 conditions apply

$2^x = 100$?

[LOG] 100 / [LOG] 2 = *Sharp EL-531VH*

100 [LOG] / 2 [LOG] = *Hewlett Packard HP6S*

100 [LOG] 2 [LOG] / *Hewlett Packard H32SII*

$x = 10^{-\pi}$?

Sharp EL-531VHB

10^x – π ⇒ **Error**

10^x π ± ⇒ **Error**

10^x 2 ± ⇒ **0.01**

10^x – 2 ⇒ **anything!**

π [STO] A 10^x [RCL] A ± ⇒ **0.00072**

2, A, π …!!!!

Sharp EL-531

"The easy entry of calculations as they appear … calculations can be performed in an easy to understand manner from the simplest to the most complex equations."

(1 + 2 ***i***) + (3 + 4 ***i***) ?

[MODE] 1 [PRGM] [CLPRGM] [LOAD] [LN] [PRGM] 1 [INPUT] 2 [XEQ] [A] 3 [INPUT] 4 [RS] [SWAP]

Hewlett Packard HP20S

- $x!=5040$
- $32+9c/5=98.4$
- Incremental,
  - $156\times2.54/100/1.80=$
  - $1.80\ldots??$
  - $2.54\times(12\times f+i)=1.80$
- Exploratory
  - $6!+9!=363600=6!\times n$

Questions

4 × –5	*1+20%*	*$2^{-\pi}$*	*√–1*	*Store*
-20 -20.000 Error 1	***1900*** ***105*** ***1.2*** ***1.2*** ***1.010101*** ***0%***		***Sqrt(neg)*** ***-e-*** ***Error*** ***(impossible)***	

Results

	4×-5	$1+20\%$	$2^{-\pi}$	$\sqrt{-1}$	Store	N=71
Right	5	9	3	0	3	28%
Wrong	9	13	2	6	6	51%
Error message	4	1	2	8	0	21%

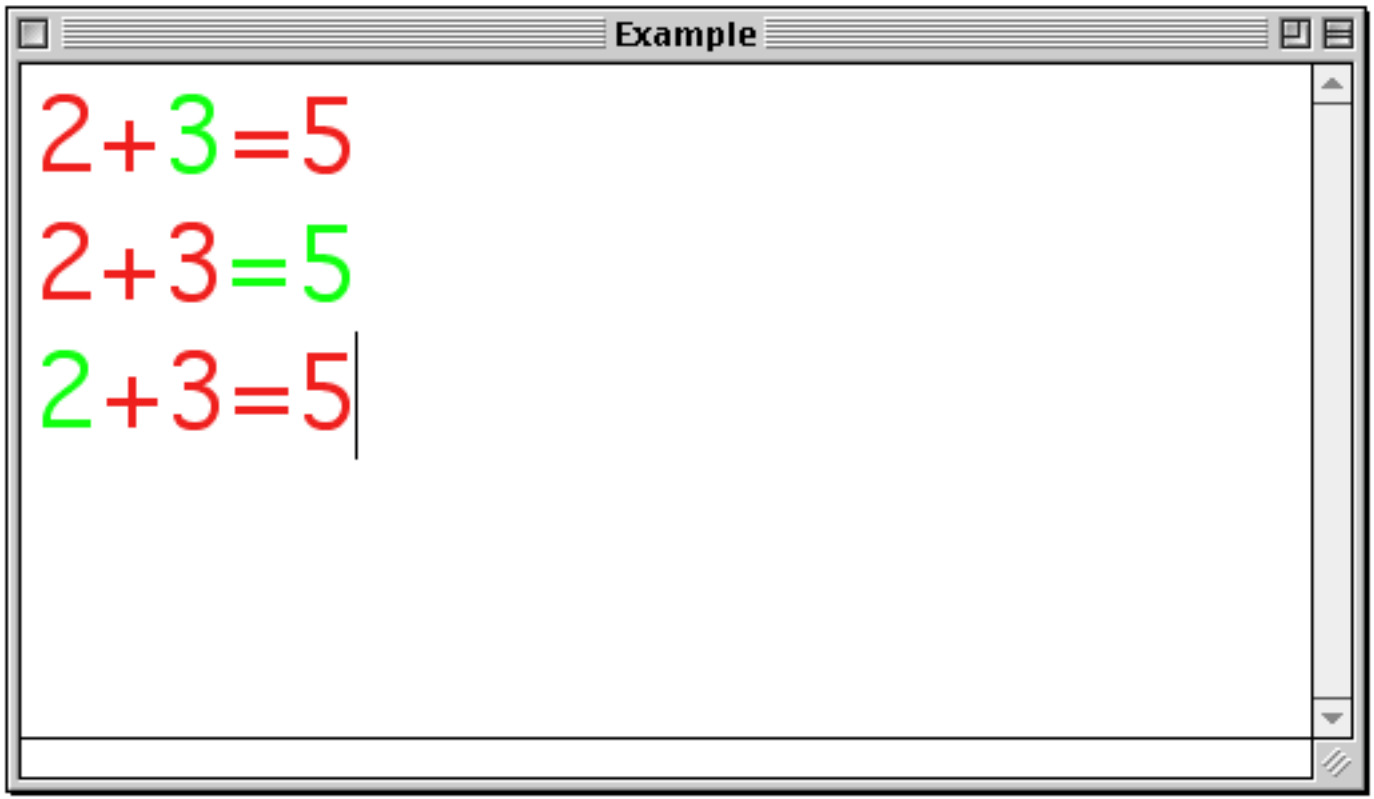
Ignoring rounding errors, eg, √5=2.2360679774997

