

## **ONLINE LABS FOR DISTANCE LEARNERS: REFLECTIONS FROM AN IRISH PILOT STUDY**

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### **ABSTRACT**

This presentation discusses the introduction of remote online laboratory (lab) work into Communications Technology modules of an undergraduate BSc. in Information Technology (IT) by distance learning. The role of online labs and virtual instruments in undergraduate education is discussed and how they relate to physical labs. Outcomes are presented of a pilot introduction of online virtual labs. An argument is made that the introduction of online virtual lab work is worthwhile. We also argue it is increasingly feasible if suitable tools can be inexpensively sourced, such as from digital learning repositories as described here.

### **INTRODUCTION**

Oscail, Distance Education Centre, in Dublin City University provides three undergraduate degrees and three postgraduate degrees by distance. For over thirty years, Oscail has presented traditional distance education programmes. However, over the past decade it has been converting these to online programmes. Increasing use is being made of Internet technologies in the delivery of Oscail's BSc in Information Technology (IT) programme. There are four subject strands within the programme: Computing; Communications Technology; Human Science and Management Science. Each stream has four modules at successive levels of progression. Each module is 15 ECTS credits at level one and two, and 20 at level 3 and 4. A module runs over an entire academic year. Students progress through successive modules in each stream until they can take electives close to completion of the programme. The Communications Technology (CT) stream introduces students to the basics of electricity and electrical circuits and then the basics of digital technology and digital logic circuits. Most of this material is covered in the first module, called CT1, with some overlapping into its successor module called CT2. It should be noted that although this subject matter comes from fields of engineering, the programme is designed to produce IT graduates, rather than engineers.

The programme is delivered online through Moodle, an open source virtual learning environment (VLE). Within Moodle, students access course materials in PDF form for printing or reading online, and resources such as useful web links. Students may attend optional tutorials at weekends. Students are assigned online tutors who are available to answer questions, and encourage and moderate student discussion of the course content. Assessment is via continuous assessment and examination. The continuous assessment consists of three assignments which students submit throughout the academic year. There is also an end-of-year examination.

Previously, physical access to lab sessions was offered to students but was suspended due to low demand. Mandatory attendance was deemed infeasible due to the diverse

geographic location of students. (It is a goal of all distance education programmes to keep mandatory attendance to the absolute minimum.) This paper describes a pilot project which aims to address this deficiency, with regards to access to physical labs, by using virtual labs delivered online through the Moodle VLE.

### **EXPERIENTIAL LEARNING AND SIMULATION**

Experiential learning shares ontological root with active learning or those learning theories that assume students are both self reflective and engaged as participants in their interactions with the world. Kolb describes learning as a cycle involving experiencing, interpreting, generalising, applying, and testing [1]. The purported benefits of experiential learning are widely reported [2]. They include changing cognitive structures, altering attitudes, and expanding portfolios of skills [3].

Distance learners can be disadvantaged compared to campus-based ones. Although information and communications technology is closing that gap (and blurring the distinctions between modes of education e.g. increased use of VLEs) challenges remain to provide the distance learner with the rich learning environment enjoyed by his/her on-campus counterpart. Specifically, distance learners suffer from lack of physical access to equipment and laboratories and the associated benefits of direct interaction and experience. The alternative is simulation. Cruickshank defines simulations as “the products that result when one creates the appearance or effect of something else” [4]. Laurel claims that:

“Educational simulations (as opposed to tutorial and drill-and-practice forms) excel in that they represent experience as opposed to information. Learning through direct experience has, in many contexts, been demonstrated more effective and enjoyable than learning through ‘information communicated through facts’. Direct, multi-sensory representations have the capacity to engage people intellectually as well as emotionally, to enhance the contextual aspects of information, and to encourage integrated holistic responses.” [5]

The use of multimedia simulations may boost curiosity, creativity, and teamwork [6]; increase learning retention and transfer [7][8][9]; provide more consistent course delivery [10]; and improve attitudes towards learning [11].

### **ONLINE LABS FOR DISTANCE LEARNERS**

This paper focuses on the use of laboratories in undergraduate education. Ernst summarises the benefits of such use as:

“First, the student should learn how to be an experimenter. Second, the laboratory can be a place for the student to learn new and developing subject matter. Third, laboratory courses help the student to gain insight and understanding of the real world.” [12]

Feisel and Rossa cite thirteen fundamental learning objectives for laboratories derived by the Sloan Foundation: Instrumentation, Modelling, Experimentation, Data Analysis, Design, Learning from Failure, Creativity, Psychomotor Ability, Safety, Communication, Teamwork, Ethics and Sensory Awareness. These objectives not only are consistent with Ernst but do not distinguish between the physical and the virtual [13].

