The Use of Educational Technology in an Engineering School: Then, Now, and the Future

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Abstract

This paper provides an overview of the use of educationally technology within the School of EE&T at UNSW in the last decade, and highlights the evolving use of such technology both now, and into the future. Since 2001, the School has made use of an innovative Virtual Classroom developed and built in-house, to deliver teaching material, both in on-line blended courses as well as support material for traditionally run courses. In addition, to support the laboratory environment, the School has also implemented Distributed Teaching Laboratory Facilities, allowing multiple laboratory classrooms to be "connected" during any lab session. Both the virtual classroom and Distributed Labs consist of interactive electronic whiteboards, video cameras and audio to transmit and capture the lecturer and/or students, and dedicated software to integrate all media streams to a computer. Moving forward, with the proliferation of iPads and other small tablet technology amongst our students, it is apparent that Engineering education, and education in general, can take advantage of, and benefit from, the flexibility of this new technology as well as the significant investment in its future. We describe how iPads and tablet devices are starting to be used in this School and our collaboration with Taylor's University College, Malaysia.

1. Introduction

There are common challenges across higher education environments, such as maintaining students' attention, and in a science or engineering context, communicating difficult mathematical concepts. In a multicultural society such as that experienced in Australian universities, there is the additional obstacle for students of lack of fluency in spoken and/or written English. Today there seems to also be societal demands for students to be involved in more extra-curricular activities of commitments, in particular part-time work due to a desire or need to support their studies. These demands can and do impact on students' study habits, including their attendance at live lectures [1].

As a result, only a small percentage of students are able to grasp the key concepts that are taught in the live lecture, and a large number of students are left to develop the critical understanding in their own time with whatever assistance they can find outside of the lecture. Their additional commitments often results in them being fatigued and their concentration span in the lecture is low or they lose continuity due to missed classes.

Due to these factors, amongst others, the School of Electrical Engineering and Telecommunications (EE&T) at the University of New South Wales (UNSW) has embarked on the introduction of innovative educational technology to support students learning. This has been a process which started over a decade ago, but has been accelerated and consistent since around 2005. Chiefly amongst this technology, a virtual classroom facility was developed to provide students the ability to review lecture material in their own time, also encouraging self-directed study [2]. The virtual classroom allows for the video recording of lecture or tutorial material incorporating real-time annotation on the interactive electronic whiteboard. This facility has been used increasingly since its first introduction, and many lectures have now been recorded this way. In particular, since 2009, the School has successfully run a suite of summer courses which rely on such lecture recordings [3].

Currently of course, and since the implementation at UNSW, we have seen a steady increase in the use of such or similar technology. Kay et. al [4] provides a comprehensive literature review on the use of video podcasts to delivery teaching material, also highlighting the perceived advantages and challenges as reported by the various articles referenced therein. In more recent works [5-8], the authors provide analysis on the various characteristics or elements of using video recordings of lectures. The word "virtual" in virtual classroom tends to imply real-time online implementation in many works. In [5], virtual classroom refers to the recording of live lectures in real-time, where a comparison is made in using the virtual classroom in both online and blended mode. A common theme in many analyses is the level of student interaction and synchronization (real-time or not), [5-6]. In [7], the authors studied the dependence of learning effectiveness on "social presence" – interestingly, it was claimed the study seemed to indicate that the presence of the instructor in the video lectures was more a disadvantage. Finally, in [8], the authors undertook a study of the use of video lectures for large undergraduate classes, finding amongst other things, that the recorded lectures were of more benefit for the lower achieving students than the higher achieving students.

With an extensive laboratory component in the School's undergraduate programs, student's learning is also strongly influenced by the lab classes and facilities. Generally, there has been increased interest in technology, particularly online technology, to improve the laboratory experience as well as improve access to labs. In particular, there is significant interest in, and implementation of, virtual and remote laboratories [9-10]. These works describe implementations of remote and/or virtual laboratories, essentially answering a problem or resource availability, such as equipment and space. To assist in traditionally run labs, [11] describes the use of video tutorials and instruction, helping students with concepts as well as the use of equipment.

A Distributed Teaching Laboratory was introduced in 2010 to enable "connected" lab classrooms, connected in the sense that laboratory teaching and demonstration can take place in one lab and be accessible in other labs. This feature also enables interactivity amongst students in all classrooms and is possible via the use of interactive electronic whiteboards and video equipment. This technology is useful for larger student groups who cannot fit into one lab room, and is particularly practical in our final year design course, where all students (80-120 students) undertake the same designs at the same time during the week, and are instructed across multiple laboratories.

