# Remote laboratories for traditional campuses

PHEE Annual Conference
(in conjunction with AiME and Co-sponsored by EPC)
Wednesday 7th June 2023
Online via TEAMS

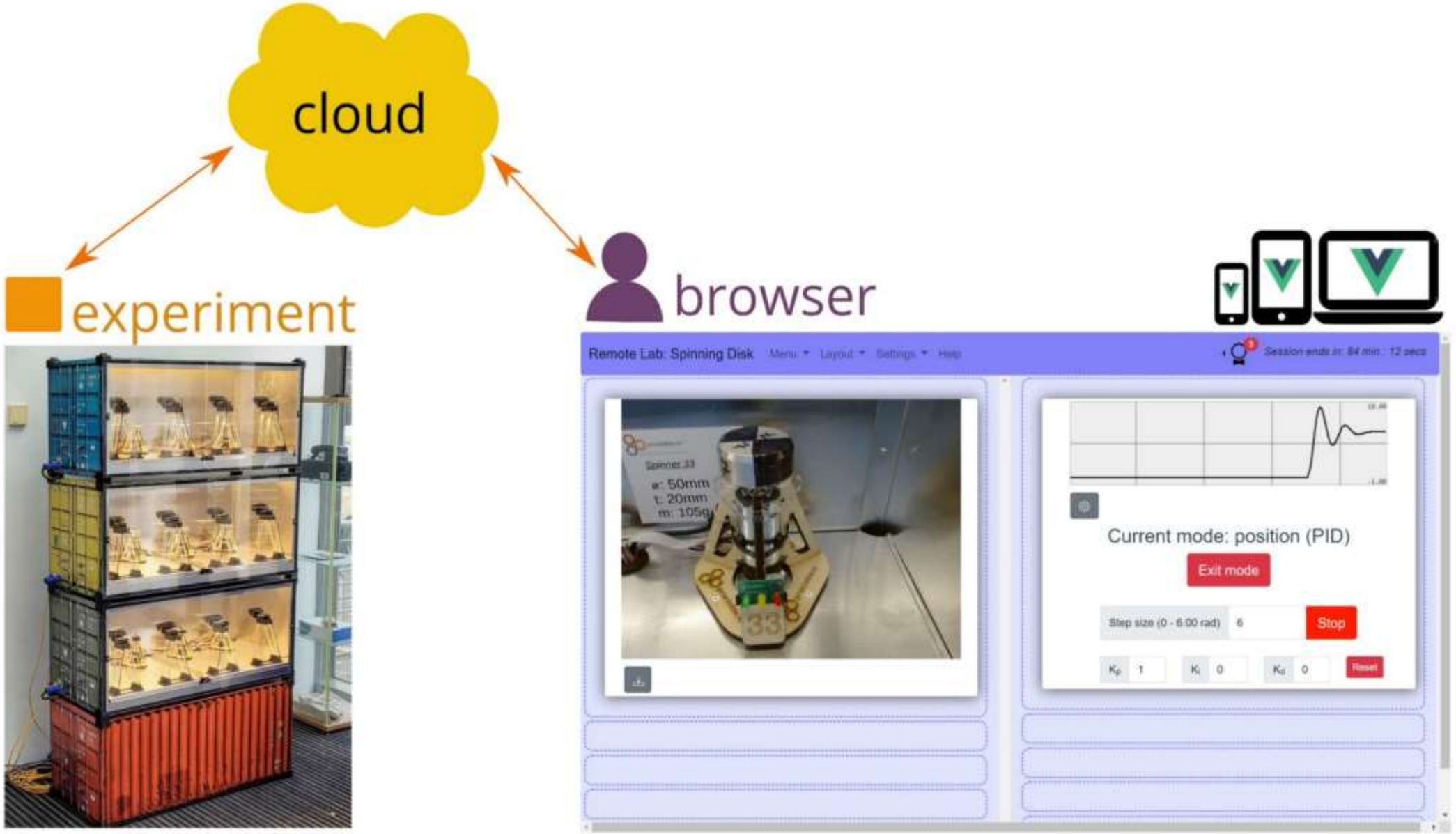

practable.io™
non-traditional practical work

Prof Timothy Drysdale
Director of Strategic Digital Education
Chair of Technology Enhanced Science Education


practable.io
Generation 1 (2020)


Generation 2 (2022)

# Students use a browser to access equipment in real-time



# Traditional campus uses (so far)

## Timetabled

- staff and students in same room at same time
- can be any teaching room (students can BYOD)
- equipment is remote (stays in its usual location, e.g. building foyer)

## Independent

- staff set task(s)
- students book at a time to suit them
- students submit a technical report for assessment

## Demonstration

- Staff member shows live experiment in class, outreach, or offer holder day

## Dissemination of research*

- Add to EPSRC grant as way to instantly reach industry/public with research demo

# Remote labs contributors (>20)

Delivery team: Andrew Brown, Imogen Heard, Calum Melrose, and seven interns.

PhD Researchers: David Reid, Sijie Zhou, + recruiting now!

Course staff: Aristides Kiprakis, Michael Merlin, Jonathan Terry, Brian Peterson, Thomas Reynolds, Marcelo Dias, Symon Podilchak & research team.

