Using remote laboratory experiments to develop learning outcomes in engineering practice

Dr Helen Lockett
Director of OpenSTEM Labs and Senior Lecturer in Engineering
The Open University
Overview

• Background
• Introduction to the OpenSTEM Labs
• Teaching engineering practice
• Process for developing remote experiments
• Case study
• Lessons learned
Background

• Accredited engineering degrees in the UK must meet learning outcomes defined by the Engineering Council Accreditation of Higher Education Programmes (AHEP) framework

• Engineering graduates achieve learning outcomes in six key areas of learning

• Engineering practice is usually taught through face to face laboratories and workshops

AHEP key areas of learning:
• Science and mathematics
• Engineering analysis
• Design
• Economic, legal, social, ethical and environmental context
• **Engineering practice**
• Additional general skills
The OpenSTEM Labs

• The OpenSTEM Labs provide remote and virtual experiments for our distance learning students

• They cover a range of STEM subjects including engineering, physics, bio-science and chemistry

• Students interact with experiments via a web browser on their laptop or mobile device.
Teaching engineering practice in Engineering qualifications

• Engineering students attend mandatory residential schools at the end of stage 1 and stage 2
• The residential schools are supplemented with remote experiments delivered through the OpenEngineering laboratory

Examples of remote experiments:
• Creep of a material
• Temperature dependence of electrical resistivity
• Strain in a thick-walled pressure vessel
• Electronics
• Heat transfer (under development)
• Wind tunnels (under development)
Development process for remote experiments

- Identify need
- Define learning outcomes
- Describe activity
- Define remote interaction
- Develop and deploy activity
Case Study – pressure vessel

- A remote experiment was proposed as part of a stage 2 mandatory module teaching stress analysis (Core Engineering B)
- The purpose of the experiment was for students to gain an improved understanding of stress and strain in pressure vessels
Initial learning outcomes

• Be able to measure experimentally the strain in a thick walled, pressurised cylinder using the provided bench equipment

• Understand the use and positioning of strain gauges to measure engineering strain and consider sources of error

• Be able to compare experimental strain measurements with hand calculations and discuss the reasons for differences
Describe activity

- Off-the-shelf equipment was selected as the basis for the experiment
- Equipment was tested and key interactions that develop practical knowledge of workshop and laboratory practice were identified:
  - Relationship between force and pressure when using a hand-wheel to control pressure in cylinder
  - Measuring pressure using a mechanical pressure gauge
  - Systematically recording data
Revised learning outcomes

• Be able to measure experimentally the strain in a thick walled, pressurised cylinder using the provided bench equipment

• Understand the use and positioning of strain gauges for measuring engineering strain and consider sources of error

• Be able to compare experimental strain measurements with hand calculations and discuss the reasons for differences

• Understand the relationship between force and pressure when using pressure equipment

• Be able to measure pressure accurately using a mechanical pressure gauge

• Be able to systematically collect and record experimental data
Define remote interactions

Use electric motor to drive hand-wheel

Camera position control

Motor power control

Students record strain values manually

Early mockup of user interface
The remote experiment was developed by a team of software and hardware developers.

Eight sets of remote equipment were developed.

Experiment was used for the first time in 2019 with a cohort 418 students.
  - Submission rate for coursework: 96 %
  - Pass rate 80: %.

High level of engagement and student feedback was positive.
Lessons learned

• Need to consider engineering practice learning outcomes as part of experimental design to ensure that the experiment is fit for purpose

• Development of remote experiments is complex and needs a multidisciplinary team

• Assessment increases student engagement
Questions?