The following sections will detail the use of the above mentioned technology in the School of EE&T, and also discuss the School's future use of educational technology. More specifically, and considering the proliferation of the use of iPad and tablet devices, the School wishes to embark on a program of improving teaching and student learning via the use of such technology.

2. A Brief History of Educational Technology in the School

The challenge of communicating difficult engineering concepts in higher education environments is not uncommon. This challenge can be greater depending on the environment within the institution/school. There are several factors which contribute to this challenge:

- Difficult engineering concepts are often mathematical in their foundation, and communicating difficult mathematical concepts in turn can be challenging;
- Students will learn at differing pace, although this could be said for all disciplines;
- The University of New South Wales and Australian universities in general, are significantly multicultural, resulting in many students not having English as their first language. There are approximately 26% international students across all Faculties, and this number is higher within Engineering.
- Due to a change in societal demands, a significant number of students work in paid part-time employment, either through desire or necessity. Data collected several years ago between 2003-2006 from students within the School of EE&T, suggested that at that time, an average of approximately 45% of students were in paid part-time work, with the trend increasing.

The factors mentioned above were resulting in a significant proportion of students not being able to clearly understand the concepts being presented in live lectures. Understanding the critical concepts outside of university contact time requires students availing themselves of any assistance necessary and is more difficult due to an apparent increase in extra-curricular activities. Such a situation also leads to a vicious cycle, where students are fatigued in further lectures, adding to their difficulties.

The rule-of-thumb adopted at UNSW with regard to study is that for every live contact hour at university (lectures, tutorials, and labs) students should spend another hour outside of class studying. For many engineering courses, there are approximately 22 timetabled class hours on average, resulting in a demanding study expectation away from class. Data, unpublished thus far, and gathered from 2003-2008, suggests that 75% of students were spending less than 10 hours of study per week outside of class, and that 36% were studying less than 5 hours per week outside of class.

Within the School of EE&T, and as recognised by the second author, traditional lecture delivery modes including blackboards (chalk and talk) and projection transparencies were not as effective as required. Even the currently more common PowerPoint presentation was not the answer to address the issues above. An alternative delivery mode was needed – a mode of delivery that would encourage self-directed study by students and assist them in garnering the required understanding of engineering concepts. It was felt vital that

students gained immediate clarification on important concepts if they encountered problems when they learned new material.

2.1 The Virtual Classroom and DVD-based Lectures

In light of the factors affecting the learning environment, a new additional method of lecture delivery was developed in 2005 by Eliathamby Ambikairajah. This method was intended to promote self-directed learning and to address the various challenges and ever more apparent issues of the traditional classroom lectures. The method involved utilising the virtual classroom facility to capture all lecture material.

The virtual classroom allows for the video recording of lecture or tutorial material incorporating real-time annotation on an interactive electronic whiteboard. In particular, the captured and distributed material includes synchronised electronic whiteboard content, the lecturer's handwriting annotations on the board and video of lecturer, as shown in Figure 1. Initially all material was written to DVDs and supplied to all students.

These lectures captured using the virtual classroom can be done in a flexible way, with or without students in the room. In particular, the lecturer may choose to develop smaller 10-15 minute electronic whiteboard-based lectures, giving more detailed step-by-step explanations for more difficult concepts, otherwise not possible in a traditional face-to-face lecture. Although not used for this purpose initially, this technology is also ideal for recording annotated solutions to selected tutorial problems, which can be uploaded for student access as an additional support mechanism.

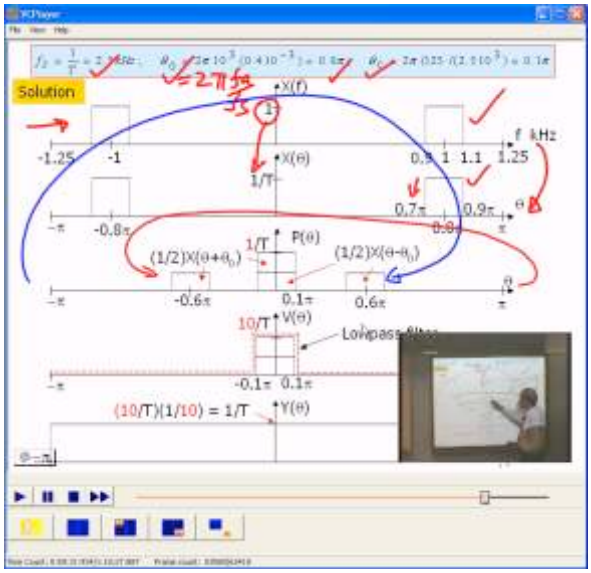

Figure 1: Screen capture of interactive electronic whiteboard lecture

The recorded lecture material provided students with the opportunity and flexibility to review whole lectures or parts of lectures which they are having difficulty with, at a time of their choosing. The lectures captured in this way were not meant to replace live face-to-face lectures, but provide an additional support resource. However, in the event that

students did miss a face-to-face lecture, the captured content provided students the opportunity to view and review the lecture material that they missed.