Infrastructure & project lead: Timothy Drysdale

Funded by the School of Engineering

# Two critical pressures on teaching

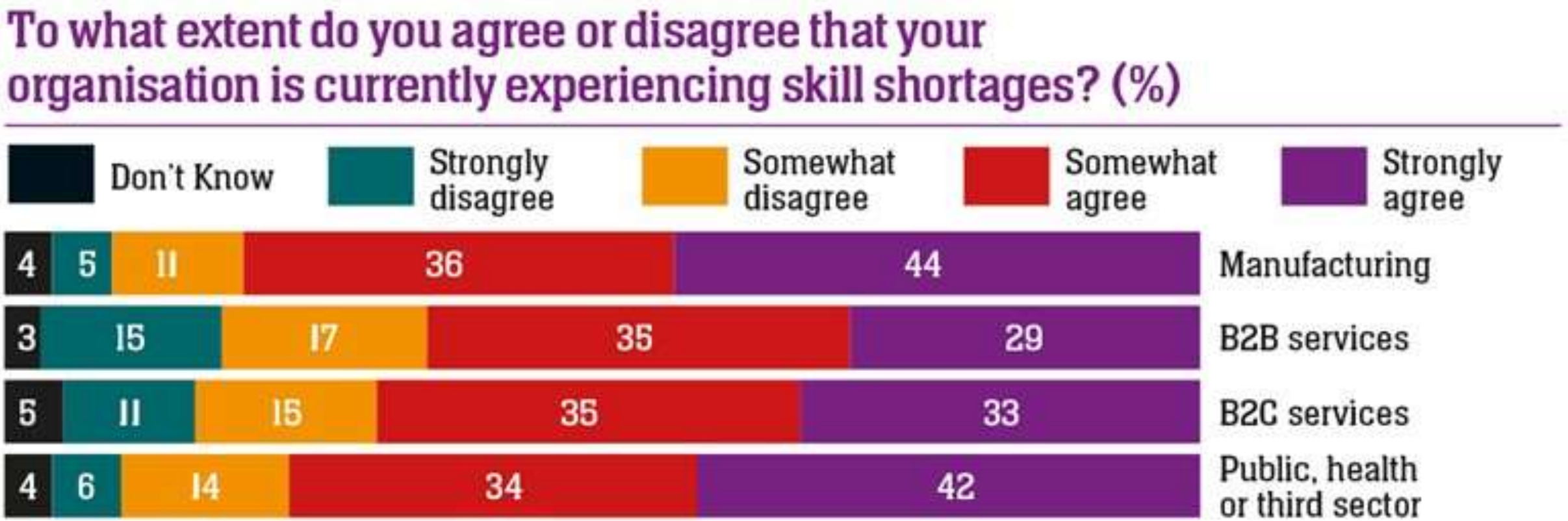
Keeping going/growing:

Doing enough traditional lab-work with increasing student numbers and fixed real estate

Responding to external change:

Large language models forcing rethink about learning and teaching (especially skills & assessment)

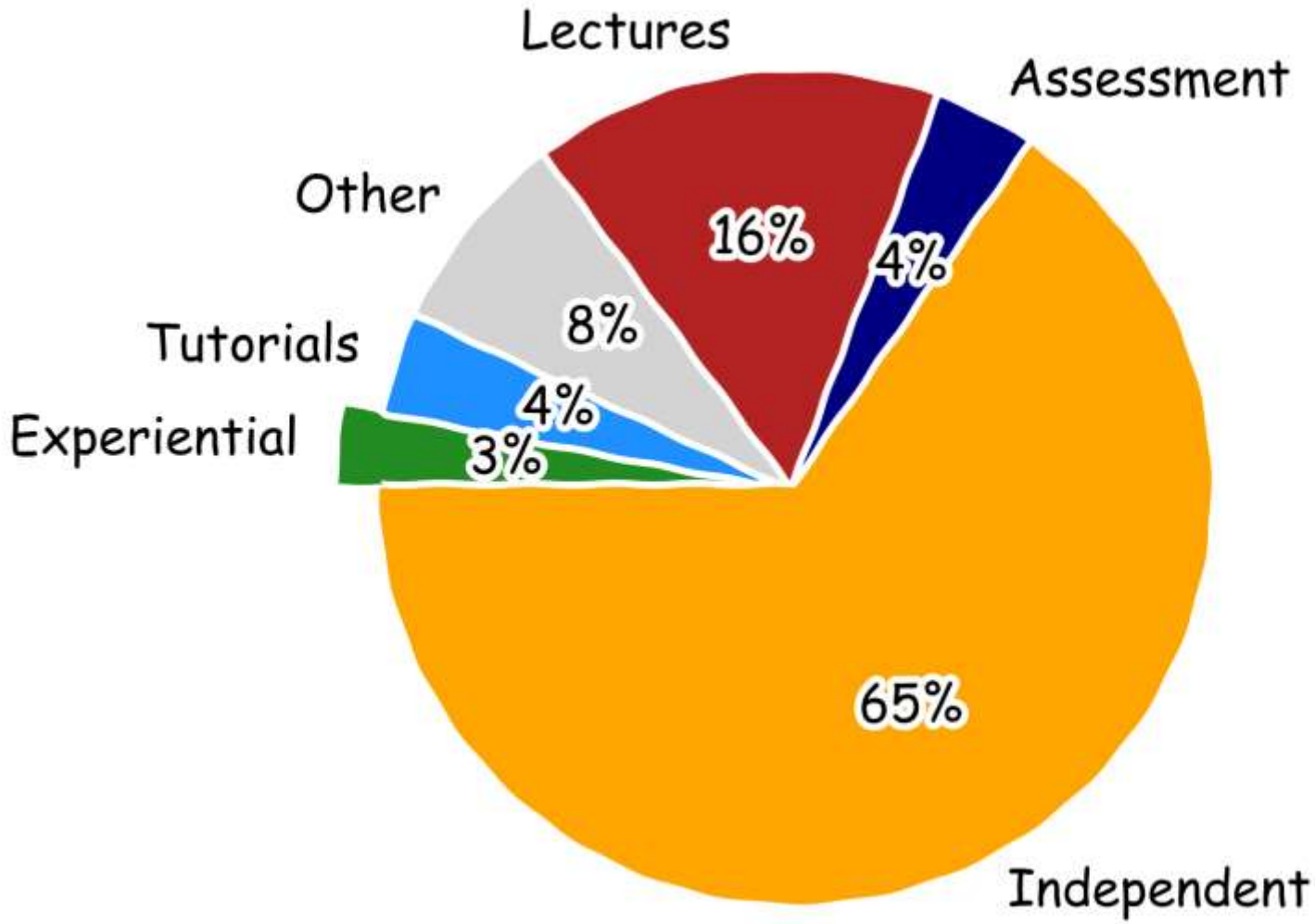
# Are we meeting (skills) demand?



