Knight (2005) *Nature*

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STACK-aided active learning environment for advanced engineering mathematics : pre- and post-Covid

Igor Chernyavsky, William Lionheart & Colin Steele

Department of Mathematics, University of Manchester

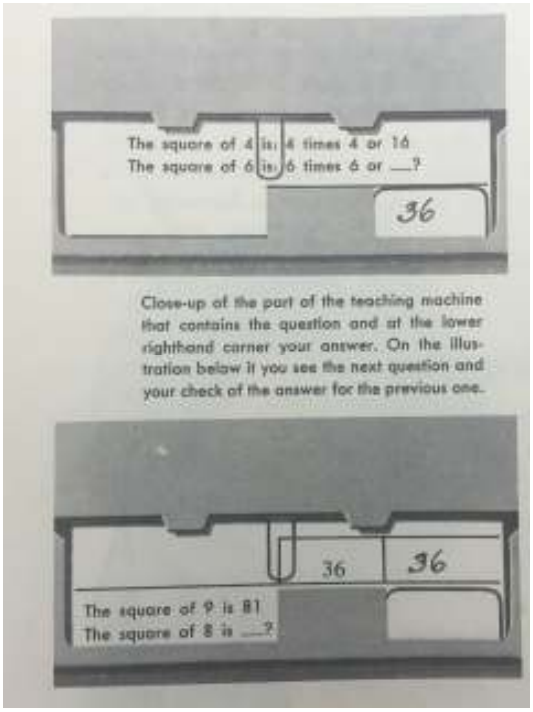
E-Assessment in Mathematical Sciences

21st June to 2nd July 2021

Setting the Scene

- Where was mathematical e-assessment in Manchester prior to this project ?

A view from the sixties



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1990s : Some use of “complete packages” brought in from elsewhere e.g. Topclass, CALM etc.

2000s : Question Mark for Windows, WebCT

Coursework Tests

Mainly for students taking maths course-units as part of other degree courses.

STACK at Manchester

- 2008-09 : First use with students
- Several Upgrades
- 2019-20 : Connection through Blackboard

Types of STACK use in Manchester

- Coursework rather than exams
- Also used for general practice
- Great majority UNsupervised

Practice and Assessment Modes

- For a particular assignment
- Practice Quiz : Can be done as many times as desired with same question stems. Full feedback provided.
- Assessment Quiz : Same question stems (in most cases) as in practice quiz. Just a single attempt. Feedback sometimes withheld.
- Mark for assignment weighted mean of BEST PRACTICE and SINGLE ASSESSMENT marks.

Other Modes

- A course with 10 weekly assignments contributing to coursework, each with unlimited attempts before deadline
- Reaching a ‘threshold’ on each assignment gives “credit”. Credit assembles on a nonlinear scale to give total credit.

Diagnostic Followup

- Diagnostic Exercise completed by entrant students in September
- Based on above, students given individual programme of work involving two sections from A to P.
- Reading and other resources for each section
- Practice and Assessment quizzes for each section allocated to student.

The situation in 2019/20

- Extensive experience of administering coursework and general practice
- STACK now linked with blackboard meaning students do not need separate account and marks moved back automatically.
- Means to acquaint students with system before any assessment

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- Extensive experience of administering coursework and general practice
- STACK now linked with blackboard meaning students do not need separate account and marks moved back automatically.
- Means to acquaint students with system before any assessment
- But not yet …. End of semester exam

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STACK-aided Active Learning Environment for Advanced Engineering Mathematics: pre- and post-COVID Experience

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Acknowledgements

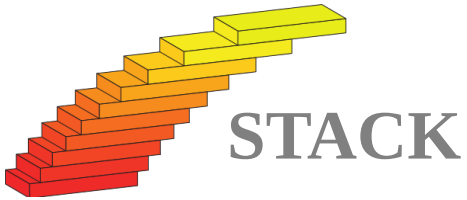
Support

Maths T&L Office

UoM e-Learning Team

Infrastructure

Chris Sangwin and STACK Users Group (Edinburgh)



