



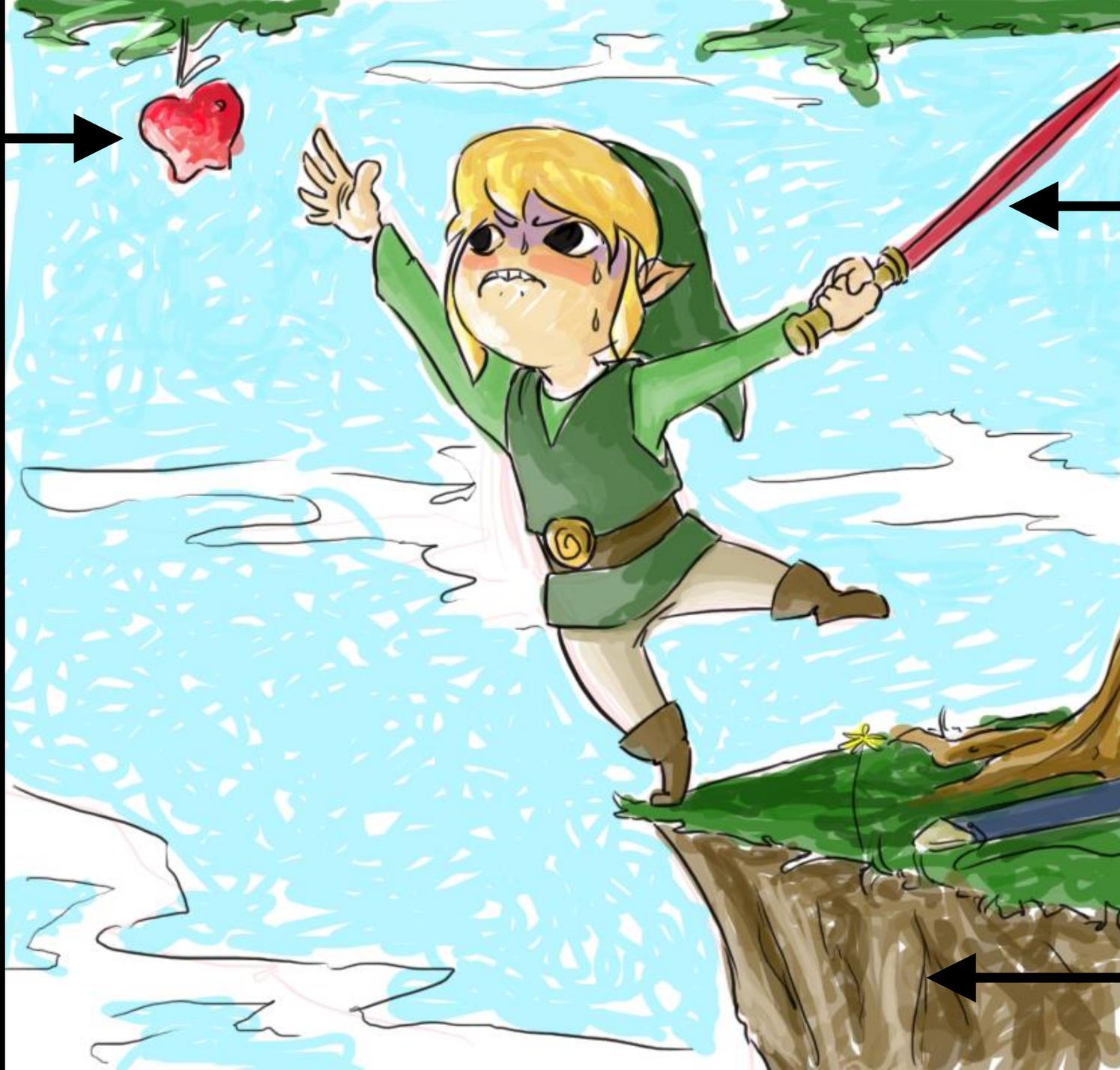
Remote laboratories

education, outreach, recruitment

Prof Timothy D. Drysdale

Chair of Technology Enhanced Science Education
School of Engineering, University of Edinburgh, Scotland