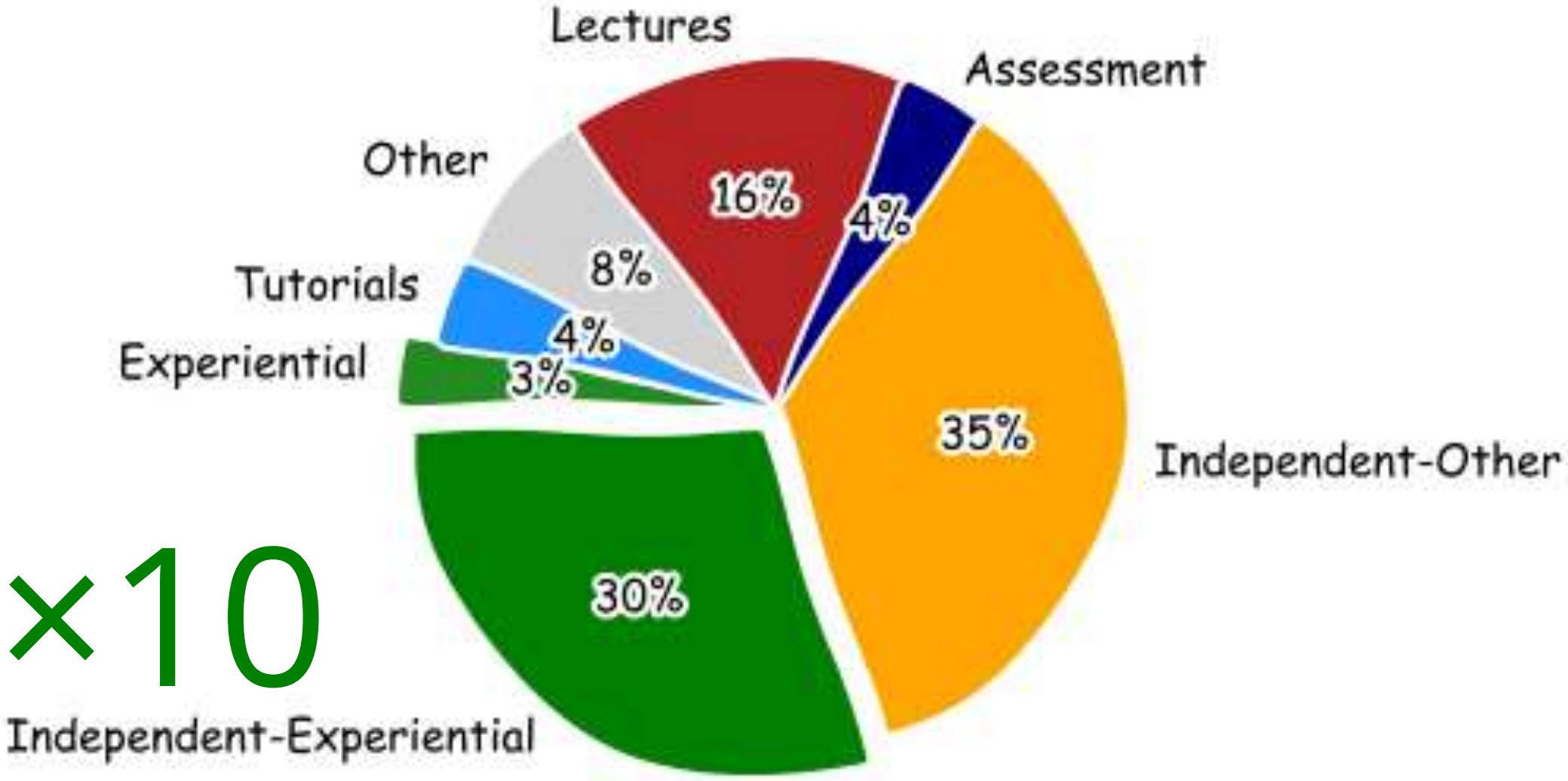

https://eandt.theiet.org/content/articles/2023/01/engineering-skills-crisis-a-multi-pronged-problem

# “Waiting for a lab session”

Credit – Tim Drysdale using Midjourney AI

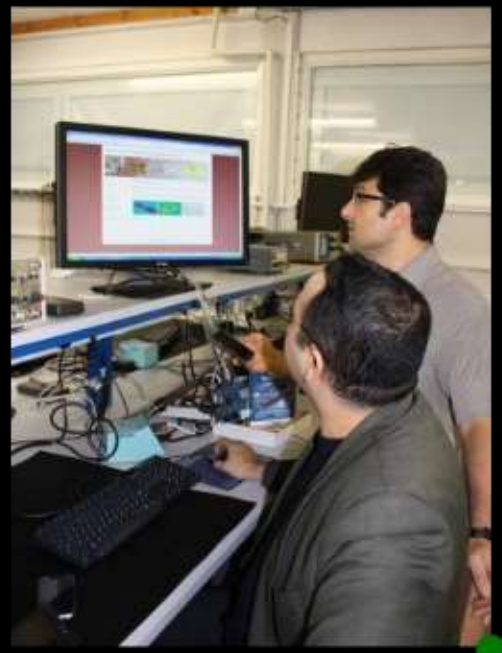



(estimated from public data for a typical city-centre campus, not weighted by enrolment)