stack-assessment.org

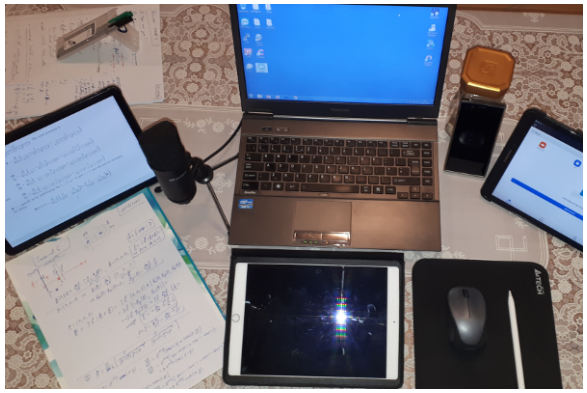
Outline

- Course Structure and Delivery
- STACK-aided Exam Format
- Technical and Pedagogic Challenges
- Learning Outcomes and Outlook

Advanced Engineering Mathematics

- Year 2 course unit of three parts
  (Integral Transforms, Vector Calculus & Linear Algebra)
- Two unit leaders
- 250+ students from Electrical and Electronic Engineering
- Highly diverse background and level of training
  (including direct-entry overseas students)

T&L Environment



www.conference.manchester.ac.uk

Advanced Engineering Mathematics
MATH29681

2019/20 Structure

ILOs

Lectures + Tutorial (weekly)

Practice Test 1

Test 1

Revision

Practice Test 2

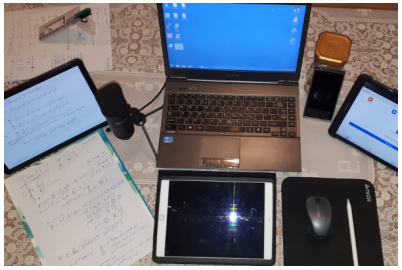
Test 2

Revision

Exam

Advanced Engineering Mathematics
MATH29681

2020/21



ILOs

Blackboard Quizzes and Milestones

Piazza Learning Environment

Review + Tutorial sessions (weekly)