The School of EE&T has now compiled many lectures using the virtual classroom facility, such that there is an apparent evolution in the method of delivery of material to our students, as seen in Figure 2. The new methodology has been used to great effect in several courses including summer semester courses run in a blended and block-mode format. Progressive student feedback on the use of the electronic whiteboard-based video lectures and tutorials has been very positive, with the overwhelming majority of students highly commending the use of the lectures recorded in the virtual classroom, and expressing the view that they appreciate the support and flexibility gained. The technology should be more widely adopted in all appropriate Engineering courses.

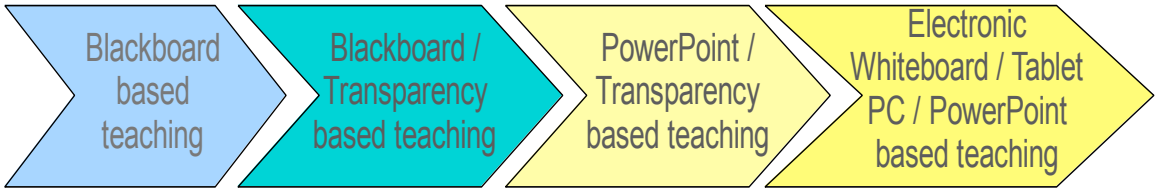

Figure 2: Evolution of lecture delivery method

2.2 The Distributed Teaching Laboratory Facility

An important part of Electrical Engineering education has always been the existence of laboratory-based education, exposing students to the practical side of engineering, and confirming theoretical concepts taught in lectures. In 2005, the School of EE&T embarked on a process of complete degree program revision, in part to ready itself for the next round of Engineers Australia accreditation. The outcome of the revision process was a degree with significant and increased laboratory component. Practically all electrical engineering courses offered in the degree program had a weekly or fortnightly lab session of 2 or 3 hours duration. Although it is felt that such an exposure to labs is a vital component in the achieving of graduate outcomes, the increase did have implications on the lab resources available, namely equipment, lab space, and lab availability.

Within the School of EE&T, Ming Sheng was responsible for designing and implementing a Distributed Teaching Laboratory facility in 2010, which enabled laboratory classrooms to be "connected" via similar technology to that used in the virtual classroom, that is, interactive electronic whiteboard, cameras and video recording facilities. The concept is illustrated in Figure 3 below. An additional flexibility was immediately gained with this facility, whereby students would be able to undertake the lab exercises at the same time in different lab rooms, and still have access to common demonstrations. Difficult exercises and concepts could be demonstrated in one room, and streamed into the others, in the form of the captured video image, but also any writing and/or drawing annotations on the electronic whiteboard. Overhead cameras allow for zooming in on lab hardware, such as electronic circuits, facilitating the close-up view and demonstration of good lab practice and more challenging concepts.