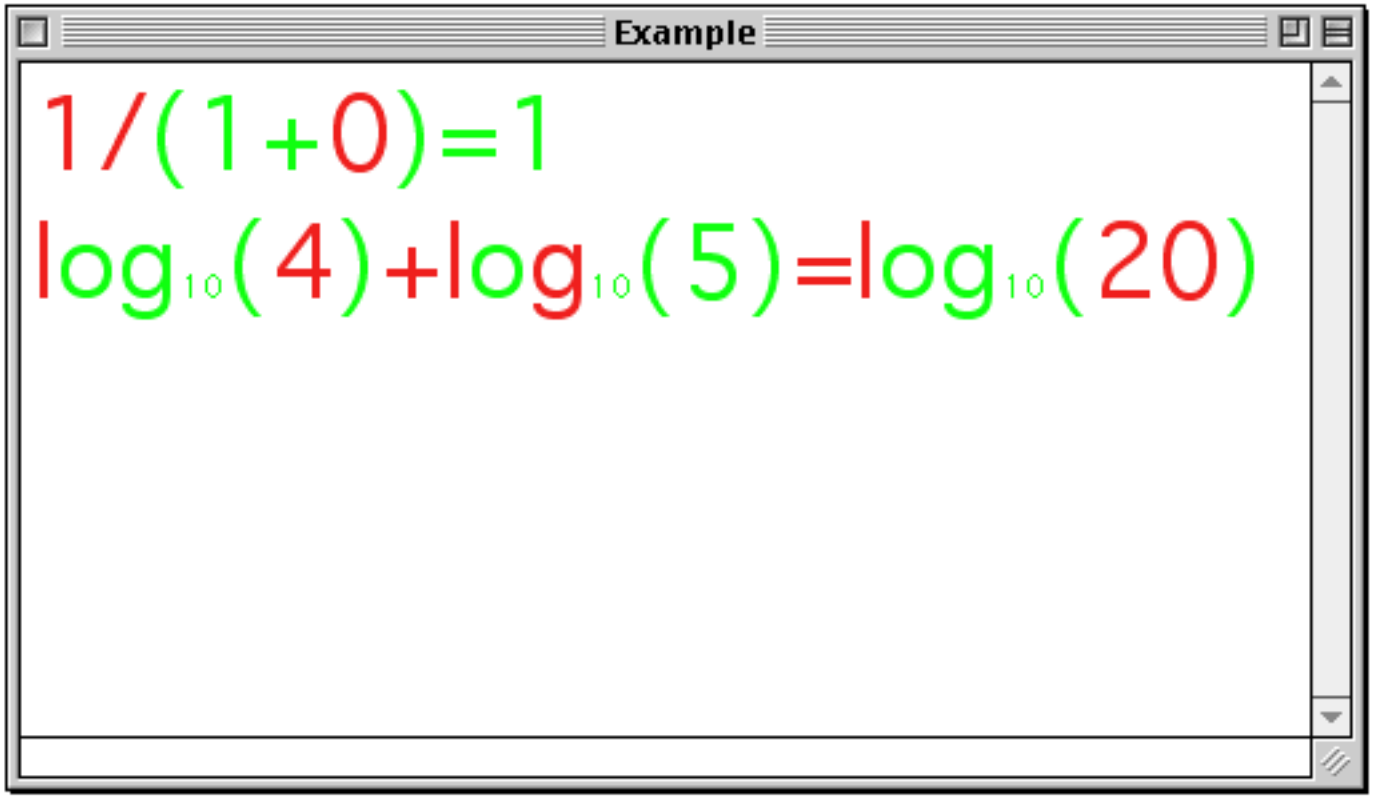
Summary of problems

- Don’t do maths
- Aren’t declarative
- Require **user to compile**
- Critical hidden state
- Don’t allow experimentation or incremental sums
- All different and unconventional
- *… good business being that way*

Now practise all that you've learned.
Follow the symbols and write the correct numeral in each box.