Revision Session

STACK Practice 1

Test 1

STACK Practice 2

Test 2

STACK Exam

STACK Revision

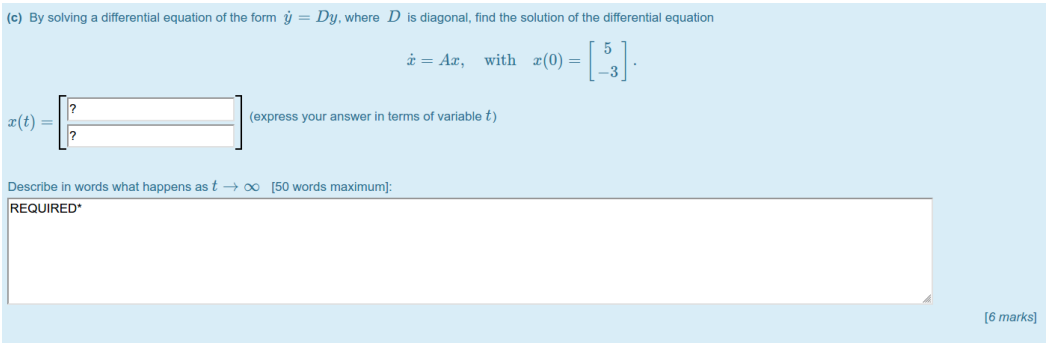
STACK-based Exam Format

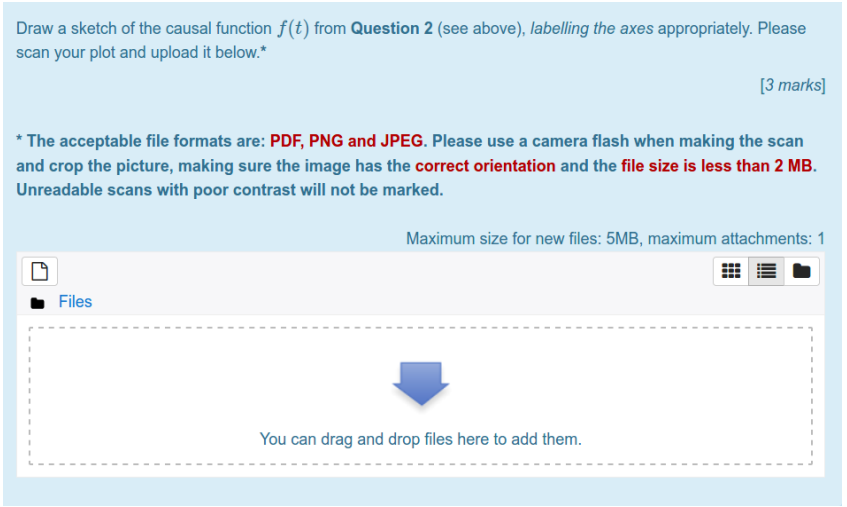
STACK + Moodle

- Robust randomisation
- Carry-through calculation errors and consistent marking
- Instant (or deferred) and detailed feedback

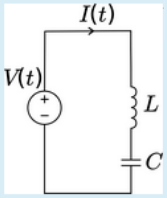
STACK + Moodle

- Robust randomisation
- Carry-through calculation errors and consistent marking
- Instant (or deferred) and detailed feedback
- Could be mixed with semi-automatic marking:
  - short textual justification
  - uploading a graph sketch



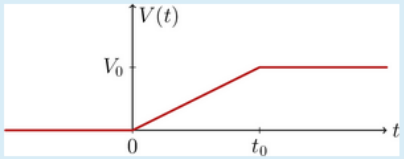


STACK: Adaptive Multi-part Questions



An electrical LC circuit (see the diagram) consists of a serially connected capacitor with capacitance
$C = \frac{2}{9}$
and an inductor with inductance
$L = \frac{1}{2}$
(both given in normalised dimensionless units).

At time $t = 0$ there is no charge at the capacitor and no electric current in the circuit. An external voltage $V(t)$ (in dimensionless units) is applied to the circuit, increasing linearly from $V(t = 0) = 0$ to $V(t = t_0) = V_0$, and is then kept constant after that time ($V = V_0$ for $t \geq t_0$; see the plot).



Here $t_0 = 4$ and $V_0 = 108$ (in dimensionless units).

(i) Express the externally applied voltage $V(t)$ as a function of time for $t > 0$.
Use **u(t)** to denote the unit step function in your answer:
$V(t) =$ REQUIRED* (express your answer as a function of t)

[3 marks]

(ii) Assuming the electric current $I(t)$ in the circuit described above obeys the equation

$$\frac{1}{2}\frac{\mathrm{d}\,I(t)}{\mathrm{d}\,t} + \frac{9}{2}\int_0^t I(\tau)\,d\tau = V(t)\,,$$

use the Laplace transform to find the associated *Transfer Function* $G(s)$ that links the input to the output of the system:
$G(s) =$ REQUIRED* (express your answer as a function of s)

Find the corresponding *Impulse Response Function* $i(t)$ that characterises the electric current in response to a unit impulse voltage input $V(t) = \delta(t)$:
$i(t) =$ REQUIRED* (express your answer as a function of t)

[5 marks]

(iii) For the external voltage $V(t)$ found in part **(i)**, apply the Laplace Transform to the equation given in **(ii)** and express the transformed current $\bar{I}(s)$ in the s-domain:
$\bar{I}(s) =$ REQUIRED* (give your answer as a function of s)

[6 marks]

(iv) Use the results of **(iii)** and the inverse Laplace transform to solve the ordinary differential equation for the LC circuit and find the value of the electric current $I(t_0)$ at time $t_0 = 4$:
$I(4) =$ REQUIRED*

[6 marks]

Technical Challenges

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- Inverse Laplace Transform for piecewise-continuous functions. Usage example (in Question Variables):

```
f: laplaceInv(e^(-s)*s/(s^2+1), s, t);
/* returns: cos(t-1)*u(t-1) */
```

Adapted from Eric Barth's (https://themaximalist.org/tag/inverse-laplace-transform). The code is available on EAMS Moodle.

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- Symbolic logarithm (extracts symbolic exponent *a* from an expression = $A * e^{a}$):

```
symlog(expr):= sort(args(inpart(expr, 2)))[1];
```

Pedagogical Challenges

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Digital Literacy

- Student's understanding of "computer-based" marking.
- Anticipating unusual syntax (e.g. u*(t) instead of u(t)).
  - Coding-style accuracy as a possible ILO.
- Empty / invalid answers in linked multi-part questions.

