Ways to improve learning with EVS:

Some recent advances, deep learning designs, and comments on relevance to maths teaching

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www.psy.gla.ac.uk/~steve/talks/evs7.html
(EVS = Electronic Voting Systems)

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What I do and don't have to offer

I have some broad experience of EVS (Electronic Voting System) use.

I have a considerable interest in theories of learning and teaching.

My first degree (and cast of mind) was physics.
(So I've "received" quite a lot of maths teaching.)
I've worked in a psychology dept for a long time.

But I haven't taught maths.

How could what follows be applied to maths teaching?

Today's menu

A. Evidence of learning success with EVS
B. Catalytic assessment: some successful designs, all around provoking learning (deep) thinking
C. Bowskill: new use of EVS not for teaching but reflection
D. Taking contingent teaching seriously
E. Comments on relating this to maths teaching

But first … the moral of this tale

For learners:

Are they trying to memorise (shallow)

Or are they trying to understand? (deep)

For teachers:

It's not the technology stupid, it's the learning design that most affects learning outcomes.

But what is it that good designs are doing?

And what kind of software support fits that?

These are the mysteries this tale is about ….

Part A.

Some evidence about how EVS can be educationally successful

Hake

Hake (1998) published a survey of 62 courses (6,542 students) all studying the same subject, all using the same standardised test, and using it both pre- and post-.

He graphed the mean gain on each course against whether or not it had used the method of "Interactive engagement".

See fig. 1 in:

Hake,R.R. (1998) Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses Am.J.Physics 66(1), 64-74

Hake's results

Mazur

Crouch & Mazur (2001) published an analysis of 10 years of Mazur's MIT course.

Again, the standardised pre- and post-test.

He concludes he has doubled the amount of learning, but the graph suggests that really, he tripled it.

See fig.2 in:

Crouch, C.H. and Mazur, E. (2001), "Peer Instruction: Ten years of experience and results" American Journal of Physics 69, 970-977

Mazur's gains

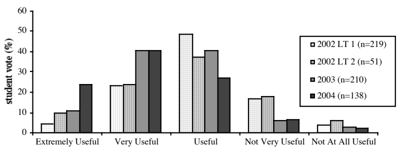
Does EVS work? Evaluation overview

Exam results: At Strathclyde in Mechanical Engineering, first year dropouts were 20% in 1998, but since using EVS are 3%.

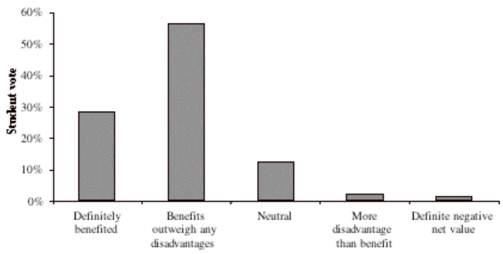
Attendance (when voluntary): in Glasgow Statistics large group tutorials for level 2: rose from roughly 20 to 80 (out of 200) when EVS introduced.

Attitude data: over all the applications at Glasgow, in all cases except one, a large majority of students said it was of overall benefit.
The same is true of teachers.

Simple "how useful?" question



Net benefit as judged by students



So:

So more effective teaching can be achieved.

“Interactive engagement” and “peer instruction” are usually delivered using Electronic Voting Systems (EVS).

But it isn’t the technology, stupid;
it’s the teaching method, the learning design that makes the difference.

Hake and Mazur don’t mention voting technology and some of the results predate it.

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Part B:

Catalytic assessment

“Catalytic assessment” is a catch phrase for questions that may look like tests, but whose important mathemagenic (learning generating) effect is hidden in the learner.

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Questions, which questions?

So more effective teaching can be achieved.

“Interactive engagement” and “peer instruction” revolve around asking students questions.

But what kind of questions?

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(qu-type 1) Assertion-reason questions

Asking not about the truth of facts, but the reasons for a true fact.
•The question states a fact
•The response options list reasons
•All of these should be true
•All should have been in the course being tested
•=> Then recognition will not help the student.