There are two types of labs where students may not be physically present with equipment in a room. Remote Labs (RL), also referred to as Virtual/Remote Instrumentation, allow participants to remotely control some tool with which to conduct experiments from which they are geographically removed. By contrast Virtual (or Online) Labs have no physical component and everything is simulated through software and accessible over the internet. It is this second type with which we are concerned here and take online/virtual labs to mean not only the use of simulation software but also that it is being accessed remotely (and not in a supervised environment where students and tutors are physically present).

Consistent with general research relating to multimedia simulations, research on virtual laboratories are encouraging. Hall finds no advantage to having a physical lab element [14]. However, others find against completely virtual systems in favour of remote instrumentation [15][16]. Abu et al. do not draw significant distinction between completely virtual and remotely operated equipment, and report success with their sophisticated virtual instrument system for power engineering [17]. Some researchers worry that students may not be able to make as many mistakes in a virtual environment and have less scope for trial and error learning (or may be more blasé in a virtual environment while conducting experiments which would be dangerous in the physical lab)[17]. One suggestion is that software labs may be used to train students prior to their introduction to the physical lab [17]. Nedic, Machotkd and Najhlsk credit the popular LabView software from National Instruments with greatly reducing the effort required to build online labs, leading to the explosion in their use and also discuss bespoke lab tools including their own.[18] Their evaluation claims online labs as low cost, relative to physical or remote ones. However others have cited the cost of LabView as a motivation for developing bespoke systems. Although software development of educational labs allows for very detailed instructional design, a significant time and labour cost is incurring before licensing costs are even considered. An alternative is to try and reuse existing systems. This issue will be returned to below.

## **USING ELECTRICAL AND LOGIC CIRCUIT BUILDERS IN A DISTANCE LEARNING COURSE**

For the CT1 (43 students) and CT2 (37) modules of the BSc in Information Technology programme two online virtual simulations were selected to pilot in the presentation that ran from September 2007 to May 2008. These resources were sourced by the authors from the Global Grid For Learning (GGFL), a federated digital learning repository to which access was granted via the Learning, Innovation and Knowledge Research Centre (LiNK) at Dublin City University. GGFL, an initiative of Cambridge University Press, brings together disaggregated resources (including SCORM learning objects, video, audio, image and text files) in one global service offering access to content from several thousand sources worldwide. The resources selected, Digital Logic Builder and Electrical

Circuit Builder, were originally conceived and developed for use by students as part of the UK National Learning Network programme. Permission was received from GGFL to use the resources for research in teaching purposes.

Digital Logic Builder is an interactive multimedia simulation which allows students to drag logic gates onto a grid and specify inputs into a circuit. Similarly, Electrical Circuit Builder allows students to create circuits by dragging components such as lamps, switches, resistors and wires onto a grid. Values can be specified for the power source and each resistor and a multimeter can be attached to two points on the circuit to measure currents. The lamp glows brighter when it is using more energy and its filament will blow if the lamp's amp rating is exceeded. A guide to using both tools is available. GGFL make the resources available as IMS content packages with SCORM 1.2 runtime capability [19]. The version of Moodle (1.7) used by DCU provides for the import of SCORM/IMS content packages however it was decided to embed the simulations directly in to Moodle as the data persistence features of the software provided by SCORM were not needed and the method Moodle used to integrate SCORM resources may have caused unnecessary confusion to students.

A lab tool was integrated into one module as part of continuous assessment i.e. its use was mandatory. Students were required to build an electrical circuit with specific characteristics and then take a screen shot of it and include it in their answer. The students then discussed this assignment online in Moodle discussion forums, monitored by an online tutor. While there was one instance where access was prohibited due to browser security settings, the few implementation issues that arose could be described as pedagogical. For example, one student was concerned that, although they felt they had the correct answer, the bulb on the circuit was not lighting up. A fellow student pointed out that the current was not great enough to light the bulb. While this issue could be resolved by placing limitation on the assignment, it did result in reflective and collaborative learning. Students discussed solutions and demonstrated how excessive current would result in the bulb "blowing up".

The use of the virtual labs also had a catalytic impact. Tutors used the virtual labs as a teaching tool in order to further develop and enhance instructional materials. For example, one tutor used screenshots of the Electricity Circuit Builder to illustrate important concepts. Without this tool the tutor would traditionally resort to drawing these diagrams by hand. The lab allowed him to develop better quality learning resources much more quickly for use both in lectures and online.