5 + 3 = □	5 + □ = 10
6 − 0 = □	3 − 3 = □
2 + 7 = □	8 + 0 = □
□ + 3 = 4	9 − 4 = □
7 − 5 = □	10 − 7 = □
5 − 5 = □	□ + 6 = 9
7 + 3 = □	2 − 1 = □
1 − □ = 0	4 + 6 = □


Example
2+3=5
2+3=5
2+3=5


Example
1/(1+0)=1
log10(4)+log10(5)=log10(20)

Part 2

- 1986…
  - Design principles
  - Prototype
- 1994…
  - Critique of commercial calculators
- 2004… *Will Thimbleby*
  - Pen user interface
  - Evaluations

Change the world?!

> "It is very instinctive and fast. It's great, I feel like Tom Cruise in *Minority Report* - Bravo!"

— Quote from one of 400 subjects

Minority Report

Minority interface

QuickTime™ and a
Sorenson Video 3 decompressor
are needed to see this picture.

Minority interface

- It looks like it works
- It looks fun
- It looks engaging
- But faked by CGI

Ours is much the same, but…

- It actually works
- It is fun
- It is engaging

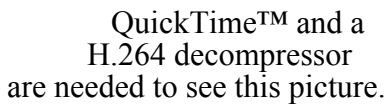
- Why does it work?
- Why is it fun?
- Why is it engaging?

“Calculators seem clumsy and hard to use — the new method is genius!

… If I could buy one I would have done A level maths!”

— A-Level student

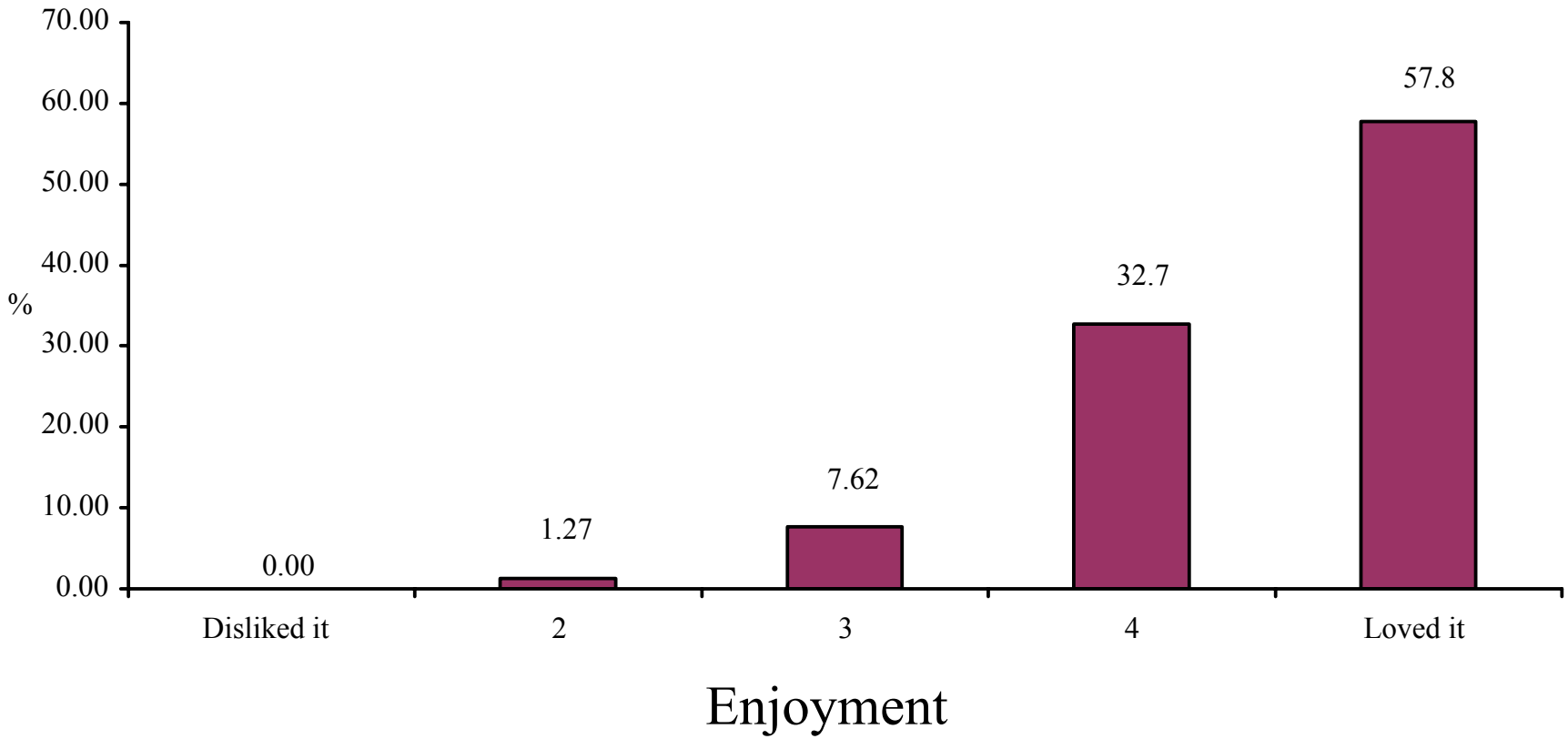
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.