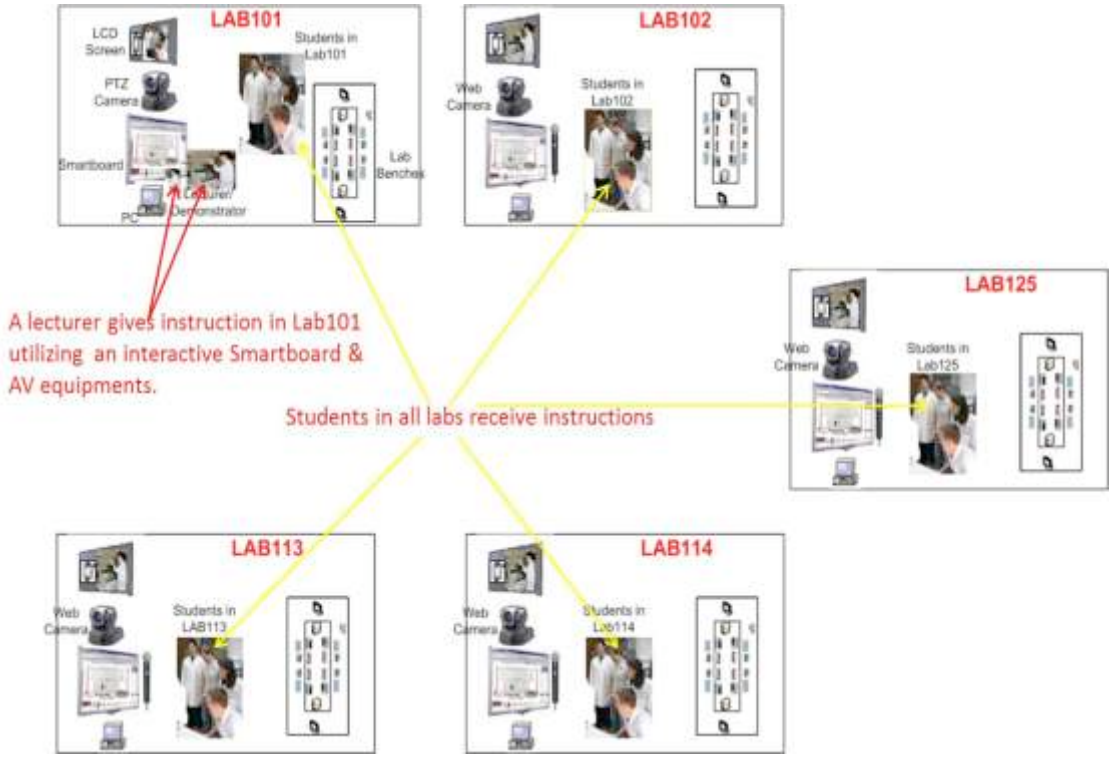

Figure 3: Distributed Teaching Laboratory

Not only can this provide a relief on laboratory teaching resources, but importantly, it is a useful additional educational resource for the students, who are provided with a better quality and more efficient, recordable demonstration, not otherwise possible previously. The Distributed Engineering Laboratory facility is gradually seeing more use within the School. Currently is it of particular use in a both first year and final year design courses, the latter of which tests the student's proficiency and competency in core electrical engineering concepts, and which requires students (80-120 in total) to undertake small design tasks simultaneously. Figure 4 shows the Distributed Teaching Laboratory in use.

Figure 4: The Distributed Teaching Laboratory in use.

3. Educational technology use in the School now and into the future

With the virtual classroom and Distributed Teaching Lab well established, the School of EE&T has been concentrating on the increased utilisation of the technology. As stated, a significant amount of lecture material has now been recorded using the virtual classroom since its implementation.

In particular, the lectures recorded in this way are now used significantly in the School's suite of summer courses. The School runs six summer course currently, over the university summer session (8 weeks instead of 12). As a means of increased flexibility, the courses in summer are run using a blended delivery approach, involving block-mode intensive tutorials and labs, and no face-to-face live lectures. Lecture material is delivered to students via the pre-recorded lectures utilising the virtual classroom. Rather than provide the material via DVDs as was originally done, of course now the more appropriate means of disseminating the material is online, via YouTube and in-house servers. To ensure students are viewing the lecture material and grasping the content, periodic quizzes are implemented, with the quiz result then used to unlock the next set of video lectures.

With increasing worldwide attention on making learning material more open, particularly in the form of MOOCs, the School of EE&T will be taking the intermediate step of availing 1st year courses to high quality High School students. It is hoped that such a step will increase the exposure of the School as well as the discipline of electrical engineering to high schools.

3.1 What does the future hold?

The technological landscape changes rapidly. Although the technology in use within the School of EE&T is still valid, valuable and effective, it is time now to turn our attention to the future and capitalise on new technology to improve the student learning experience. With the proliferation of iPads and small tablet devices, a significant proportion of the student population is already in possession of such technology. For this increasing student cohort with these devices, they are a natural part of their lives, and tools which they are quite intimately familiar with. There is much debate about whether they are, or will be, effective tools in the student learning experience. iPads and other tablet devices, as well the their software, are being increasingly used and trialed in an educational setting, predominantly in high schools (K-12) currently, although with some exposure in the tertiary sector [12-14]. In [15], the authors comment on the increased student engagement from students via the use of iPads inside and outside the classroom.

The School is now embarking on a program of introduction of iPads and/or tablet devices into our teaching. It is hoped that iPads and tablet devices can assist students and facilitate them in becoming more engaged in the learning process, as well as further promoting self-directed learning. In this program, the School/University is not providing students with devices, and so will make the assumption that not all students own a device. The introduction of the devices therefore, is limited to selected teaching staff, with the aim of seeing how to improve the learning environment and process for students. In other words, how they can add value to our teaching methodologies.

