

Putting the course inside the quiz

Chris Sangwin

School of Mathematics
University of Edinburgh

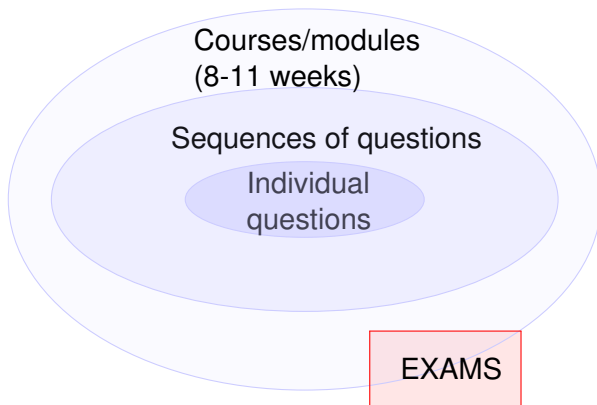
June 2023



Background



Assessment and education



Assessment combined with resources

Putting the book inside the quiz

Putting the course inside the quiz

All materials are inside the quiz.

- 1 Written notes
- 2 Video clips (split up as needed)
- 3 Online assessments

We started this in 2018, not just as a COVID response.



Fundamentals of Algebra and Calculus

- 20 credit year 1 course
- University of Edinburgh.
- 2018–19. Approx 100 students.
- 2019–20. Approx 220 students.
- 2020–21. Approx 220 students.
- 2021–22. Approx 300 students.
- 2022–23. Approx 450 students.



Educational design

Based on a number of established educational principles.

- Faded worked examples
- Scaffolding
- Interleaving of topics
- Recall



Assessments

High standards required on weekly online tests

Mastery = 80%+

Distinction = 95%+

# Mastered (80%+)	# Distinctions (95%+)	Mark	Grade
< 7	-	0	F
7	-	45%	D
8	2 or 3	55%	C
9	4 or 5	65%	B
10	6 or 7	75%	A1
10	8 or 9	85%	A2
10	10	100%	A3

To pass the course students must get 80%+ in 7 or more weeks
(Not a single exam with a 40% pass mark....)



Demonstrating FAC

<https://stack-demo.maths.ed.ac.uk/demo>

More information about STACK

<https://stack-assessment.org/>



What is wrong with MCQ?

If you choose an answer to this question at random what is the probability you get it correct?

- 1 25%
- 2 50%
- 3 66%
- 4 25%



Reversible mathematical processes

Direct	Inverse
Multiplication of numbers	Prime factoring of integers
Laws of Exponents	Laws of logarithms
Expanding brackets	Algebraic factoring
Single fraction	Partial fraction
Differentiation	Symbolic integration
Verify a solution (evaluate)	Solve an equation



What is STACK?

STACK is a “question type” for mathematics.

- STACK generates random questions.
- Students' answers contain mathematical content.
- STACK establishes mathematical properties of students' answers with computer algebra (CAS, Maxima)
- STACK generates formative, summative and evaluative outcomes. (i.e. feedback, score)



Why did I build STACK?

Assessment is the cornerstone of effective education.



MC does have a place in a sequence

Q23. Select the answer which is the appropriate form to use when expressing

$$\frac{x}{(x+1)^2(x^2+2)}$$

in partial fractions.

- $\frac{A}{x+1} + \frac{Bx+C}{x^2+2}$ [0%]
- $\frac{A}{x+1} + \frac{B}{x^2+2}$ [2%]
- $\frac{A}{(x+1)^2} + \frac{B}{x+1} + \frac{C}{x^2+2}$ [61%]
- $\frac{A}{(x+1)^2} + \frac{B}{x+1} + \frac{Cx+D}{x^2+2}$ [24%]
- I don't know [7%]



Adventures in algebra

Crowder, N. A. and Martin, G. C. (1960) *Adventures in Algebra*,
Doubleday.

Students follow a non-linear path through the book.



YOUR ANSWER: Yes, Q_L is divisible by some prime number.

You are correct. In fact, Q_L , being the product of all the prime numbers, is divisible by *any* prime number, since it has all the prime numbers as factors.

Let's see what else we know about Q_L .

Is it an odd number or an even number?

Odd. **page 103**

Even. **page 108**

I don't know. **page 115**



YOUR ANSWER: Yes, Q_L is divisible by some prime number.

You are correct. In fact, Q_L , being the product of all the prime numbers, is divisible by *any* prime number, since it has all the prime numbers as factors.

Let's see what else we know about Q_L .

Is it an odd number or an even number?

Odd. page 103

Even. page 108

I don't know. page 115



YOUR ANSWER: I don't know whether Q_L is odd or even.

It's simple.

Any number which can be divided by 2 without a remainder is an even number, by definition.

Now P_1 is 2, and P_1 is a factor of Q_L , isn't it? And Q_L can be divided by any of its factors without leaving a remainder.

So Q_L is exactly divisible by 2, and therefore Q_L is an even number.

Please return to page 99 and select the right answer.



115

[from page 99]

YOUR ANSWER: I don't know whether Q_L is odd or even.

It's simple.

Any number which can be divided by 2 without a remainder is an even number, by definition.