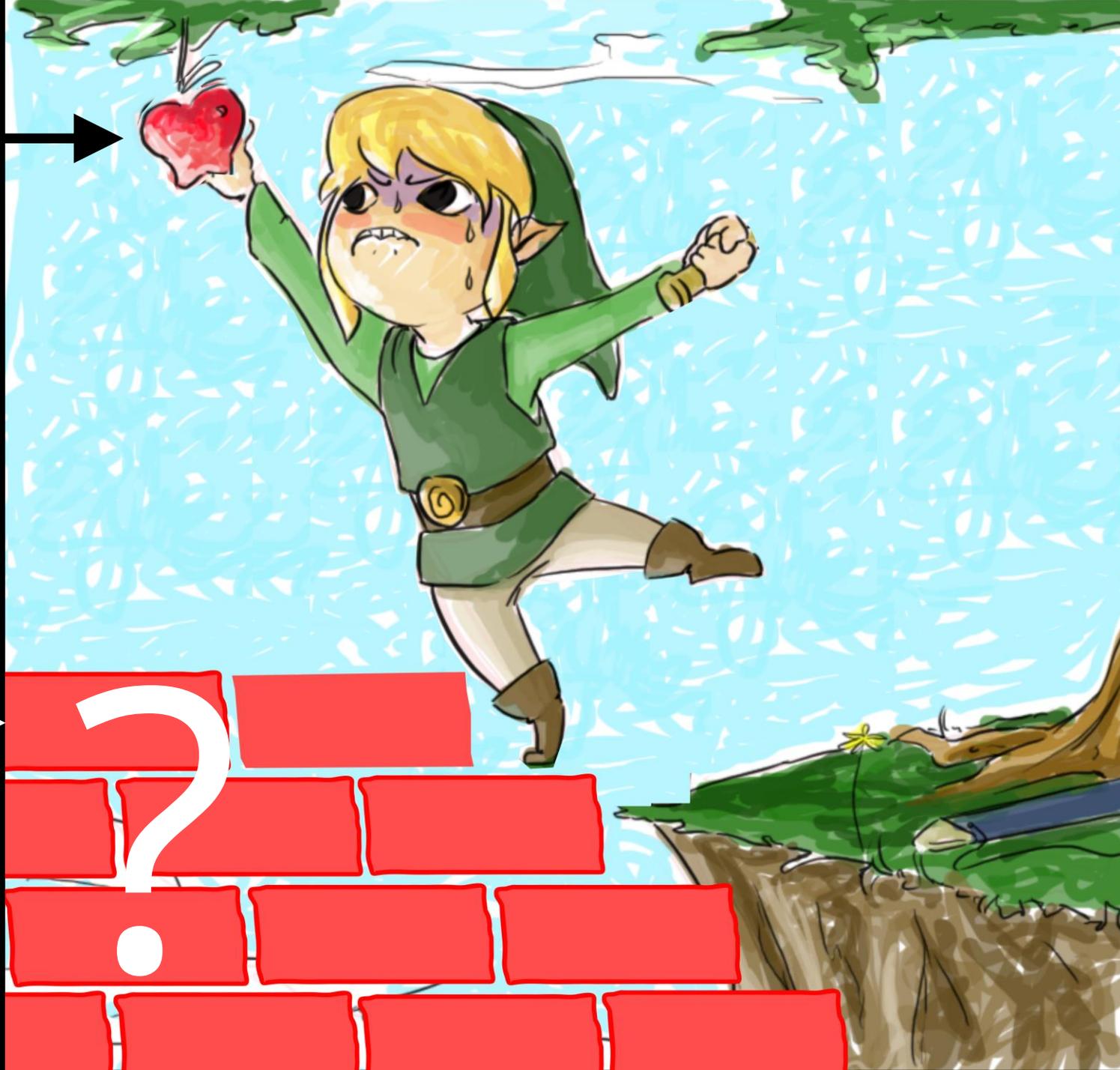
better
STEM
education



>30 years
of modern
internet
technology

~190 years
laboratory
teaching

better
STEM
education



new
ways

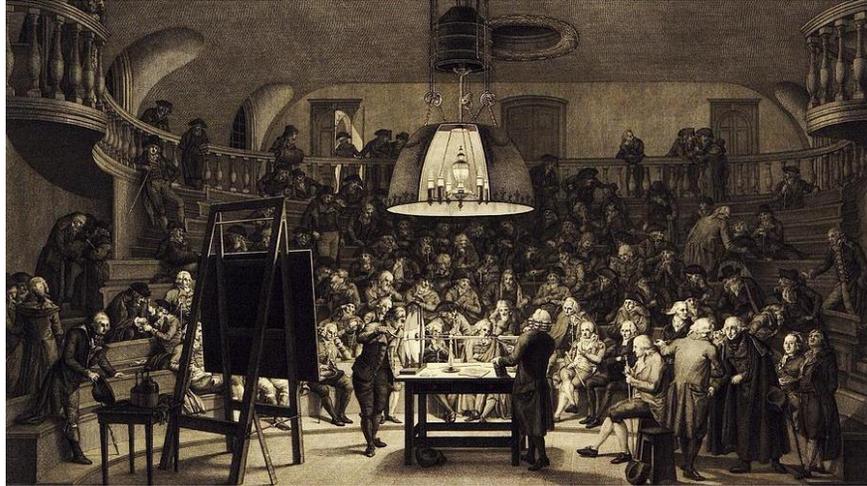


Remote laboratories

enlightenment

professionalism

digitalisation



lecture



+ laboratory



+ online

1700

1800

1900

2000



University of Sheffield >£90M



University of Birmingham >£40M

Opinion piece: non-traditional practical work for traditional campuses

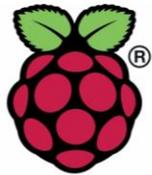