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  - Coding-style accuracy as a possible ILO.
- Empty / invalid answers in linked multi-part questions.

Student's feedback: "… to master the skills of accurate output of our mathematical knowledge …"

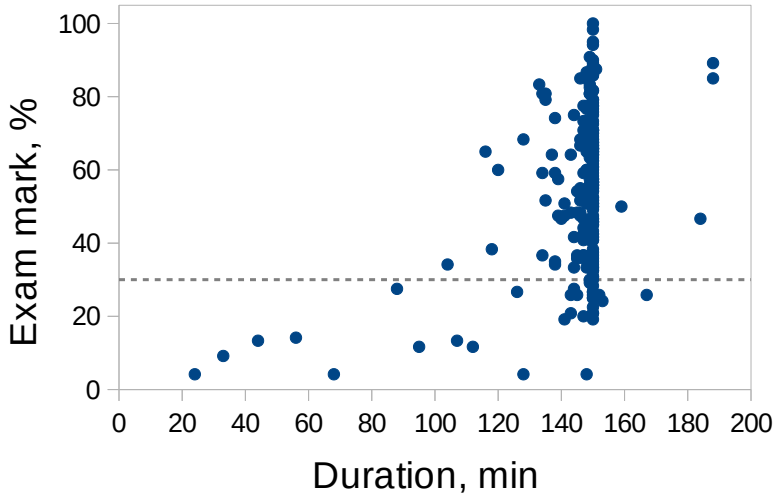
Pedagogical Challenges

Invigilation & Support

- "Wolfram Alpha"-like engines.

- Time management:

  How to approximate the traditional experience?



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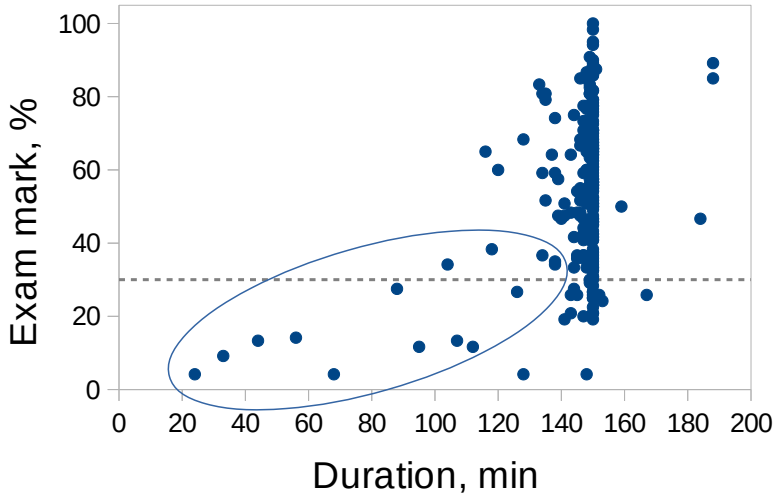
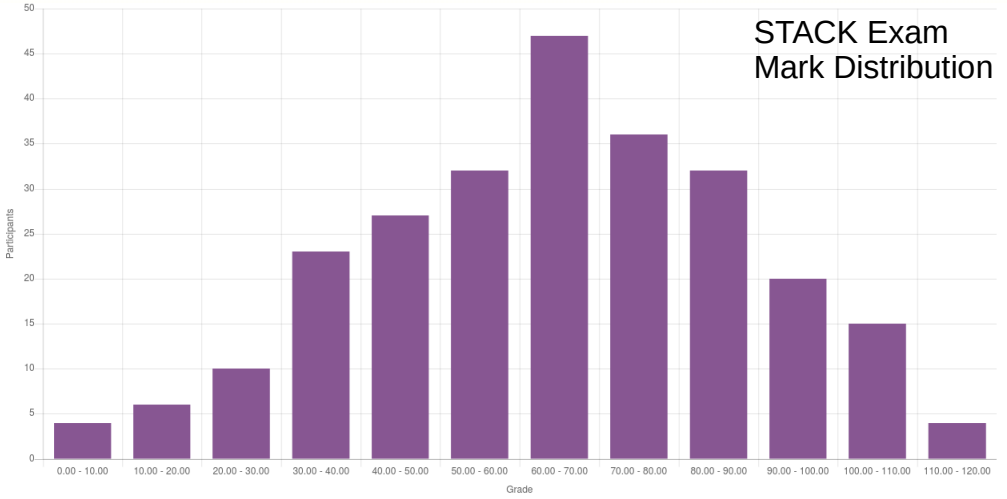
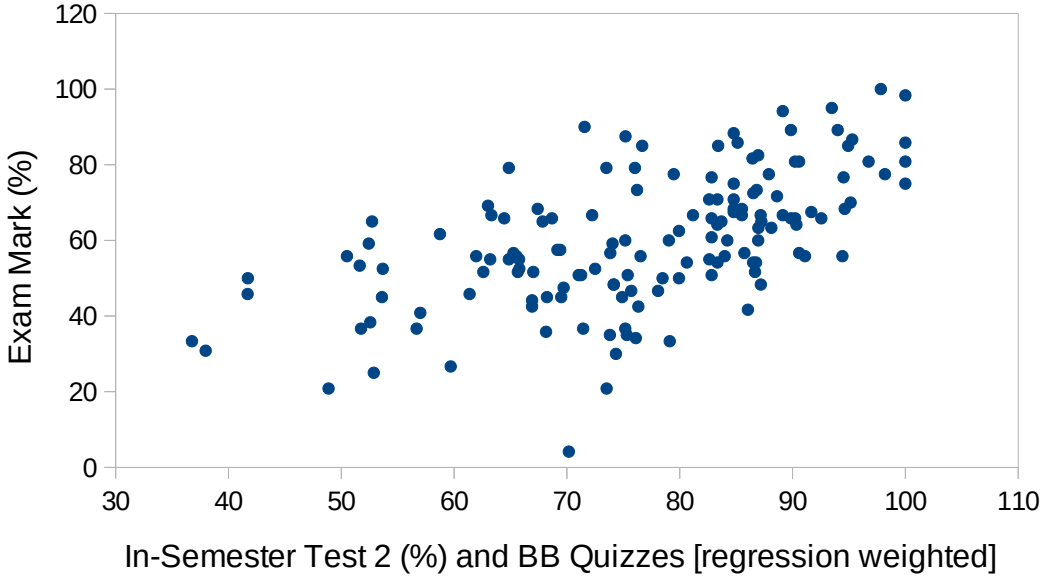