QuickTime™ and a
H.264 decompressor
are needed to see this picture.

Demo

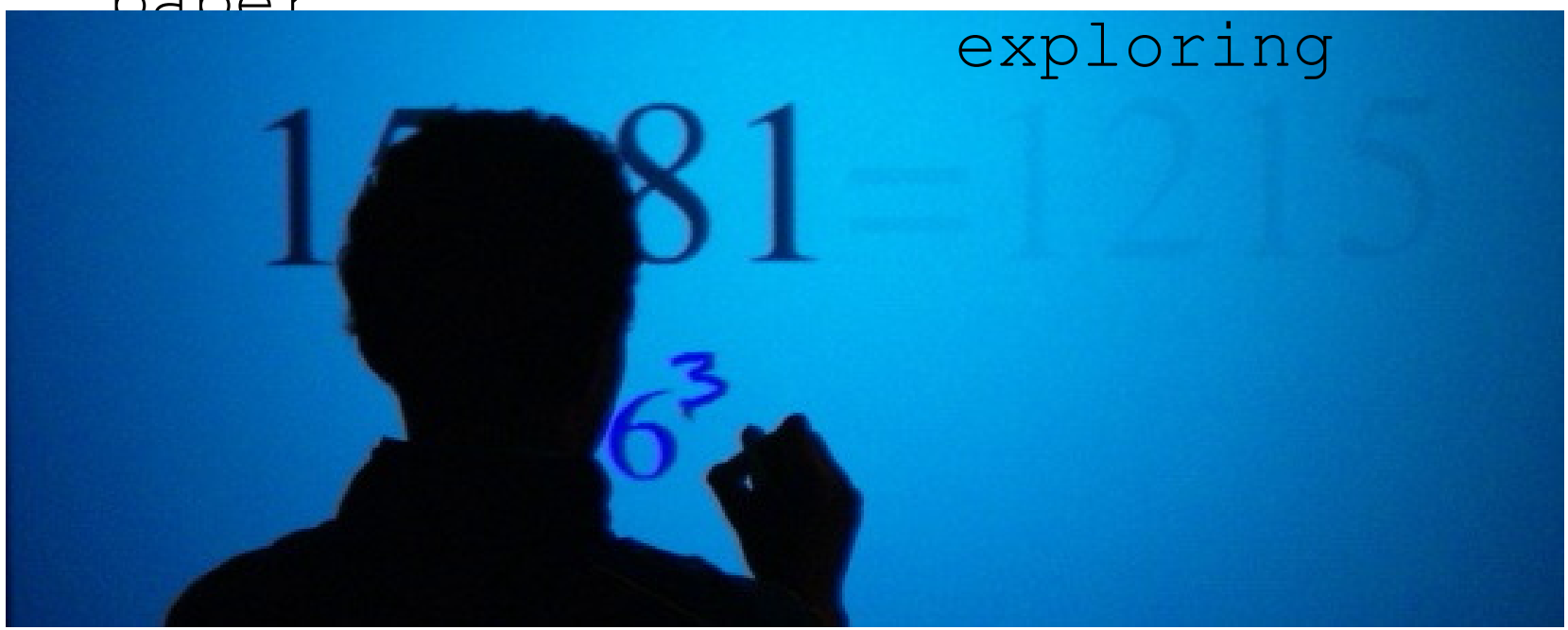
Royal Society evaluation

- Thousands of users
- 420 feedback forms returned
- Primary age to retired
- GCSE – PhD – FRS