CAAC (Computer Assisted Assessment Centre) website advice on MCQ design:
http://www.caacentre.ac.uk/resources/objective_tests/index.shtml

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Questions about reasons (sky)

The night sky is dark because:

A. The Universe is infinite in size

B. The Universe is expanding

C. The Universe is made up of, mostly, Dark matter

D. The Universe has only existed for a finite amount of time

E. The distribution of stars is not smooth, but fractal

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(qu-type 2) Asking about confidence

Hunt (1982) (in an artificial experiment) showed that participants who first chose an answer and then had to indicate a confidence level learned about 20% faster than those who just chose an answer.

(This general issue is sometimes called “metacognition”: when the learner isn’t just a recorder of information but reflects on their learning and may modify their learning activity because of this.)

Gardner-Medwin’s CBM (confidence based marking) is a direct application of this.

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(qu-type 3) Mazur's Brain teasers

The point is to provoke debate, internal and between peers.
Cf. Socratic questioning, and "catalytic assessment"

Remember the old logo or advert for Levi's jeans that showed a pair of jeans being pulled apart by two teams of mules pulling in opposite directions. If one of the mule teams was sent away, and their leg of the jeans tied to a big tree instead, would the force (tension) in the jeans be:

- half
- the same
- or twice what it was with two mule teams?

Peer Instruction: Mazur Sequence

1. Concept question posed (brain teaser)
2. *Individual Thinking*: students given time to think individually (1-2 minutes)
3. Students provide individual responses
4. Students receive peer feedback – poll of responses presented as histogram display
5. *Peer Discussion*: students instructed to convince their neighbours that they have the right answer.
6. Retesting of same concept
7. Students provide individual responses (revised answer)
8. Students receive feedback – poll of responses presented as histogram display
9. Lecturer summarises and explains 'correct' response

Miyake and "constructive interaction"

We can understand Hake's and Mazur's demonstrated practical educational successes in terms of the theory developed in developmental psychology of how peer interaction promotes individual's conceptual advances.

Miyake (1986) got researchers round her lab to discuss their understanding of sewing machines.

Detailed analysis of the conversations showed that this was NOT teaching, yet both did advance their conceptions.

Christine Howe's work (1)

Long series of studies on peer interaction causing conceptual development.

Good selected paper:
Howe, C.J., Tolmie, A, and Rogers,C. (1992)

To get the effect, you need to work on the setup:

Peers with different prior beliefs
Elicit commitment to their personal view in advance e.g. write their view, then show peers this opinion.

Christine Howe's work (2)

- Benefit is delayed (e.g. 4 weeks)
- Final conceptions are different in solo than group interviews
- More advanced child ALSO advances still further
  I.e. it is NOT information transmission
- "not agreement but private conflict resolution"

⇒ Mechanism is metacognition
(Howe, McWilliam, Cross 2005)

Smith et al. 2009 paper in <u>Science</u>

- IE / Mazur type method, but in level 1 Genetics, not physics
- Re-test was not only the identical question, but another similar (isomorphic) one.
- Even when no-one knew the right answer, many students learned from the peer discussion (for 15 of 16 topics)
- Biggest improvement on the more difficult questions
- Delayed benefit in the sense of some got the isomorphic one right even if persisting in wrong answer for repeated question.

Went from 52% correct to 72.52% correct
(7.4% got worse; 28% better)

(qu-type 4) Learner authored questions

This is another powerful teaching tactic.

Basic idea:
Students have to design a test MCQ (best in a small group) complete with reasons why each response option is right or wrong.

Have to aim for questions that discriminate (splits class).

Why is this effective? Same underlying reason as Mazur: the factual question requires them to generate reasons ….

Catalytic assessment

"Catalytic assessment" is a catch phrase for questions that may look like tests, but whose important mathemagenic (learning generating) effect is hidden in the learner.

(For the full argument see my paper on this.)

