Thesis Report

# Abstract

# Introduction

## Context

Remote learning has increased in popularity in recent years. The trend towards remote learning has been driven by a variety of stakeholders, including universities, students and new market entrants seeking to undercut the traditional tertiary education model through offering low-cost alternatives. From the perspective of higher education, remote learning confers significant advantages including cost reduction, greater flexibility, and higher levels of student satisfaction, with the flow on benefits thereof. The COVID-19 Pandemic has greatly accelerated this trend. Government restrictions across the world have prevented in-person class attendance. As a result, universities have been forced to rapidly adapt and transition all classes to an online model.

For many programs, this transition to online learning was relatively unproblematic. The exam proctoring challenge notwithstanding, certain courses were very easily transitioned to a completely online model. Courses and programs that require laboratories, however, found the transition to completely online learning challenging. These courses tend to exist within the academic domains of Science, Medicine, Design and Engineering.

The term ‘Laboratory’ has multiple meanings. The term primarily denotes the physical space where researchers conduct experiments, and where students perform structured experiments under the supervision of a laboratory demonstrator. Somewhat confusingly, ‘laboratory’ within the context of an undergraduate course is often shorthand for a type of class which involves ‘laboratory experiments’, or a particular ‘laboratory experiment’. For the purposes of this report, we will use the term in this latter sense unless contraindicated.

Engineering laboratories are an essential part of most engineering courses. Laboratories give students the opportunities to apply abstract knowledge in concrete ways, which reinforces core concepts. Laboratories encourage students to ‘learn by doing’, through trial and error and experimentation. Often knowledge obtained through trial and error is better retained and assists in the development of intuition which complements the structured analytical skills developed in the more theoretical aspects of a particular course. Engineering design also occurs within the context of laboratories.

Within electronics courses specifically, laboratories challenge students to build working circuits. Students are required to learn how to operate equipment like power supplies, signal generators and oscilloscopes. Laboratories, often by design, reveal the limitations of idealised component models. Laboratories transition from highly structured

## Problem Statement

# Literature Review

This literature review will begin by broadly analysing the role of experimentation within the pedagogy of Engineering. The pertinent questions this literature review aims to answer are: Why do we place such emphasis on experimentation within engineering education? What are the broad objectives of laboratories and experiments? How do conventional in-person laboratories achieve these objectives? What is the importance of physicality in these laboratories, and is it in-principle possible to achieve all the benefits of in-person laboratories remotely within the constraints of current technology?

The second aspect of the literature review will examine the state-of-the-art with regards to remote learning. Using the normative criteria established in the previous section, current approaches to remote laboratories will be assessed and scrutinised. Current approaches to remote laboratory learning will also be assessed using design objectives explicated in detail at the beginning of the review; specifically, the cost, reliability, ease-of-use, and adaptability of current approaches. The various approaches will also be assessed in terms of idiosyncratic quirks and features. The aim of this section is to determine if current approaches have shortcomings with respect to normative or design criteria, to identify precisely what the shortcomings are and to determine whether the shortcomings can be overcome in-principle.

## The Pedagogy of Electronics Laboratories

### Progressive Education and John Dewey

### The Role of Laboratories in Electrical Engineering

## Current Remote-Learning Strategies and Existing Solutions

<https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7004872>

## General Limitations of existing solutions

Circuit simulation software, including LTSpice and iCircuit, is widely used in professional settings. Proficiency in this software is emphasised in undergraduate programs for precisely this reason, and because circuit simulation can allow students to gain an intuitive, as opposed to purely analytical, understanding of electronics. It must, however, be stressed that these programs exist primarily for design and testing.

# Design

## Project Scope, Constraints and Solution Space

# Bibliography

Gustavsson, Ingvar, Kristian Nilsson and Thomas Lagö, ‘On Physical Experiments and Individual Assessment of Laboratory Work in Engineering Education’ in Proceedings of the International Conference on Management of Emergent Digital Ecosystems (ACM, 2009) 506