In order to further explore possible uses and their effectiveness more broadly, collaboration in this area has been initiated with Taylor's University in Malaysia. The Faculty of Engineering at Taylor's University is introducing innovating teaching methodologies in its Foundations in Engineering program, which includes the provision and use of iPads to students. Among several innovations, the use of iPads is focused on the flexibility and power of the iBooks app. It is intended that courses in the Foundations in Engineering program will be offered as MOOCs. With all students being provided with an iPad at Taylor's University, the approach employed is already contrasting and will provide for useful comparisons. Both student and teacher perspectives can be obtained at both UNSW and Taylor's University.

Additional contrast will be provided through the use of different apps. Broadly speaking, apps for both the generic task of teaching, in other words the pedagogy, and discipline specific apps exist and will be explored within the School of EE&T at UNSW.

The task of generic teaching can be aided by many apps, such as those for presentation, collaboration, and mobility. Within the School of EE&T, the semester has just started, and we have yet to see any impact on the use of iPads and tablet devices. However we have earmarked several assistive technologies for trial within courses now (although not limited to these):

- *Explain Everything* – a feature rich presentation app for the iPad which enables dynamic annotation and page insertion, and recording facilities. This is arguably the mobile equivalent of the virtual classroom described above, except for the video capture of the lecturer as shown in Figure 1.
- *Airserver* – this software when installed on a PC or other Desktop/Laptop, provides a network access point, which when connected to wirelessly from an iPad, enables the iPad to mirror its screen to the server machine. The advantage of such a server lies in the lecturer mobility achieved. That is, the ability of the lecturer to be mobile within the lecture room space with the iPad's screen contents displayed on a projector screen connected to the server machine. Multiple devices can be connected to the server. This capability will have limited use, and may be quite useful in smaller classrooms, particularly where group work may take place – as long as each group has an iPad or tablet, they may display their work to the rest of the class.
- *Polleverywhere* or *Top Hat Monocle* – these are web-based polling or online homework tools. These tools do not require students to have an iPad or tablet device, nor a smart phone. Use in the lecture classroom simply requires students to have the ability to SMS. Smart phone or iPad users can access the tools via the internet though. Such tools may be used to get immediate feedback from students within a class, or to ask quiz questions within a class (or outside the class) and get immediate responses and results data.

In the discipline of Electrical Engineering and Telecommunications, there is definitely a shortage of usable and effective apps. Among those which show good promise as a teaching aid, *iCircuit* will be trialed. This app promises to be of particular use in fundamental electrical engineering courses for junior students in their first two years of an undergraduate degree, including electrical circuits, digital circuits, circuits and signals,

and analogues circuits. Examples of circuits created in *iCircuit* are shown below in Figure 5.

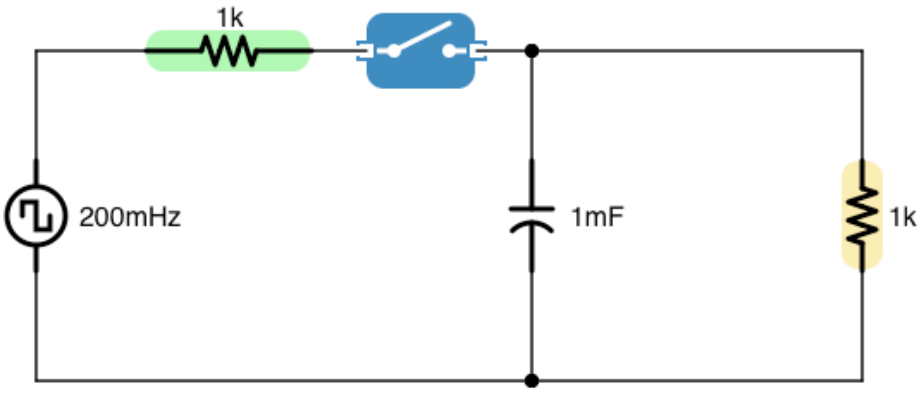

Figure 5: *iCircuit* example 1

4. Conclusion

This work has described the evolution of the use of educational technology in the last decade within the School of Electrical Engineering and Telecommunications at UNSW. The introduction of the virtual classroom and Distributed Teaching Lab have provided valuable resources for the betterment of student learning within the School. This technology will continue to be used in to the foreseeable future. The School, in collaboration with the Faculty of Engineering at Taylor's University will now look to the future and the use of iPads and/or tablet devices to assess their impact on the student learning process. As the iPads are introduced and utilised within courses this semester, student feedback and data will become available and can be compared with that from Taylor's University.

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