"Catalytic assessment: understanding how MCQs and EVS can foster deep learning" British Journal of Educational Technology vol.40 no.2 pp.285-293

[This ref. is on the handout sheet]

Linking to the learner's own questions

Behind the notion of "catalytic assessment", and its focus on how learners may notice a bug in their understanding, and then correct it, is:—
The general point that learners bring with them, not a blank mind (though you can bore it into blankness) but their own ideas, questions, worries, prior conceptions.
Failing to address these means your 'teaching' will be unconvincing to the good students, irrelevant and incomprehensible to the bad.

That lies behind the success for elementary physics teaching of "brain teasers'" play with everyday experiences.

The learner's own questions (2)

Does this apply in maths teaching?
The nearest approach in my memory might be:

What could I say to a learner asking WHY does -1 X -1 = +1?

Knowing that it "fits" with other desirable maths and experts' recommendations is not satisfying. Like saying that pretending that Father Christmas exists will lead to gifts. Not a model of rational thinking.

Well, multiplying a -ve number is magnifying a deficit: that makes sense: -1 X 3 = -3.
But multiplying BY a -ve number? You can't repeat addition less than one time ….
Addressing this kind of thing might be the math equivalent of doing the work of brain teasers?

So:

So more effective teaching is achievable.

And it can be achieved with EVS, asking questions of various types.

But it isn't the technology.

It isn't even really the format of the question (e.g. Bloom category / level), but what **kind of thinking** it elicits in the learner.

However what is very often important is the "learning design" in the sense of what the teacher does with, or rather, in response to, the answers that come back to questions….

Part C:

Bowskill: new use of EVS not for teaching but reflection

Student generated induction

At the start of this academic session, we did an induction session for all the new students in one faculty to a novel recipe.

Big success with the students.

- Asked them about their concerns about being a student here
- Got them to discuss it
- Assembled a representation (using EVS) of the groups' concerns as a whole
- Got older students to comment on how they addressed each concern

Overall recipe, linking sessions

1. Level 2 session: elicit their retrospective and prospective concerns (about the year they just completed, and the new year starting); and their ideas about solutions.

2. Keep a few volunteers on to orient them for meeting level 1 students.

3. Level 1 session: elicit their prospective concerns, and possibly thoughts on finding solutions.

4. Joint meeting: go over the concerns, and the level 2 mentors comment on the solutions they favour for each.

Recipe within one session

Snowballing:

- Ask students to write down what their chief concern is
- Get them to discuss this with the 3 nearest people
- Get each group to text in their joint chief concern
- The presenter groups these into top 6?, 9? Concerns
- Get everyone (EVS) to rate amount of concern they personally have for each of the shortlisted ones
- Sort them by accumulated concern levels: show that display

Nick Bowskill's L-design

http://www.psy.gla.ac.uk/~steve/bowskill/

What to call it?

- Student generated PDP

- Group construction of common ground on group-relevant and significant matters.

?Use it for a different purpose: at the start of a new maths topic, collect learners' prior conceptions of / problems with the topic?

Part D:

Taking contingent teaching seriously

Basics underlying EVS use in class

You have to be ready with a plan of what you will do with the different possible response patterns from your questions. If you do nothing with them, you'll look, and be, stupid (unless you really are doing catalytic tactics).

Newcomers think you use EVS to get "student engagement". But experienced users see the chief benefit as feedback to the presenter on that audience.

Why? Because that lets them do things differently depending on the audience.
I.e. it is formative feedback for/to the Teacher.

Contingent teaching

The essential thing that EVS does is allow the presenter (and audience) to see at a glance what the spread of opinion in the room is: the favourite opinion, the degree of consensus or lack of it. And to do it for huge audiences too.

This is the fundamental functional advantage EVS gives.

Furthermore, what is the point of face to face meetings?
Only if what the presenter says depends on that audience is it actually worth meeting.

I.e. the teacher's actions must be contingent on the audience's (just previous) actions.

Linked questions

Many important contingent learning plans design questions not in isolation, but in relation to each other in various ways.

Two types of these I've already described:

Link-type 1. Mazur's recipe links 2 votes (and a discussion) on the same question text. (Smith et al. linked 3 votes.)

Link-type 2. Bowskill's design for student generated PDP links student proposed issues to a shortlist to plenary votes on the relative importance of each item on the shortlist.