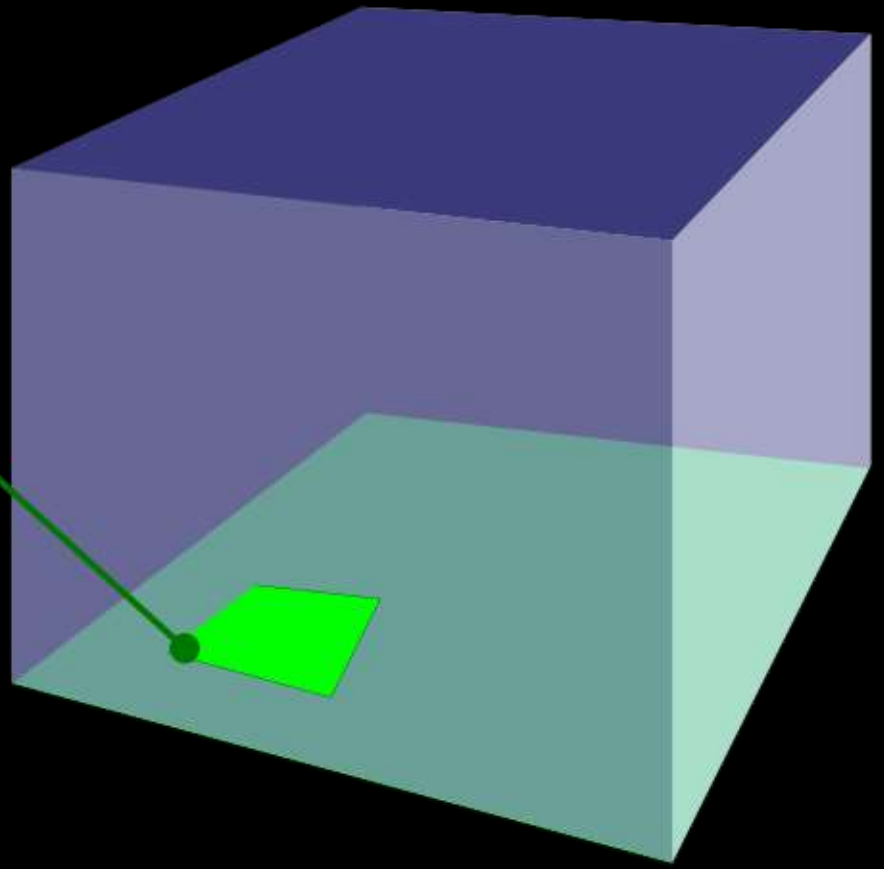



×10

(estimated from public data for a typical city-centre campus, not weighted by enrolment)



total student-experiential-hours



limited by
- available lab space
- building opening hours

more students => fewer experiential hours per student

# State-of-the-art laboratories (“more”)

The Diamond, University of Sheffield, 2015

~£90M Capital
19 Labs, 50 Staff
Serves 5000 students

The CTL, University of Birmingham, 2018

~£40M Capital
3500 UG STEM students

Space can be unavailable due to location, funding, timing or any combination of these factors.
Edinburgh is a small city, tightly packed!

*“How do we deal with this expansion [of student numbers]? How do we still engage students early on with the world of engineering? How do we show them the messiness of engineering, the political and social aspects? ... How do we do this beyond the capstone project? This type of education, the type of education we want to have, is expensive. So how do you do this for all students, large cohorts of students, without compromising on everything?”*

R. Graham, (2018) “The global state of the art in engineering education,” New Engineering Education Transformation, Massachusetts Institute of Technology, Cambridge, MA, USA

2015
|
2018

The Open University

The OpenEngineering Laboratory

2018
↓
ongoing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non-traditional practical work

Opinion Piece:

# Non-Traditional Practical Work for Traditional Campuses

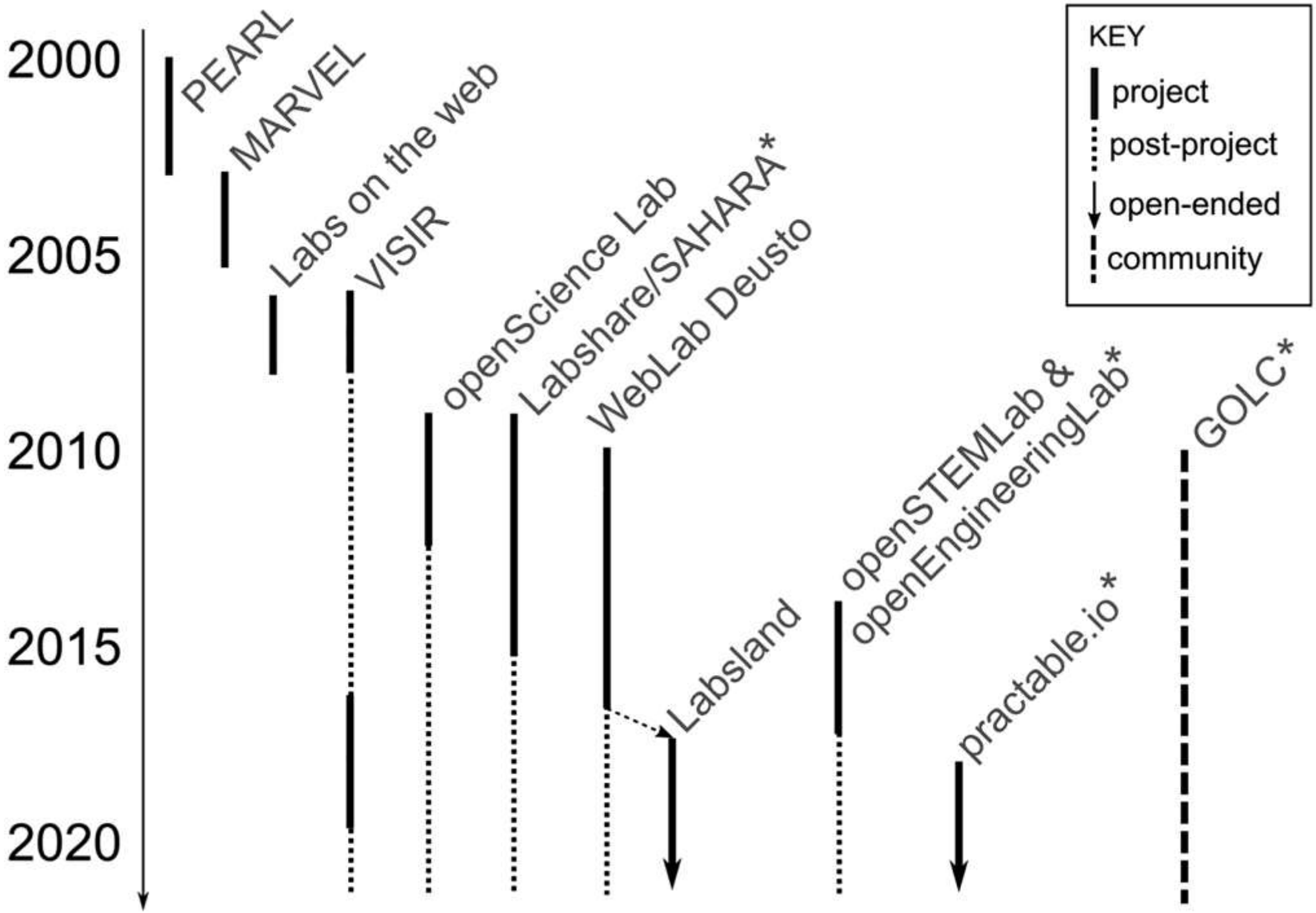
https://www.tandfonline.com/doi/full/10.1080/23752696.2020.1816845

