Free Range Mathematics

A recurrent concern in Mathematics education is that external pressure leads to teaching 'to the test', as opposed to teaching which allows students to range freely through mathematical ideas. How can education policy support teaching with a wider horizon than the next examination? What should these wider horizons be?

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Introduction

Assessment – of students, of their teachers and of the institutions where they study – is necessary BUT may drive behaviour which militates against the true goals of education

School and university leaders, teachers, league tables, quality assurance agencies, parents, employers all, understandably, set great store on

EXAM RESULTS

Teaching thus often directly geared to the next test

Why is this seen as a bad thing?

- The direct approach may not actually optimise test scores
- Learning does not transfer to subsequent work
- Tests may not measure what we think they are measuring

People who have clocked up success in an exam are often criticised by employers and those teaching them at the next stage for not knowing what they are supposed to know

Outline

- Teaching
- Assessment
- Inspection and quality assurance
- Mathematics
- Research questions and the future
- Conclusion

The syllabus for Core 1 A-level maths included *finding the derivative of a polynomial function*

Key facts

1. the derivative of x^n is nx^{n-1}
2. you can differentiate a term at a time
3. multiplying a function by a constant c multiplies its derivative by c

Typical question:

"Differentiate $(1-2x)^2$ with respect to x, giving answer in its simplest form."

You only learn maths when your brain is engaged

Things which can hinder

- Making every classroom experience feel like a test
- Making every mistake feel like a crime

Things which can help

- Knowing that false starts and errors are often productive
- Encouraging oral discussion and working together
- Encountering hard problems in supportive environment

Concrete objects

Patterns

'Playing with Infinity'

Interesting questions

Experimental maths

Open ended investigations, as in GCSE coursework c 1990

$\square$	$+$	$\square$	$\times$	$\boxed{8}$	$=$	40
$+$		$+$		$\div$		
$\square$	$+$	$\square$	$\div$	$\square$	$=$	8
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$\boxed{3}$	$+$	$\square$	$-$	$\square$	$=$	2
$=$		$=$		$=$		
13		55		24	$=$	

1. Teaching a new idea, and then setting questions to check that it has been learned
2. Setting questions which enable a student to 'discover' the new idea

Both (as well as intermediate positions) have a place in teaching Mathematics

Nikolay Konstantinov

Learning how to learn maths

Is the prejudice that teaching to the test is a bad thing correct?

How to we measure teaching outputs?

Is success greater if teaching beyond and around the test?

"However, our results indicate that professors who excel at promoting contemporaneous student achievement, on average, harm the subsequent performance of their students in more advanced classes." Carrell and West 2010

Is it possible to design really good exams, so that 'teaching to the test' will be excellent teaching?

Short answer: no!

But some things might help

- Oral exams
- 'Stepification'
- Not expecting perfection for top grades
- Reduced time pressure

Spectrum:

threatening high stakes .... benign supportive

How can we credit activity which isn't directly captured in assessment of individuals?

How can we measure long term outcomes?

Are coarse labels such as 'outstanding', 'requires improvement', 'silver' helpful?

Express $\sqrt{2}$ as a continued fraction of the form

$$q_0 + \cfrac{1}{q_1 + \cfrac{1}{q_2 + \cfrac{1}{q_3 + \cfrac{1}{\ddots}}}}$$

where q_0, q_1 etc are positive integers.

Contrived contexts can hinder understanding

Use contexts which are familiar or important

Link with work in other subjects

No need to justify every piece of mathematics by application - build picture of coherent enterprise

Explain that artificially simple settings needed while wearing L-plates

Research questions and the future

Many question - how to answer them?

"Harnessing Educational Research"
Royal Society report October 2018

- Support the use of research to inform teaching
- Teachers need more support to use evidence and insights from research to develop their practice and understanding
- We need a new organisational structure with an Office for Education Research at its heart. This Office would bring together governments, governmental organisations, researchers, teachers and other funders.

And finally

Aim to teach so that exams are more like hurdles taken in stride rather than than high jumps which one can barely get over

Aim to establish inspection and accountably regimes which encourage free range teaching

Encourage development of rich textbooks and resources

Allow teachers time to creatively prepare and collaborate

References

https://www.nber.org/papers/w14081
Scott E. Carrell & James E. West, 2010. "Does Professor Quality Matter? Evidence from Random Assignment of Students to Professors," Journal of Political Economy, University of Chicago Press, vol. 118(3), pages 409-432, 06. citation

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https://en.wikipedia.org/wiki/Nikolay_Konstantinov

1.

$\boxed{1}$	$+$	$\boxed{4}$	$\times$	$\boxed{8}$	$=$	40
$+$		$+$		$\div$		
$\boxed{9}$	$+$	$\boxed{7}$	$\div$	$\boxed{2}$	$=$	8
$+$		$\times$		$\times$		
$\boxed{3}$	$+$	$\boxed{5}$	$-$	$\boxed{6}$	$=$	2
$=$		$=$		$=$		
13		55		24	$=$	

2. $q_0 = 1, q_1 = q_2 = q_3 = \cdots = 2$