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The future of engineering education:
Doing it differently

Professor Peter Goodhew FREng

Prague: May 2015

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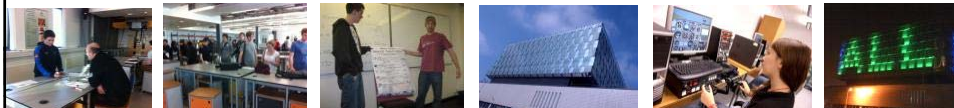
Some background

Engineering education is rather important to our countries (and their economies):

- There are more Engineers than doctors or teachers or accountants or lawyers;
- A graduate will probably work for 50-60 years
- Most engineering programmes were established many years ago
- Over the past 100 years there has been a great deal of research into learning
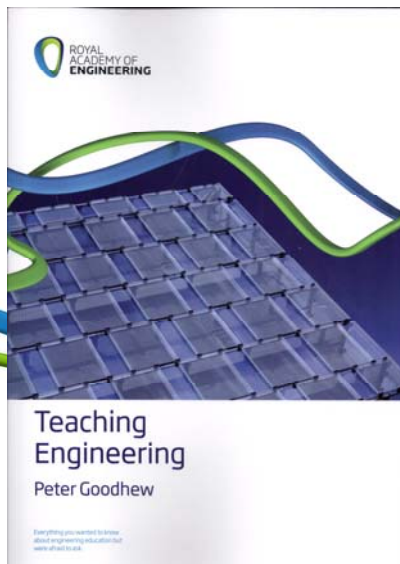
Today's question

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What is an appropriate education for an engineering graduate?

The set text

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Teachingengineering.liv.ac.uk

Teaching Engineering

Peter Goodhew

Everything you wanted to know about engineering education but were afraid to ask.

... and you can add comments!
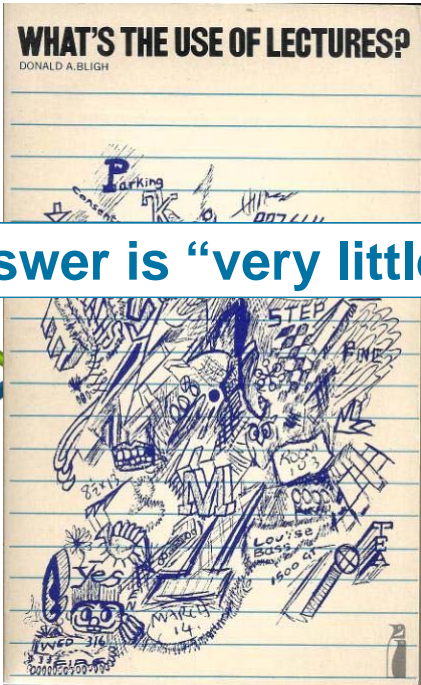
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WHAT'S THE USE OF LECTURES?
DONALD A.BLIGH

Published in 1971

The answer is "very little"

"I use lectures to catch up on sleep, or to update my Facebook page"

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What does the future hold for everyone?

Working lifetime of 50-60 years
More developments than we can imagine
Multiple careers
Immense global challenges
Death and taxes[1]

1: Christopher Bullock, 1716, followed by many others!

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What does the future hold for the T of engineering?

More engineering disciplines
More engineering students
Larger range of abilities in any specific science or maths subject
Greater need for communication skills
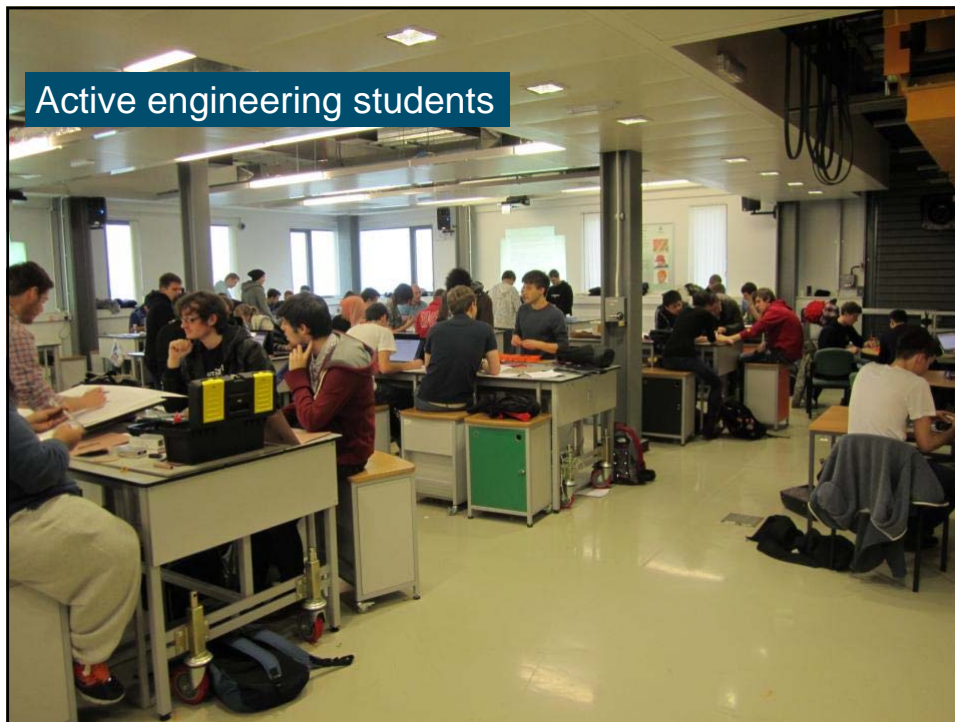Not everyone will need to deploy maths