Timothy D. Drysdale, Simon Kelley, Anne-Marie Scott,
Victoria Dishon, Andrew Weightman,
Richard Lewis, Stephen Watts

Higher Education Pedagogies, 5:1, 210-222, 2020

Received 29 Jul 2019, Accepted 12 May 2020, Published online: 14 Sep 2020

"I really enjoyed this visionary piece and look forward to recommending it once published."
*- Reviewer*


2000
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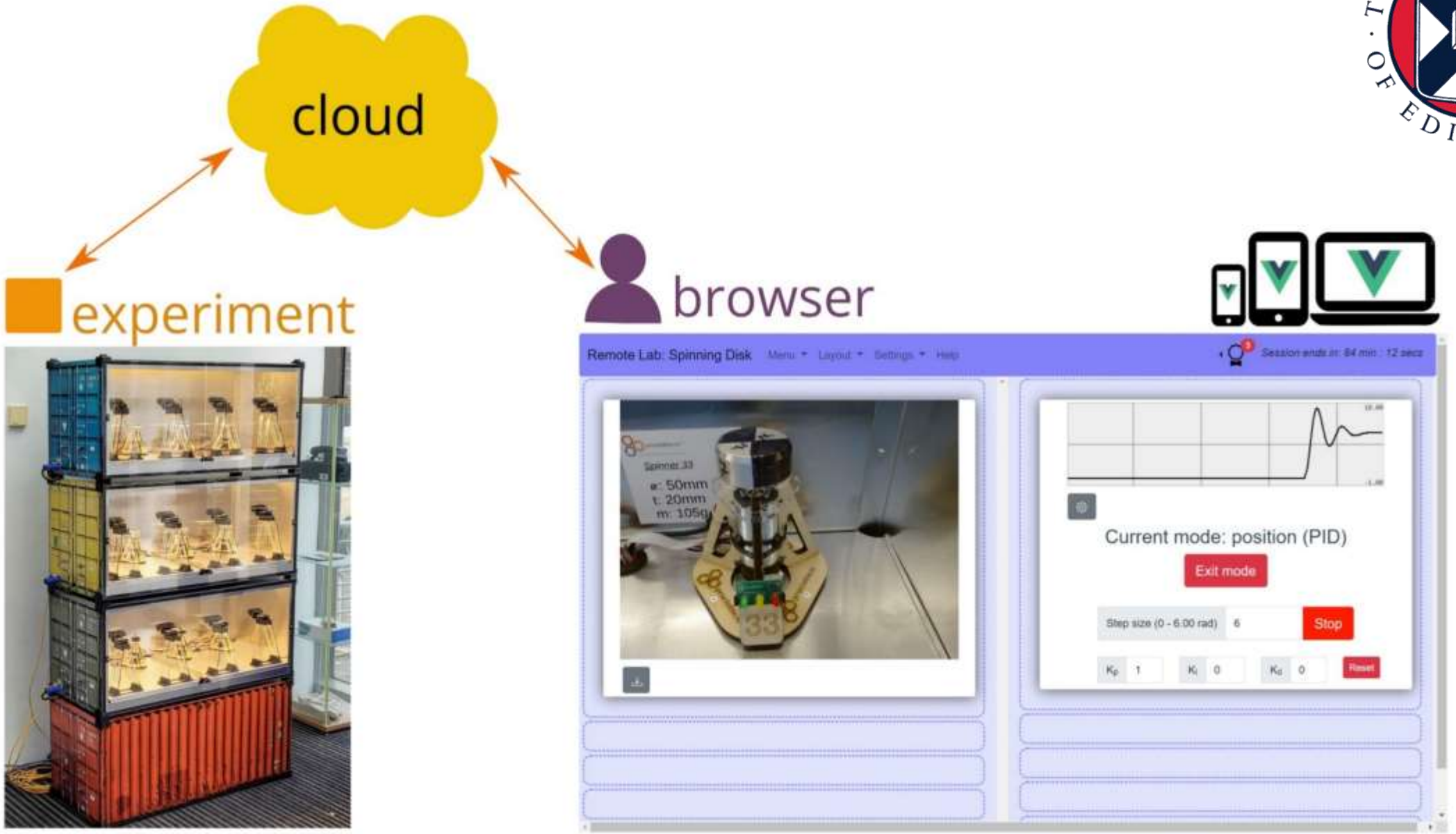
PEARL
MARVEL
Labs on the web
VISIR
openScience Lab
Labshare/SAHARA*
WebLab Deusto
Labsland
openSTEMLab &
openEngineeringLab*
practable.io *
GOLC*
KEY
project
post-project
open-ended
community

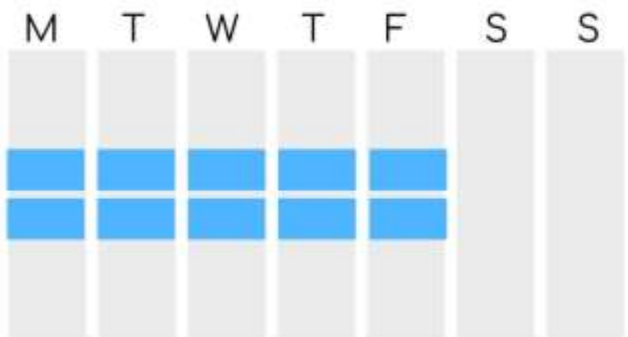
# State-of-the-art laboratories (“different”)