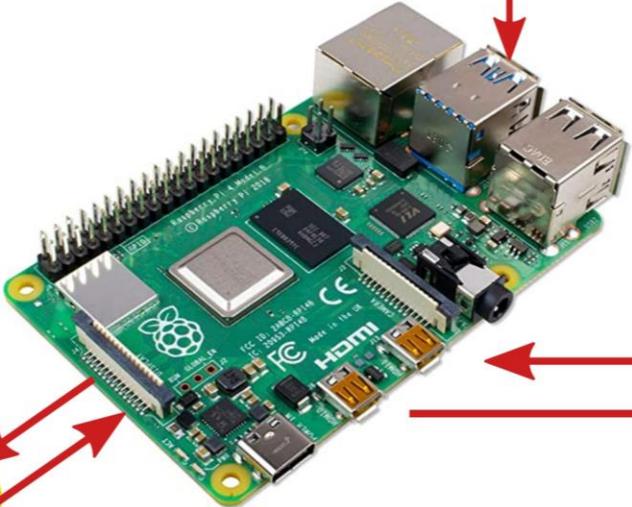
Timothy D. Drysdale Simon Kelley Anne-Marie Scott Victoria Dishon Andrew
Weightman Richard James Lewis and Stephen Watts

Edinburgh, Leeds, Manchester, Cardiff, Bath, and Athabasca

Traditional practical work for higher education in STEM subjects is under pressure.

- We must embrace a less instrumentalist view of practical work in physical spaces
- We should adopt a critical post-humanist approach which mixes both humanity and technology to achieve a sum greater than the parts, not bound by the limits of either