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What?

Can teachers of engineering do better?

Many things, for example:

Active learning
Flipped classroom
Team working
Design, build, test
Concept questions

Active engineering students

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A concept question

A ladder is upright against a vertical wall. Both the wall and the floor are perfectly slippery (no friction between ladder and floor or wall). You pull the bottom of the ladder away from the wall slightly and it starts to slip down. At some angle it loses contact with the wall. What does this angle depend on?
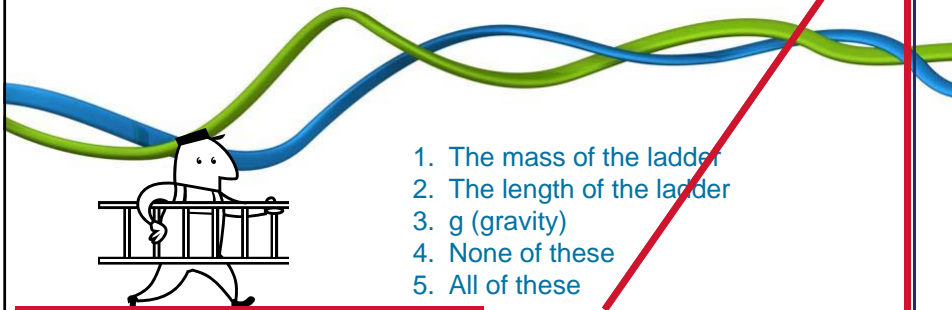
1. The mass of the ladder
2. The length of the ladder
3. g (gravity)
4. None of these
5. All of these

Some issues for debate

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- What attitudes and attributes make an engineer?

- What is the proper balance between knowledge and understanding?

- What is the appropriate balance between fundamental eternal truths and authentic, motivating experiences?

- To what extent can necessary (fundamental or trivial) background be delivered "just-in-time"?

Some issues for debate

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- What makes an engineer?
- Knowledge vs understanding?
- Fundamental vs authentic?
- Pre-teach or "just-in-time"?

These are things which should be decided by universities and professional bodies!

... but I can (and will) offer a few thoughts

"Engineering graduates should be able to _do_ something"

Recent RAEng reports relating to education

1. Thinking Like an Engineer
2. Skills for the Nation
3. Jobs and Growth
4. Engineering Graduates for Industry
5. Educating Engineers for the 21st Century
6. Achieving Excellence in Engineering Education
7. Educating Engineers to Drive the Innovation Economy
8. Educating Engineers in Design
9. Engineering a Low Carbon Built Environment
10. Recognition and Reward for Excellence in Teaching
11. Teaching Engineering

In the pipeline
1. The Universe of Engineering
2. Pathways to Success in Engineering
3. The Econometrics of Engineering Education
4. Recognising and Supporting Excellence: Experiential Learning
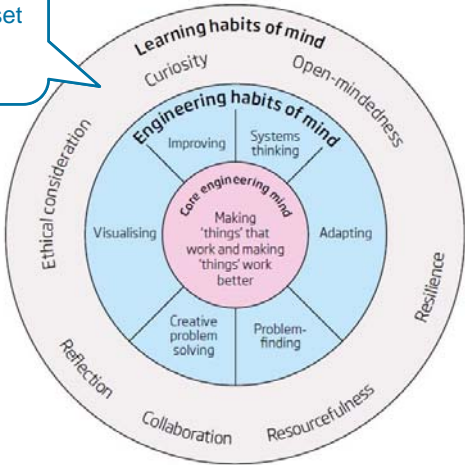5. Recognising and Supporting Excellence: E-learning

What makes an engineer? Engineering Habits of Mind (EHOM)

These attitudes are initially set in primary schools

Thinking like an engineer
Implications for the education system

Summary report. May 2014

2014

Knowledge vs understanding

What are the differences between knowledge, understanding, skill and competence? Which do you currently assess?