# in-person

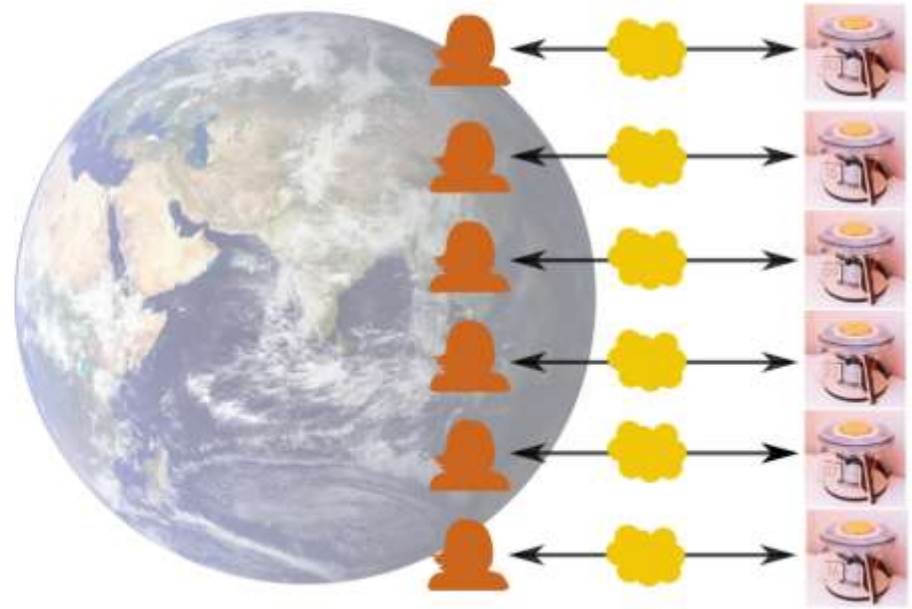
- must attend on-campus
- usually groups sharing kit


- only when building open




# online

- participate from anywhere
- usually individual sessions



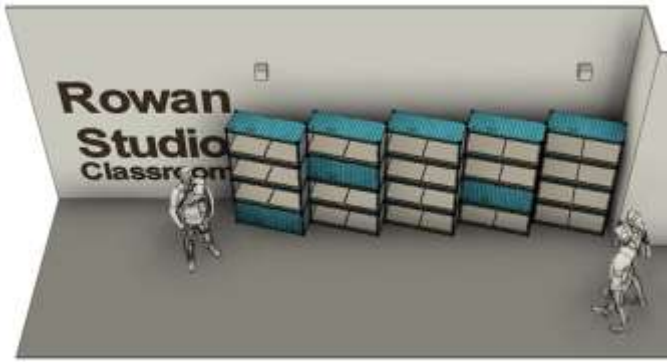
- available any time

# Estates efficiency (>150×)

| | traditional | remote | improvement |
|---|---|---|---|
| Opening hours | 10 hrs / day | 24 hrs / day | 2× |
| Footprint | >1.5$m^2$ | <0.1$m^2$ | 15× |
| Stacking | 1 per area | 5 per area | 5× |

# Add value to existing real estate

- New generation can be hosted in public foyers
  - Does not take up any teaching or research laboratory space
  - Only needs power and data sockets
- Adds an attractive “science museum” feel to campus
- Students can visit experiments when on campus
- Increases visibility of activities to visitors, and internally




| What | Used by | For | Comment |
| --- | --- | --- | --- |
| Industrial control | Trained operators | Business value | Long term access to few systems |
| IOT/ smart systems | Various | Business/ Curiosity | Long term access to few systems |
| Remote labs | Untrained users | Learning & experiences | Short term access to many systems |

# Emotional engagement ( “no” delay)

| Delay | Comment |
|---|---|
| <200ms | Not noticeable |
| 400ms | Threshold region |
| >600ms | Definitely noticeable |

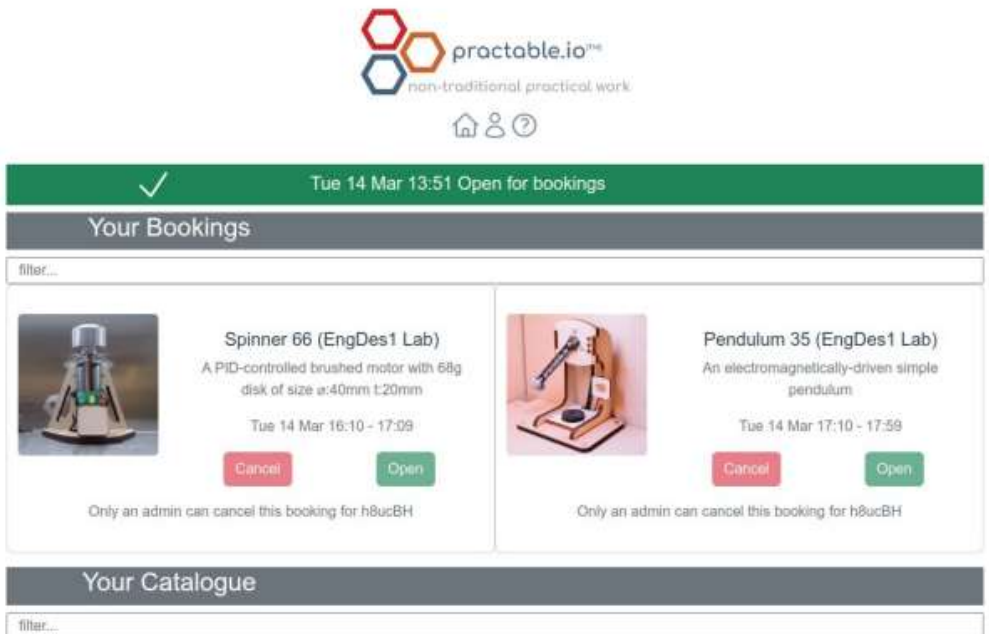
Kohrs C, Angenstein N, Brechmann A (2016) Delays in Human-Computer Interaction and Their Effects on Brain Activity. PLoS ONE 11(1)

| London to | One-way |
|---|---|
| Bristol | 4ms |
| Cardiff | 6ms |
| Edinburgh | 11ms |
| Manchester | 8ms |
| Newcastle | 6ms |

https://wondernetwork.com/pings/London

# Booking system

- New for 2023:
  - Bookings can be made in advance & cancelled
  - Bookings can be pre-prepared for in-person labs
  - Custom policies manage access times and usage