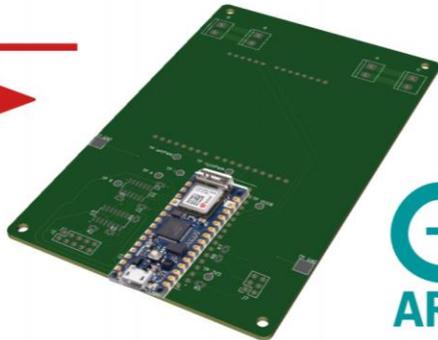
Low cost components



Raspberry Pi



single-board computer for secure communication



custom electronics



laser cutting
3D printing



	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

2015
|
2018



The Open
University



The OpenEngineering
Laboratory

2018
↓
ongoing

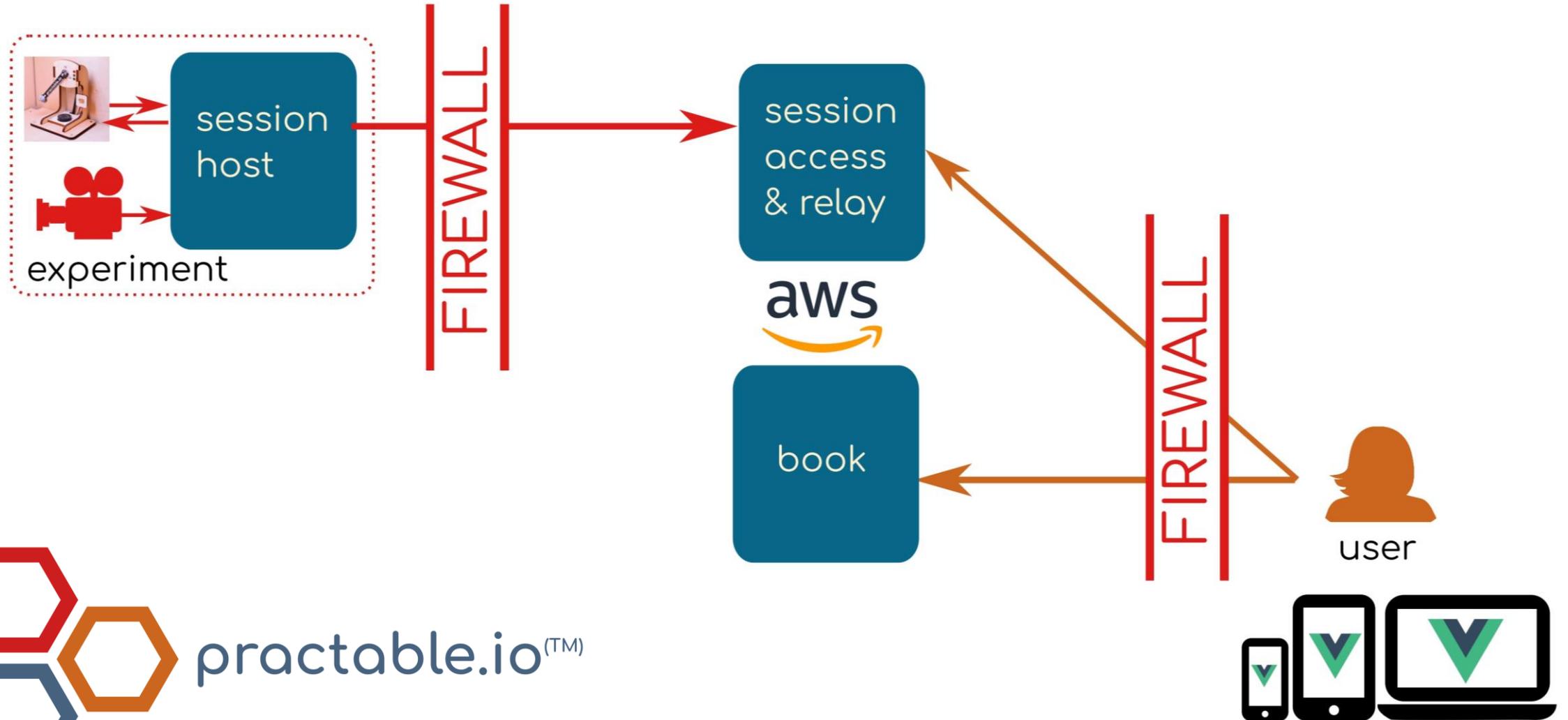


practable.io^(TM)

non-traditional practical work



Infrastructure - hidden, dominant factor

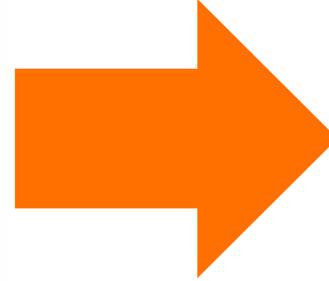




2021 - temporary

Vital contributions:

Gareth Harrison: funding champion; David Reid: user interfaces; Andrew Brown: physical design; Calum Melrose: assembly; Doug Halley, Iain Gold, Alasdair Christie, Richard Scott, Imogen Heard, c/o Sally Morgan & Chris Sturgeon: additional technical input; Fraser Miller, Bruce Duncan and Pawel Sokolowski: network; Matt Tasker, Eck Kirkland, Central Estates: building; Aristides Kiprakis: spinning disk co-development; Symon Podilchak, Maksim Kuznetsov: VNA co-development; plus others! Funded by School of Engineering