(link-type 3) Class test

30 mins working on paper
5 mins keying in answers to EVS
Presenter goes through the aggregated answers, with explanations.

Rapid turnround
Cost effective
Dialogic, not monologue, feedback

(link-type 4) Diagnostic tree questions

A. McColl level 1 stats. Whole session based on a diagnostic tree. Quadrupled attendance (20 → 80 of 200)

B. Tim Drysdale: software support for organising slides for this.

(link-type 5) Linked questions per concept

Mark Russell: superior tactic of linked questions for diagnosis.
"Using an electronic voting system to enhance learning and teaching" Mark Russell (2008) Engineering Education vol.3 no.4 pp.58-65

N ≈ 71 students
Three questions testing same underlying concept of pressure gradient (how pressure varies with depth in water).

Mark Russell (2)

Figure 3.
Student response to Q1
(correct answer highlighted)

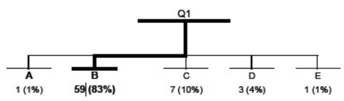


Figure 4.
Student response to Q2
(correct answer highlighted)

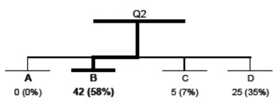
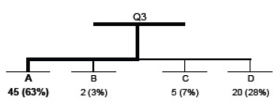
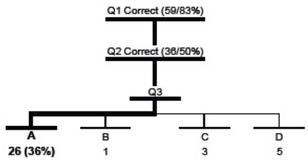


Figure 5.
Student response to Q1
(correct answer highlighted)



Mark Russell (3)

Figure 8.
Coupled responses to Q1, Q2 and Q3
(correct answer highlighted)



(link-type 6) Multi-step solution presentations

Meltzer & Manivannan suggest breaking down the time honoured method of "going through" a solution on the board into steps, and having the audience try to do each step (and vote on it) one by one.

It should certainly keep the audience together in the same place (while solo solutions lose learners down diverse error paths).

Problem
A 25 kg block has been sliding on a frictionless, horizontal ice surface at 2 m/s. Suddenly it encounters a large rough patch where the coefficient of kinetic friction is 0.05. How far does the block travel on this rough surface?

Some steps

Step 1. How many different forces are now acting on the block? (Ignore air resistance.)
a) 0 b) 1 c) 2 d) 3 e) 4 f) 5

Step 2. What is the direction of the weight force? (see diagram) A B C D E F

…….

Step 5. Is the block accelerating?
a) Yes b) No c) Not enough information

Step 6. What is the acceleration in the Y direction?
a) >0 b) <0 c) =0 d) Not enough information

…….

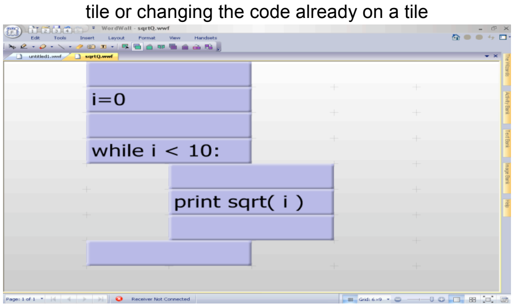
Quintin's programming example

What follows are some screen shots of an interactive use of "Wordwall" EVS software in an introductory computer programming course.

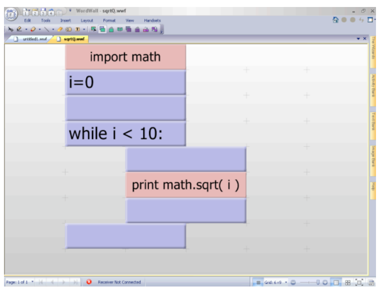
It allowed students to vote on which part of the partial solution to fill in or correct; and then on what change to make to that element.

In Wordwall, you can pre-prepare display tiles so that "the answer" or other change is ready "on the back of the tile" i.e. to appear at a click.