*Example of a pre-booked 2hr session with 2x experiments (1hr each)*

# Assessed coursework for class of 250

| | traditional | remote | improvement |
|---|---|---|---|
| Usage (full time equivalent 1:1 hours) | 125 | 2500 | 20× |

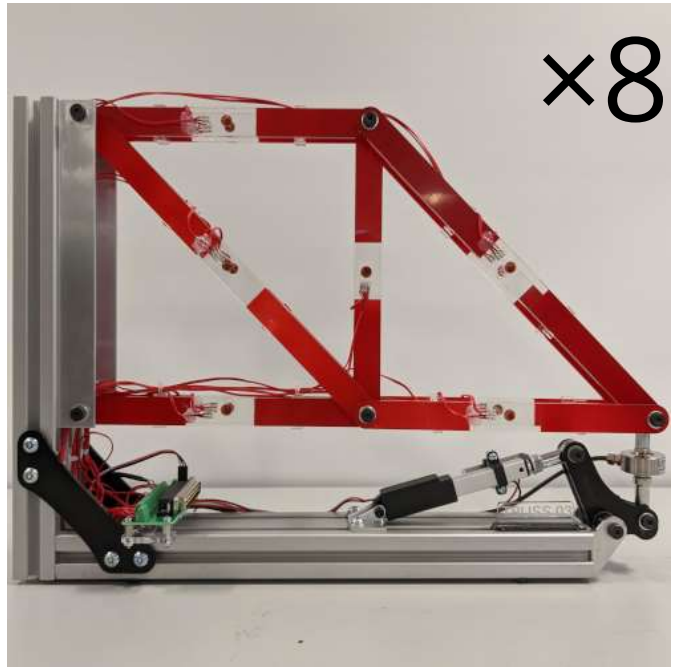
12 experiments in three containers: foot print <1.5m$^2$
(since expanded to 48 experiments for 450 students)

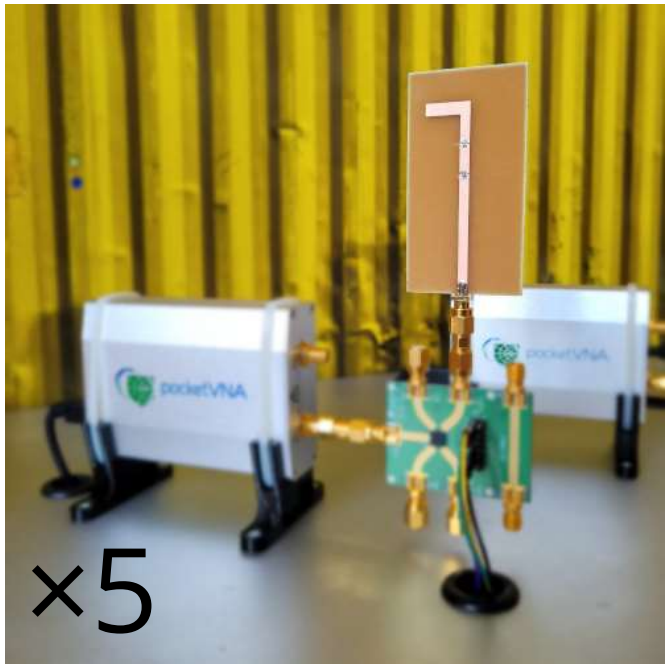
# First practicals for 1st year (class of 450)

- Can’t timetable in our traditional labs (not enough space)
- Synchronous sessions with staff and students in same room
  - Any space with tables will do (lecture theatre at a push)
  - Access remote labs in pairs, using own devices
  - Staff circulate around students in the usual “lab” manner
- Whole class can do 2hr lab in two afternoons (7 sessions)


×32


×48

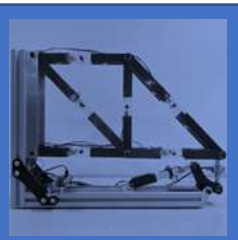






In build



×16

×6

×48

# Student response (standard UEQ)

| parameter | 2021 | 2022 | 2023 |
|---|---|---|---|
| | 3rd year (250) | 3rd year (250) | 1st year (450) |
| Attractiveness | positive | positive | positive |
| Easy to learn | positive | positive | positive |
| Dependability | neutral | positive | positive |
| Efficiency | positive | positive | positive |
| Stimulation | positive | positive | positive |
| Novelty | positive | neutral | neutral |

# Perception of skills practice

| Easier with REMOTE |
| --- |
| Collecting data |
| Managing lab time |
| Comparing to theoretical models |
| Setting up equipment |
| Presenting data |
| Working safely |

| No significant difference |
| --- |
| Analysing data |
| Investigating unknown quantities |
| Exploring beyond the lab book |
| Measuring accurately |
| Controlling variables |

| Easier with PROXIMAL |
| --- |
| Designing my own experiment |
| Working with others |
| Using multiple senses |

# Student comments (2021 class)

-“It is a great tool, and made me feel more motivated than a purely simulated one would have.”

-“Ability to take multiple sets of data and “play” around with numbers to deepen understanding”

-“[I]t gave me more time to figure things out and feel like I really understood the content. The UI was also very easy to understand and clear.”

-“Able to proceed at my own pace; not feeling rushed and under pressure.”