Learning Outcomes

Quantification of Active Learning

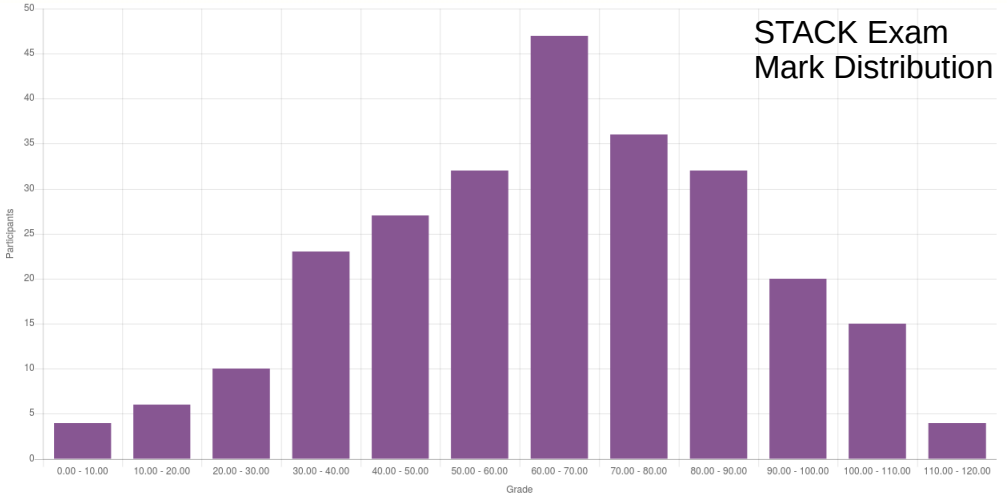
- Robust semi-automatic marking
- Quantitative analysis of learning outcomes