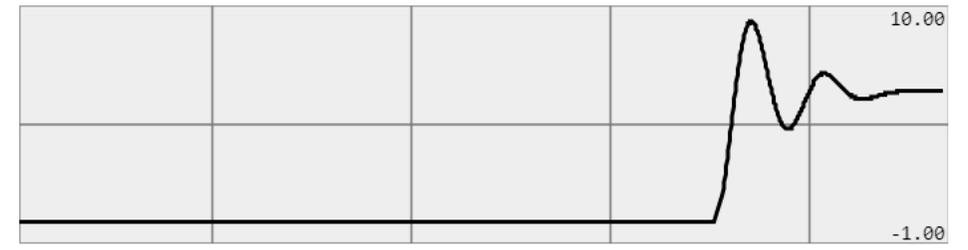
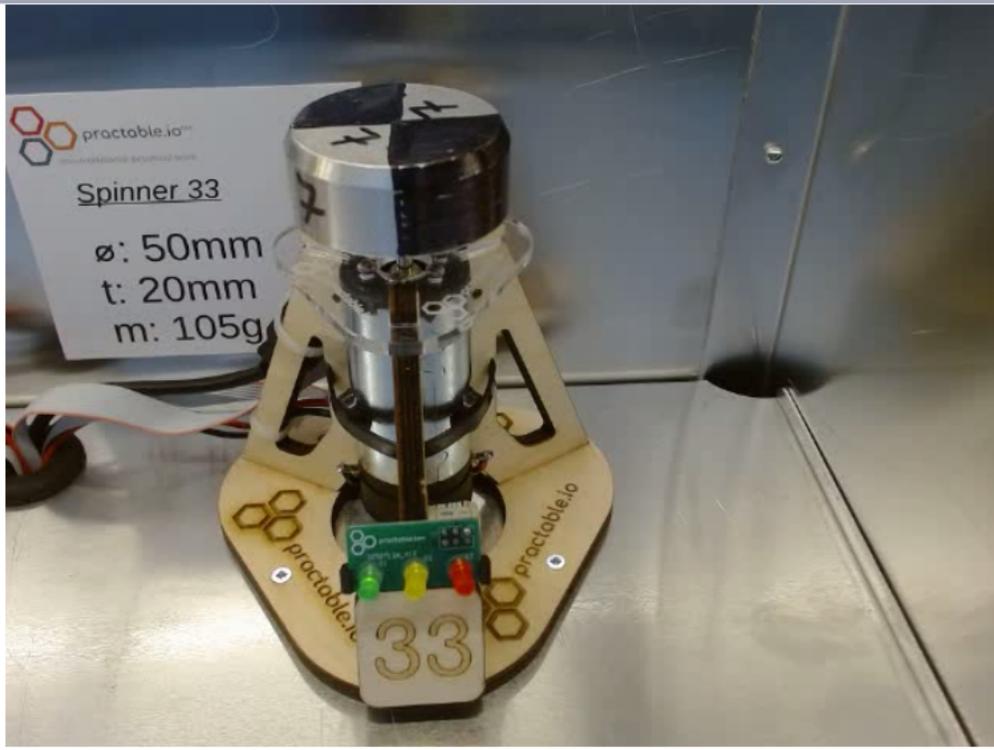
2022 - permanent



Proportional Integral Derivative Control



CIE3
SCEE09002
Aristides Kiprakis



Current mode: position (PID)

Exit mode

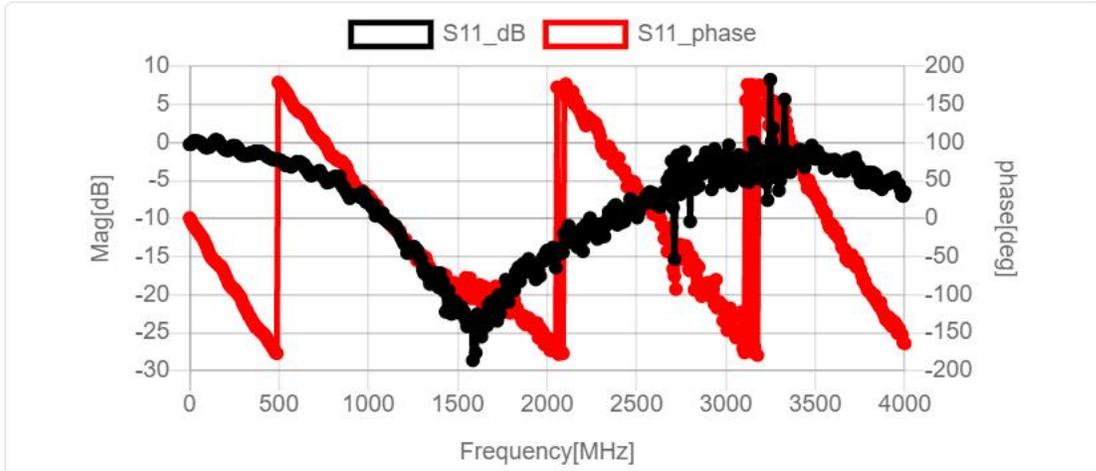
Step size (0 - 6.00 rad) **Stop**

Reset

One-port Radio Frequency Circuits



Emag3
ELEE09023
Symon Podilchak



Phase Wrap Unwrap

Real/Imag dB/phase
 .csv s1p

Download

1 port Calibration and Measurement

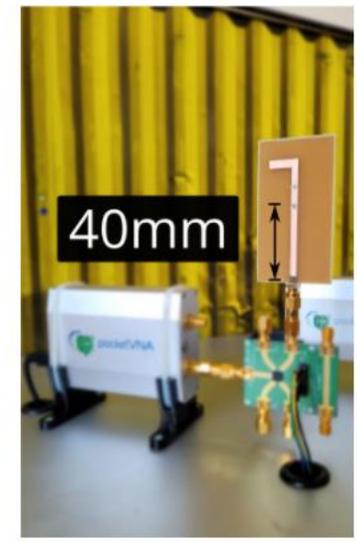
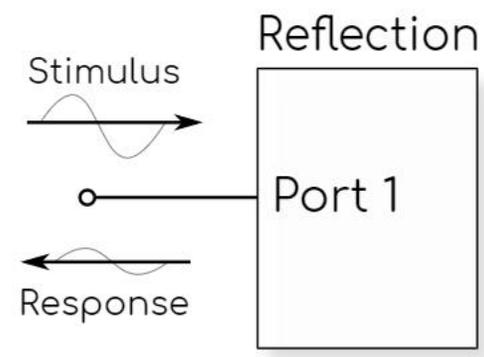