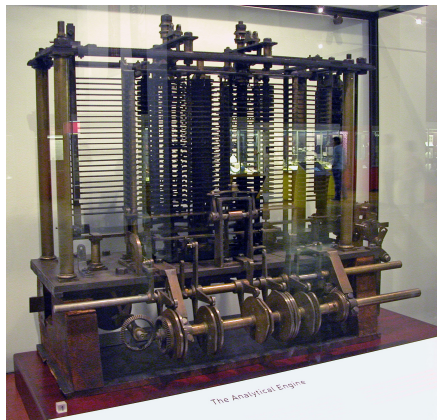
Now P_1 is 2, and P_1 is a factor of Q_L , isn't it? And Q_L can be divided by any of its factors without leaving a remainder.

So Q_L is exactly divisible by 2, and therefore Q_L is an even number.

Please return to page 99 and select the right answer.



Babbage and the Analytical Engine



This is the *Analytical Engine* invented by Charles Babbage. This is one of the first mechanical computers.



Technology which looks back

Babbage set out to *print log tables!*

13 Deg.		LOGARITHMIC SINES,									
	Sine	Diff.	Cosec.	Tang.	Diff.	Cotang.	Secant	D.	Cosine		
0	9-3520680		10-6479120	9-3633641	5760	10-6366359	10-0112761	292	9-9887239	60	
1	9-3526349	5469	10-6473651	9-3639401	5760	10-6360599	10-0113053	292	9-9886947	59	
2	9-3531810	5454	10-6468190	9-3645156	5746	10-6354845	10-0113345	292	9-9886655	58	
3	9-3537264	5446	10-6462736	9-3650901	5740	10-6349099	10-0113637	293	9-9886363	57	
4	9-3542710	5440	10-6457290	9-3656641	5733	10-6343359	10-0113930	294	9-9886070	56	
5	9-3548150	5432	10-6451850	9-3662374	5726	10-6337626	10-0114224	294	9-9885776	55	
6	9-3553582		10-6446418	9-3668100	5719	10-6331900	10-0114518	294	9-9885482	54	
7	9-3559007	5425	10-6440993	9-3673819	5713	10-6326181	10-0114812	294	9-9885188	53	
8	9-3564426	5419	10-6435574	9-3679532	5706	10-6320468	10-0115106	295	9-9884894	52	
9	9-3569836	5410	10-6430164	9-3685238	5699	10-6314762	10-0115401	296	9-9884609	51	
10	9-3575240	5397	10-6424760	9-3690937	5692	10-6309063	10-0115697	296	9-9884303	50	
11	9-3580637		10-6419363	9-3696629	5686	10-6303371	10-0115992	296	9-9884008	49	
12	9-3586027	5390	10-6413973	9-3702315	5679	10-6297685	10-0116288	297	9-9883712	48	
13	9-3591409	5382	10-6408591	9-3707994	5673	10-6292006	10-0116585	297	9-9883415	47	
14	9-3596785	5376	10-6403215	9-3713667	5666	10-6286333	10-0116882	297	9-9883118	46	
15	9-3602154	5369	10-6397846	9-3719333	5660	10-6280667	10-0117179	298	9-9882821	45	
16	9-3607515	5361	10-6392485	9-3724992	5653	10-6275008	10-0117477	298	9-9882523	44	
17	9-3612870	5355	10-6387130	9-3730645	5646	10-6269355	10-0117775	298	9-9882225	43	
18	9-3618217	5347	10-6381783	9-3736291	5639	10-6263709	10-0118073	299	9-9881927	42	
19	9-3623558	5341	10-6376442	9-3741930	5633	10-6258070	10-0118372	299	9-9881628	41	
20	9-3628892	5334	10-6371108	9-3747563	5627	10-6252437	10-0118671	300	9-9881329	40	



FAC Evaluation

Use of a “diagnostic test”.

Well established, with good information characteristics.

	Pre-test	Post-test	Gain
FAC	62.1	77.4	15.3
Non-FAC	76.1	78.1	2.0

Students can and do rise to meet high expectations.



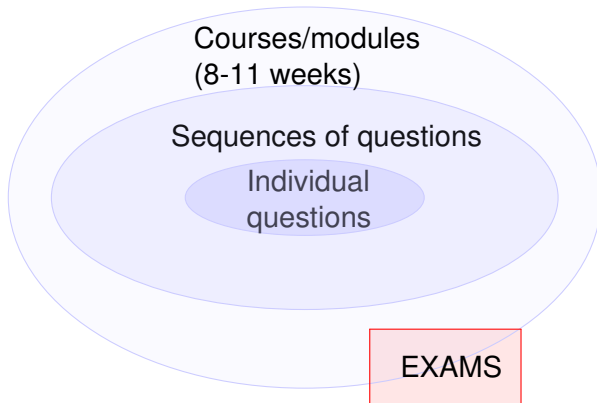
We are not trying to replace teachers....



William Hogarth, *Scholars at a Lecture*, 1736.



Assessment and education



(Online/on-screen examinations are inevitable!)



References

Designing and evaluating an online course to support transition to university mathematics (2021)

George Kinnear, Anna K. Wood & Richard Gratwick

<https://doi.org/10.1080/0020739X.2021.1962554>



Conclusion

- Our fully online course has been successful
Carefully engineered from educational research
- Unusual assessment arrangements
Students met the challenge.
- STEM subjects really need special tools beyond MCQ
These tools exist and are robust