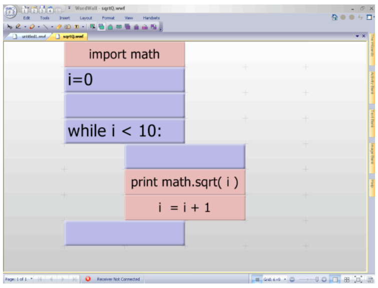
The problem is to write out the square roots of the numbers 1 to 10. The students can vote on any of these tiles to indicate something that should be different – either adding code to a blank tile or changing the code already on a tile



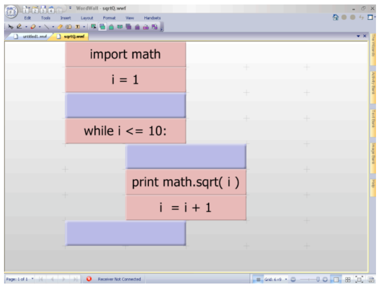
The students picked the *print sqrt(i)* as the first error (ie this tile got the most votes). In discussion in the class, we came to the code on the pink tiles as the solution. These were hidden on the back side of the tiles.



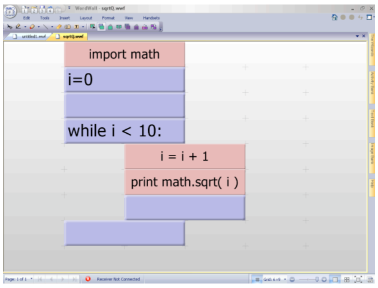
The students then voted the blank tile below *print math.sqrt(i)* as the next tile to change. Again, in discussion, we opted for the new line of code. I ran this in a Python window, and of course it didn't work, since the first value of i is 0.



So this is one solution – setting i to 1 to start with and changing the test on i to stay in the loop



and this is another – moving the position of i's increment and leaving the original test.



Comment by Quintin (the teacher):

•There was a fairly easy/fluid interplay between class and teacher with the combination of the Word Wall, enabling me to flip over tiles easily to show different options, and the handsets, which allowed the students to direct the exploration, and also the use of Python to execute bits of code to validate or otherwise the students' answers.

Reprise: the moral of this tale

For learners:

Are they trying to memorise (shallow)

Or are they trying to understand? (deep)

For teachers:

It's not the technology stupid, it's the learning design that most affects learning outcomes.

But what is it that good designs are doing?

And what kind of software support fits that?

These are the mysteries underlying this tale

Part E: How might this all connect to Maths teaching?

Is this any use for Maths?

I've talked about some of the dramatically successful cases of using EVS, and related it to some ideas about how to explain this. In principle such theory should tell us how to re-apply the lessons to each and every discipline. But in reality that is not something I could possibly do alone: only if people in the discipline meet me half way, by thinking of connections to their own contexts.

The way forward may be to try to think less like an expert (replicating proofs and operations you are now convinced are correct), and more like a mathematician: trying to convince yourself of their correctness and how they relate to possible objections, alternative methods, …. Because those are the mental operations the best students will in fact be engaging in, and which in any case lead to the deepest learning and longest retention ….

The place of your input, and of EVS, in <u>your</u> math course

An unpublished study looked at maths student use of:

- Face to face lectures [1st]
- Recordings (podcasts) of lectures [3rd]
- Drop in to a maths learning support centre [2nd]

Students did NOT use them evenly as a blend;
BUT fell into types which each focussed mainly on one of the resources plus a 4th type who didn't focus on any of the 3.

1. So does your support make them ignore other course bits?
2. Is it the resources that are important? (or is it practising examples alone that is the heart of learning maths?)

2.2 Gibbs: it is not the quantity of contact time but how successfully it causes productive non-contact time work.

The interpersonal element

Do your learners choose resources because that is what they need, or because they are looking to gain or avoid a particular type of contact?

Route finding and maps vs. asking (and need vs. preference)
•Strong preferences, not universal need
•But different resources are optimal for different problems

Lecture theatre seat location effects: can affect attendance and exam results. My suspicion: it's some feeling of interpersonal engagement.

Miller & Cutts: a single carefully designed EVS session in a course.

A place to stop

So: what use is this to maths teaching?

For the slides, handout etc. see:

http://www.psy.gla.ac.uk/~steve/talks/evs7.html