Photo of the DUT (40mm Transmission Line)

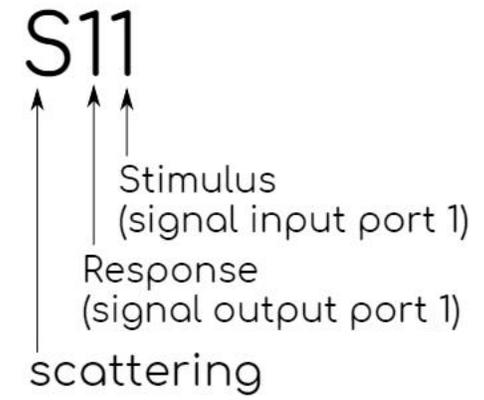


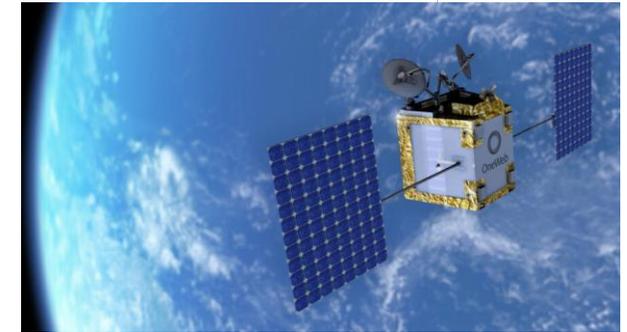
Diagram of one-port (S11) measurement

Real/Imag dB/phase

Frequency[MHz]	S11/dB	S11/phase[deg]	S11/unwrapped phase[deg]
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13 lab learning outcomes:

	USE	CREATE
1. Instrumentation	?	✓
2. Models	✓	✓
3. Experiment	✓	✓
4. Data Analysis	✓	✓
5. Design	?	✓
6. Learn from Failure	✓	✓
7. Creativity	✓	✓
8. Psychomotor	✗	✓
9. Safety	✗	✓
10. Communication	✓	✓
11. Teamwork	✓	✓
12. Ethics in the laboratory	✓	✓
13. Sensory Awareness	?	✓



L. D. Feisel, A. J. Rosa, "The Role of the Laboratory in Undergraduate Engineering Education, Journal of Engineering Education, 94:121-130, January 2005



Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research

James R. Brinson 

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<https://doi.org/10.1016/j.compedu.2015.07.003>

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Highlights

- Data supports equal or greater outcome achievement in virtual/remote labs vs. hands-on.

Blended and online learning: A comparative study of virtual microscopy in Higher Education

Herodotou, Christothea; Muirhead, Dave K.; Aristeidou, Maria; Hole, Malcolm J.; Kelley, Simon; Scanlon, Eileen and Duffy, Marcus (2019). Blended and online learning: A comparative study of virtual microscopy in Higher Education. *Interactive Learning Environments* (Early Access).

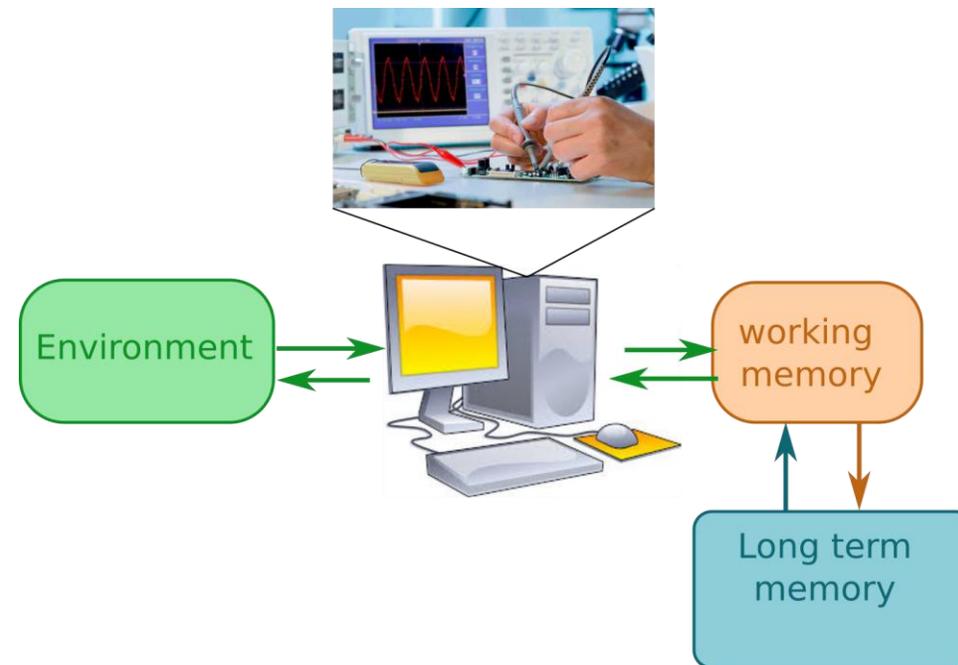
EDITED BY
David Boud
Rola Ajjawi
Phillip Dawson
Joanna Tai