HIGHER EDUCATION PEDAGOGIES
2020, VOL. 5, NO. 1, 57–60
https://doi.org/10.1080/23752696.2020.1771610

Taylor & Francis
Taylor & Francis Group

DELIVERING THE NEXT GENERATION OF LEARNING AND LEARNING IN STEM



# The future of higher education (HE) hangs on innovating our assessment – but are we ready, willing and able?

G. L. Knight [a] and T. D. Drysdale [b]

[a]Centre for Innovation in Learning and Education (CILE), School of Engineering & Applied Science, Aston University, Birmingham, UK; [b]School of Engineering, Institute for Digital Communications, University of Edinburgh, Edinburgh, UK

**ABSTRACT**

Graduates are entering a sociotechnological world, with teaching and assessment needing to reflect that, by shifting from a 'recall-on-paper' to 'do-it-for-real'. With increasing student numbers, it is not feasible to have staff-student ratios and round-the-clock availability required to provide instant feedback and ever-more interactive teaching sessions, so digital solutions are the only option. There is already growing comfort with using computers in formal assessment; however, more work is required to extend beyond performance indicators enabling digital assessments, to addressing how students apply their learning to relevant work-based scenarios. This opinion piece discusses the issues HE currently face to ensure students develop the employability skills that equip them to be proficient in the skills directly related to their degree subject but

**ARTICLE HISTORY**
Received 28 June 2019
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Accepted 12 May 2020

**KEYWORDS**
Employability skills; assessment diversity; digital solutions

EXTERNAL FACTORS

Teaching Matters blog

*Promoting, discussing and celebrating teaching at The University of Edinburgh*

THE UNIVERSITY of EDINBURGH

**9TH MAY 2023**

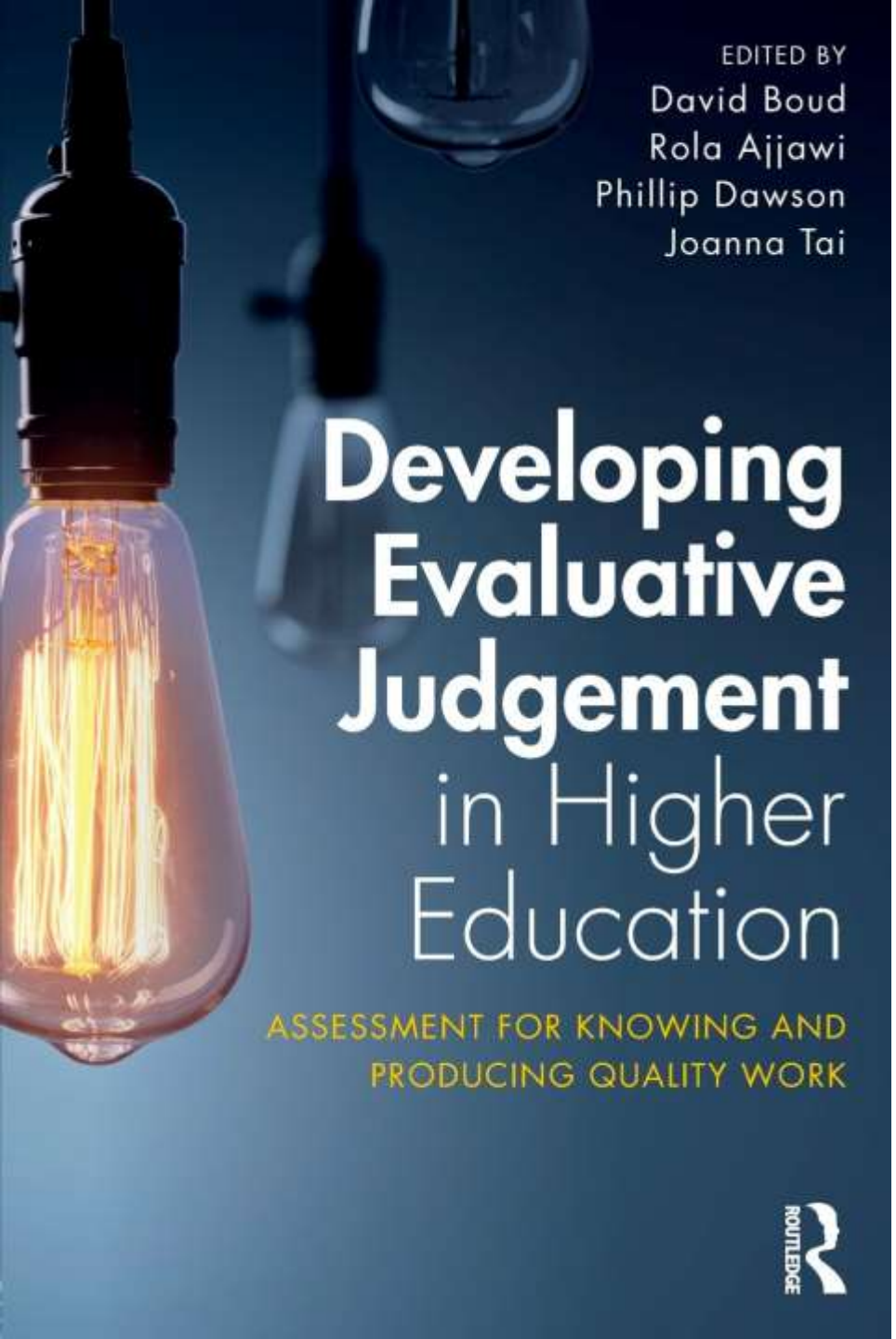
# Generative Artificial Intelligence – ban or embrace?

EXTERNAL FACTORS

bit.ly/tdtmboe

# Authentic assessment in a world with LLM


Cost-effective to assess PROCESS (not just output)




# Feedback on demand

- Effective learning involves discomfort
- Feedback and support required to maintain student engagement through beneficial difficulties
- Automated feedback available on demand required for asynchronous activities
- Recent research results are very encouraging
  - Work is under preparation for publication

# Benefits of remote labs

- Add capacity for practical work at low cost
  - 150x more estates-efficient than traditional labs
  - Faster to build than a new laboratory
  - Avoid timetable issues
  - Support EDI initiatives by being more flexible

- Prepare for future developments
  - Increase graduate skills through additional experiential learning
  - Enable authentic assessment of (iterative) engineering tasks
  - Embrace large language models by measuring process not output

# How do I get hold of remote labs?

- DIY – all our code & designs are open source
- Rent – access our existing experiments
- Buy – hardware & service package
  - Hardware & UI from existing designs
  - You own the hardware and host on your campus
  - Cloud services operated by us
  - Setup and support
- Commission custom designs
  - hardware
  - user interfaces
  - Analytics
  - Assessments

Schedule a demonstration session: timothy.drysdale@ed.ac.uk