## **EVALUATION**

Semi-structured interviews were conducted with the three tutors involved. They reported great satisfaction with the virtual labs. They cited, in the case of electricity, the ability to show visually things such as Kirchhoff's and Ohm's laws; to "see" flows and meters and to take screenshots. One of the tutors felt making the tools available as an optional resource would not have been as worthwhile as incorporating them into assessments as mandatory exercises. The tutors all enthusiastically engaged with the technology. This is

not wholly unsurprising given their engineering and technical backgrounds. While the tutors expressed frustration that two virtual labs were relatively limited in scope, they were interested in using GGFL to discover, evaluate and incorporate new resources.

Previous research of Oscail online resource usage has found that non-mandatory resource usage spikes around notifications about, or discussions of those resources [20]. An analysis of how the labs were used in courses where they were optional and mandatory was made. It revealed that similar proportions of students accessed the resources but where resources were part of mandatory assignments frequency of usage was greater (on average 3.6 times compared to 1.7). Although it would be expected that students access resources more when they can achieve marks it is perhaps surprising that students still make a relative amount of use of optional resources. For instance over a third (9) of the 29 students who accessed the tools in CT1 (n = 43) did so more than once, which is noteworthy for marks-orientated and time-poor distance learners.

An analysis of the exam questions taken by students yielded an interesting finding. In the exam, the average score for the question in the area covered by Electrical Circuit Builder was 60% of the available marks, the same as the overall question average of 60% (21 questions, 28 students). However the number of students who took this question was high at 26 compared to an average question attempt of 18 students and was the second highest scorer for total student marks gained per question.

Students were surveyed about their experience of using the online lab tools through an online questionnaire via Oscail's custom-developed student feedback tool. Respondents gave the following average likert scores when asked to agree with statements about the labs (1=completely agree and 5 = completely disagree). As mentioned above there are two groups who used the virtual labs, one as an optional resource for self-directed study and the other as part of continuous assessment contributing to their final module mark. There were eight and nine respondents respectively from the groups of 43 and 37 students.

Likert Statement	Digital Logic Circuit Builder	Electrical Circuit Builder	
		As Optional Resource	Part of Continuous Assessment
Easy to use	2	1.8	1.8
Enhanced my learning	2	1.8	1.3
Would like more lab work	1.7	1.8	1.2

	Digital Logic Builder	Electrical Circuit Builder
Average Times Used	9.5	8.8

Student comments emphasised the experiential benefits of the virtual labs e.g.

“I thought this was a brilliant tool and really helped me understand logic circuits. I cannot say strongly enough how much this enhanced my learning. Excellent.”

“Very easy to use made things more practical to see something actually in use.”

## **CONCLUSION**

Collaboration in online learning has been extensively studied [21][22] including its use in experiential and particularly experimental contexts, but has remained hitherto costly to implement [23]. Here we describe small scale online virtual labs in conjunction with a virtual learning environment for collaboration through asynchronous online discussions. Oscail has had success utilising online discussion forums for peer assessment and teamwork [24][25]. Building this element formally into online lab work seems feasible and worthwhile and is planned for the future. The use of the virtual labs provided a satisfactory substitute to physical labs within the context chosen and much scope for the collaborative element to be expanded exists. This can be achieved through the careful selection of resources and innovative assignment rather than having to increase the technical sophistication of the environment or invest in a costly and time-consuming development effort.

Learning resource repositories such as GGFL, NEEDS (The National Engineering Education Delivery System) and in Ireland the National Digital Learning Repository (NDLR), are gaining increased traction in education [26] [27]. Much research and development has focused on creating learning objects, describing and archiving them and developing models and guidelines for their reuse. The crucial emerging change is that the number of learning objects available from repositories is reaching critical mass. What are now needed are case studies of successful reuse – perhaps the least glamorous part of the process – to test whether development efforts have been worthwhile. Is there an incentive to repurpose and reuse existing technology and press it into educational service in new contexts? There may be trade-offs. A simple generic lab may be easy to embed, pedagogically and technically, into a new learning context. A more complex lab may be more difficult to source and reuse but its greater functionality may make it a more worthwhile educational tool. Not all resources travel well. Another issue is how best to integrate online labs into on-campus teaching. Can they be used to reduce the time spent in physical labs or play a role in safety training? An attempt has been made here to address some issues emerging from the use of online lab tools but there remain many research questions to be answered in this area.

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