Developing Evaluative Judgement in Higher Education

ASSESSMENT FOR KNOWING AND
PRODUCING QUALITY WORK



Automated authentic assessment



Break toxic cycle of feedback dependency

JOURNAL OF
CHEMICAL EDUCATION

Article

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Making Sense of Students' Actions in an Open-Ended Virtual Laboratory Environment

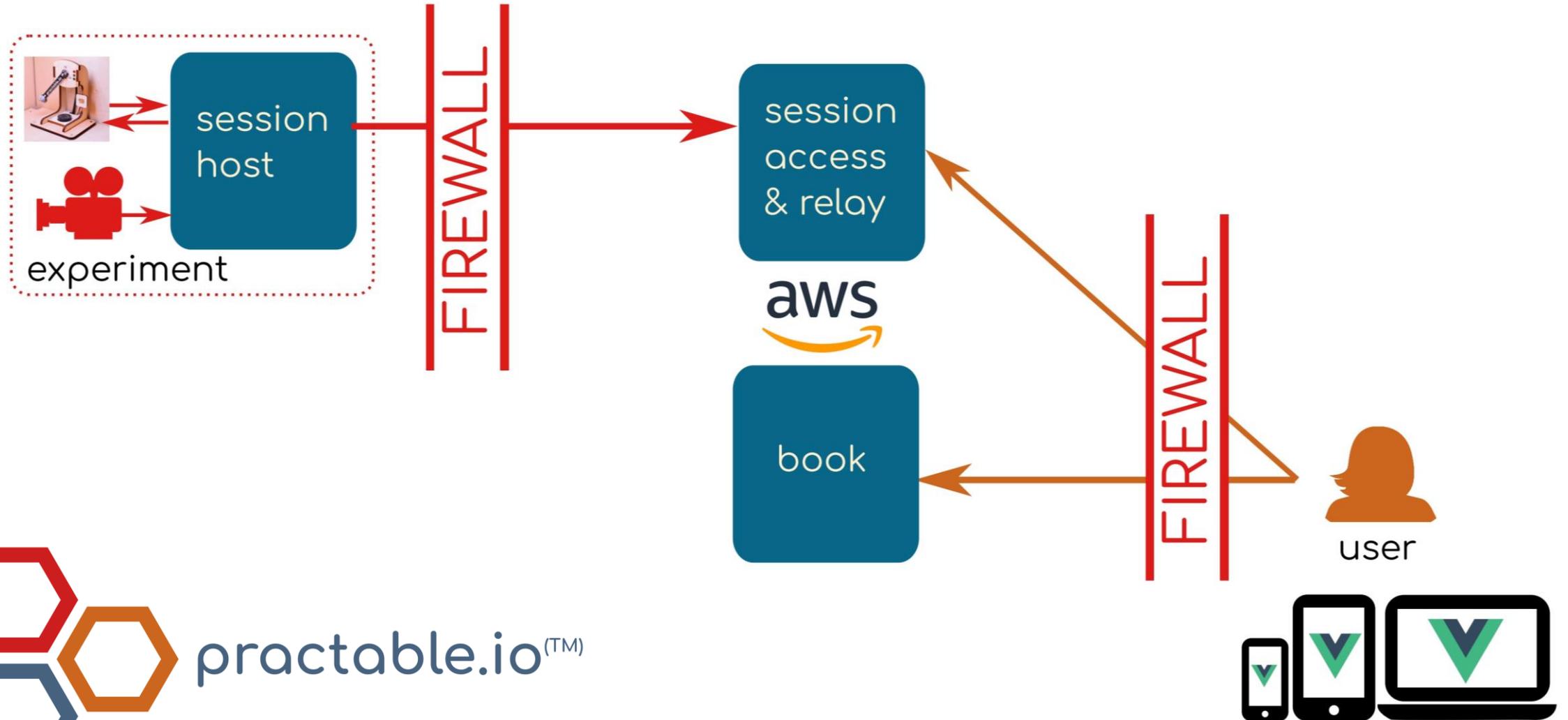
Ya'akov (Kobi) Gal,[‡] Oriel Uzan,[‡] Robert Belford,[§] Michael Karabinos,[†] and David Yaron^{*,†}