Is it possible to demonstrate understanding in the absence of knowledge?

Knowledge is easily available (e.g. MOOCs), but critical thinking usually has to be encouraged (face to face).

Fundamental vs authentic

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Authentic (real-world) experiences are transient but exciting.

Fundamental understanding leads to long-term wisdom and transferable skills but can be challenging (students may say boring).

Pre-teach or JIT?

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Just-in-time learning is driven by need, but is hard to manage.

Pre-teaching (in anticipation of future need) is conventional and easy to organise but fails to motivate many students.

So: Blended learning

Don't think of simply blending teaching and learning styles – lectures, on-line, projects, PBL.

Consider blending:
• Engineering HOM with personal development
• Knowledge acquisition with understanding
• Authentic experiences with eternal truths
• Student-driven JIT with staff-driven anticipatory teaching
How much of this could be student-driven?

Innovation around the world

• All PBL (Aalborg)
• Liberal engineering (AUC, Florida Poly, Harvey Mudd, NMite)
• Student-designed programmes (AUC, Olin)
• Many projects (Olin, High Tech High ..)
• Distributed learning (Minerva)
• Blocks, not modules (Quest)
• Entrepreneurship (Zeppelin, Olin)
• Gender parity (AUC, SUDT ...)
• Design-led (SUDT)
• No lecture theatres (NMite)
• Gender balance
• SSR around 10

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Some barriers to improvement

Research

Arrogance

Externally-imposed quality procedures

Students and staff from different educational cultures

Few metrics and slow evidence for excellent teaching

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The horizon: NMite (Hereford), Olin et al

Admit 50% women

No lecture theatres

No "years"

JIT

No written exams

BYOD

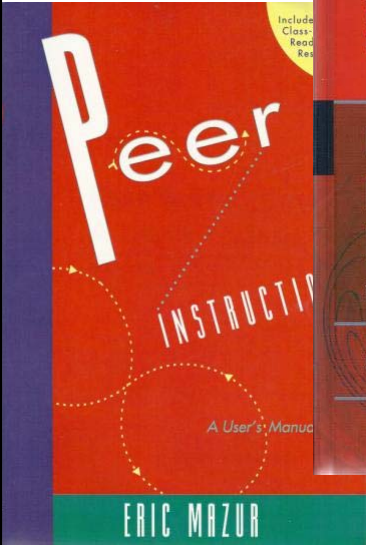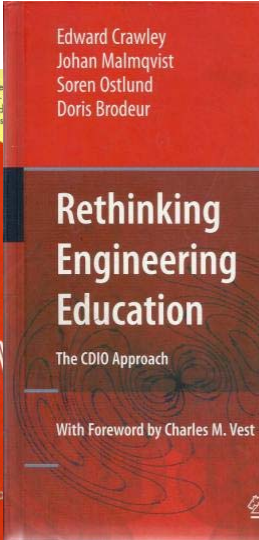Few polymaths (maybe some opsimaths)

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Over to you

… for questions, comments and debate!

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Edward Crawley
Johan Malmqvist
Soren Ostlund
Doris Brodeur

Rethinking Engineering Education

The CDIO Approach

With Foreword by Charles M. Vest

Springer

Teaching Engineering

Peter Goodhew

ERIC MAZUR

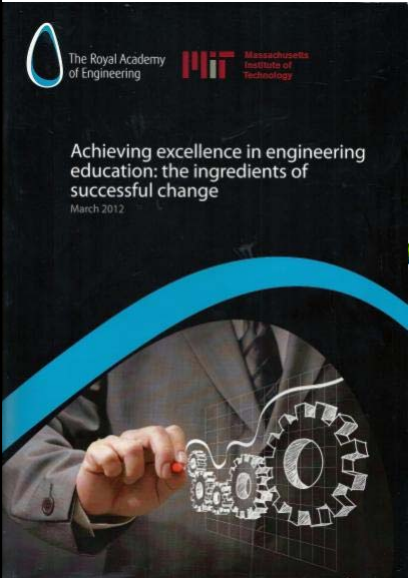*"I learn more from being asked questions, and having to respond"*

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The Royal Academy of Engineering | MIT Massachusetts Institute of Technology

Achieving excellence in engineering education: the ingredients of successful change
March 2012

"It is rare for Engineering faculty to come together to talk about education"

The Active Learning Lab at The University of Liverpool

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What might the future hold?

Modest advances in engineering
MOOCs?
Unknown technology and social behaviour
Global challenges