70.00
60.00
50.00
40.00
%
30.00
20.00
10.00
0.00
0.00
1.27
7.62
32.7
57.8
Disliked it
2
3
4
Loved it
Enjoyment

What does it do?

- It is a calculator
- It works like paper
- Visible and correct mathematics
- Enables exploring



Why does it work?

- Principled design
- Combination of principles effective

"It works the same way as my mind when arranging equations"

"It stops you making mistakes"

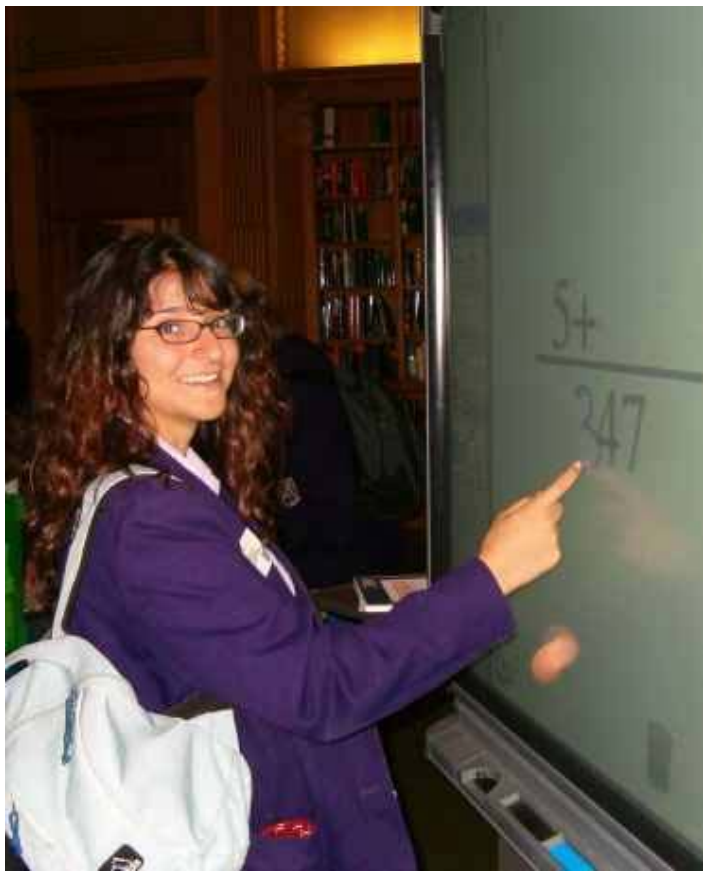
Conclusions to Part 2

- Surprisingly fun, *even* for maths
- Developed from principles
- Unusually large evaluation
- It works really well

What's right with it?

- Standard notation
- Ink editing
- Instantly declarative
- Output = input
- Continuous feedback
- Morphing
- Kinæsthetic
- More fun than 'right affordance'

Questions…



- Positive
- Negative
- Interesting

Turing's legacy

"Computing is normally done by writing certain symbols on paper. In elementary arithmetic the two-dimensional character of the paper is sometimes used. But such a use is always avoidable, and I think that it will be agreed that **the two-dimensional character of paper is no essential of computation**. I assume then that the computation is carried out on one-dimensional paper."

A M Turing, "On computable numbers, with an application to the Entscheidungsproblem," ***Proc. London Mathematical Society,*** Series 2, 42 (1936-7) pp230-65 (corrected Series 2, 43 (1937) pp544-6).

What next?

Questions?

Answers?

Computers copy nasty 1970s electronics

New approach copies 3000BC technology!

Ink editing

- Not syntactic editing
- Directly manipulatable
- Visible

- Symmetry with paper
- Logical effect of pen

Instantly declarative

- Eager evaluation
- Lack of modes
- Always correct and consistent

- Difficulty: has to cope with partial input flexibly, but…

Equal opportunity

- Makes use of partial input to provide usable benefits
- ?

Continuous feedback

- Informs user of state at all times
- Keeps user's model and computer's model syncronised