[†]Department of Chemistry, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, United States

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Infrastructure - hidden, dominant factor



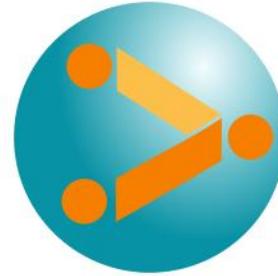
go practical



real-time experiments



interactive control



accessible world-wide



save space, cost



easy cloud infrastructure

Open-source remote laboratory experiments for controls engineering education

DP Reid¹ , J Burridge², DB Lowe² , and TD Drysdale¹

Acknowledgements

We are grateful to the course organiser Dr Aristides Kiprakis for developing the new teaching materials and working with us to validate the experimental hardware and user interface; Andrew Brown designed the mechanical hardware and built the experiments together with Calum Melrose. Additional essential support was provided from Technical, Buildings, IT, and Professional Services staff. The work was funded by the School of Engineering.

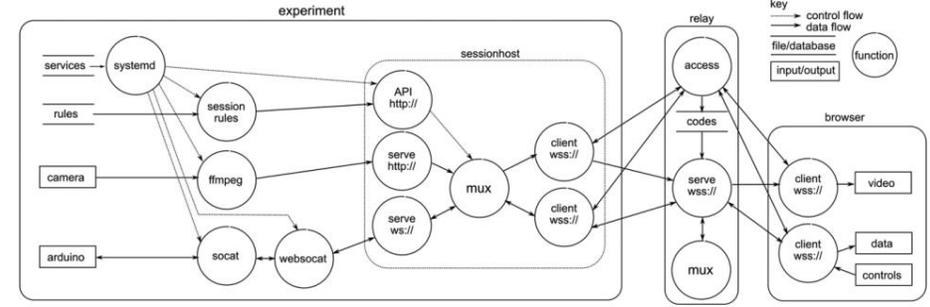


Table 3. Student perceptions of whether skills-based tasks are easier to accomplish with a remote or proximal lab experience.

Skill easier with REMOTE lab	No significant difference	Skill easier with PROXIMAL lab
Collecting data	Controlling variables	Use multiple senses to gather information
Managing my lab time	Measuring accurately	Working with others
Working safely	Comparing to theoretical models	
Setting up equipment	Designing my own experiment	
Presenting data	Analysing data to reach conclusions	
	Exploring beyond the scope of the practical work	
	Investigating unknown quantities	

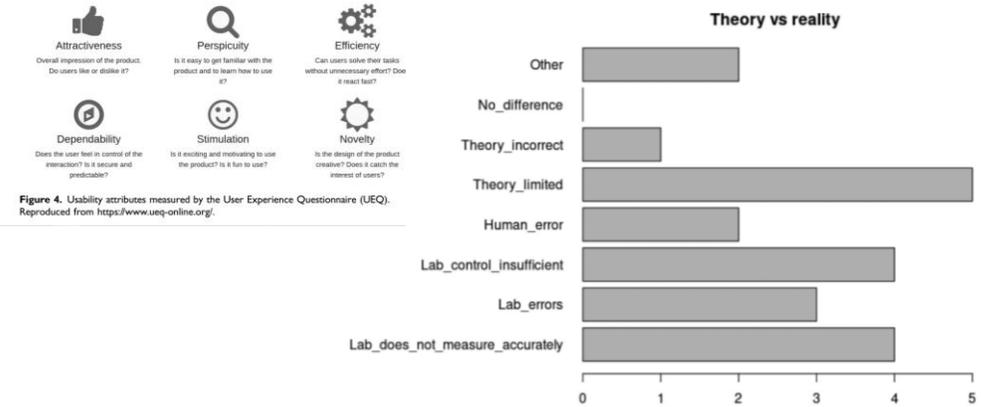


Figure 4. Usability attributes measured by the User Experience Questionnaire (UEQ).
Reproduced from <https://www.ueq-online.org/>.