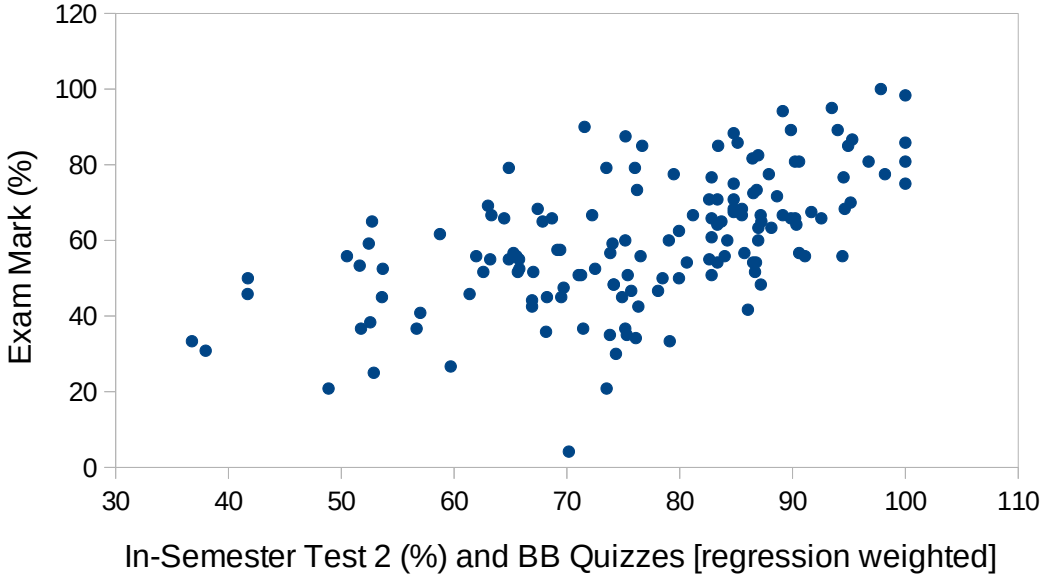




Quantification of Active Learning

- Robust semi-automatic marking
- Quantitative analysis of learning outcomes
  - **2019/20**: early engagement correlates with high outcomes
  - **2020/21**: sustained engagement correlates with high outcomes

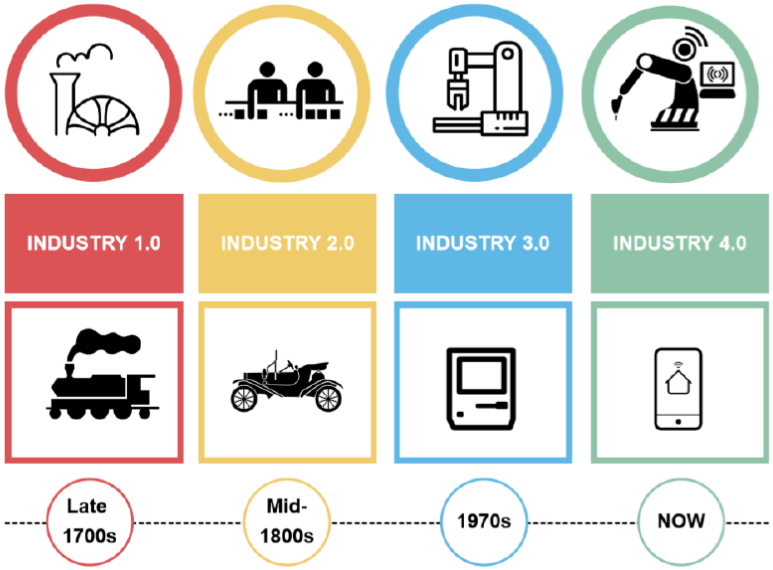




Summary & Outlook

- STACK provides a robust environment for teaching and assessing advanced engineering mathematics.
- Digital literacy poses a barrier for some students.
- Active learning-aided outcomes can be quantified.
- The extra effort pays off for large classes.

Thank you for listening!



Morisson A & Pattinson M (2019) *Industry 4.0*. Lille: Interreg Europe Policy Learning Platform.

Education 1.0	Education 2.0	Education 3.0	Education 4.0
Postal Correspondence Courses (late 19th cent.)	Open University (1960s)	MOOCs (2010s)	Post-COVID (2020s)

Graphics adapted from www.flaticon.com.