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Using online and multimedia resources to enhance the student learning experience in a telecommunications laboratory within an Australian University

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Abstract
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Keywords
multimedia, university, australian, within, laboratory, telecommunications, experience, learning, student, enhance, resources, online

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Using online and multimedia resources to enhance the student learning experience in a telecommunications laboratory within an Australian university*

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ABSTRACT: A laboratory component of an undergraduate telecommunications course consistently scored poorly for student learning experience on student surveys at an Australian university. Consultation with experienced academic staff revealed the need to modify the teaching resources available for the laboratory to include web-based multimedia and interactive resources. This new material was developed and made available to students and teaching staff in early 2011 via an Australian university e-learning package which was used to deliver the subject. The students and demonstrators were then encouraged to use this new resource to prepare for the three hour laboratory sessions. Surveys of students who took this laboratory in previous years were then compared to surveys of students using the latest version of the telecommunications laboratory in 2011 and 2012. The demonstrators themselves were also asked to provide feedback on their impressions of student learning. The comments from the laboratory demonstrators, feedback from the students, and assessment results indicate that the new online teaching material for both laboratory teaching staff and students has significantly improved the student learning experience. That this occurred two years in a row indicates that this improvement has ongoing benefits, irrespective of the teaching staff involved with the subject. The lessons learned can be applied to other similar learning environments.

KEYWORDS: Telecommunications; video instructions; modular communications system; e-learning.


1 INTRODUCTION

Various studies have investigated the use of the online delivery of laboratory material for enhancing the student learning experience in engineering (Alonso & Barreto, 2004; Kassim et al, 2004; Al-Dhaler, 2004; Hussmann et al, 2004; Lopez-Martin, 2004; Gustavsson, 2003; Jensen & Wood, 2003; Naghdry et al, 2002; 2003; Vial & Doulai, 2002; 2003; Raad et al, 2006; Vial et al, 2007; 2010). It is well established from these studies, and others, that the use of online technologies and material enhances student learning. Another technique used in university education in the Australian context has been examined in recent studies by Mazzolini et al (2012). They showed that the advantages of using the Instruction Lecture Demonstration (ILD) model, which is a type of active learning (AL) to enhance student learning and understanding in an engineering context which they applied in an introductory electronics course. In addition, the study by Mazzolini et al (2012) included laboratory activities designed around the skills needed in a particular engineering or science-based discipline. Their study occurred in the presence of a large cohort of students, 100 to 200
from various discipline backgrounds, which included engineering and science students. Interestingly, in their discussion of their observations of the student learning experience, they indicated that a blending of AL with the use of ILD (in the associated lectures) provided the best results irrespective of the quality of the lectures (Mazzolini et al, 2012). Their study also indicated that demonstration and practice enhance the engineering students’ understanding and learning experience. It is in this context and learning philosophy that the Australian engineering telecommunications laboratory multimedia online materials were provided for our study.

Other measures to enhance the undergraduate learning experience has been through teacher training. Recent studies have shown that a large percentage of university teaching is conducted by sessional teachers. Sessional teachers are teaching staff that do not have a continuing position of employment. Studies have shown that sessional teachers tend to receive very little training (Australian Learning and Teaching Council, 2008; Lueddeke, 1997). Two recent Australian studies have tried to solve this problem, by providing specialised training to the demonstrators in the laboratories, and the tutors who provide direct face-to-face teaching services to the students (Santhanam & Codner, 2012; Nikolic et al, 2014a). Both studies demonstrated that the training helped improve the student experience, but were inconclusive as to the contribution in improving the learning outcomes of the laboratory experiments.

Other studies have looked at the needs of international students in meeting engineering-related assessment outcomes (Gornisiewicz & Bass, 2011). In their study they used assessment tests based on the previous week’s learning material which could be done during the tutorial with collaboration from other peers and tutors:

“There are no time constraints regarding the test either, the students get the test at the beginning of the tutorial and they can return it at the end. They are allowed to collaborate, which encourages team work” (Gornisiewicz & Bass, 2011).

These tests were not used for assessment purposes but they showed a correlation between students who did these tests and improved final assessment marks. This is an example of the use of extra learning material to improve the student learning experience.

Using online multimedia-based teaching material is another way of enhancing the student learning experience. The benefits of adding multimedia resources was highlighted by Nikolic et al (2014b). They investigated the factors that influence student satisfaction in a laboratory environment. The study found that the quality of the laboratory notes, in terms of clarity and resources, was one of the most important factors which can increase student satisfaction in the laboratory.

Studies have also focussed on problem- based learning in teams, as individuals, or for academics in learning cultures (Krishnan et al, 2011; Mann & Chang, 2012; Jaeger & Adair, 2012). These studies are investigations into learning effectiveness and into academic associations aimed at improving the student learning experience. They also provide examples of online material which has been developed for this purpose. One example is Jaeger & Adair (2012), who provided simulation activities programmed in Java.

This paper details the development of online laboratory notes with multimedia modules for use in an undergraduate telecommunications laboratory. It also demonstrates how this led to a perceived improvement in student and tutor lab experience.

2 HISTORICAL CONTEXT

This study was undertaken in the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong for undergraduate students. Those students undertaking an electrical, computer or telecommunications degree must complete the telecommunications course ECTE363. The number of international students undertaking the course is approximately 45-55% (depending on the year).

The history of this particular laboratory starts in the early 1990s when the primary author was the initial developer of the then new telecommunications laboratory. In the intervening years, the laboratory had been modified to concentrate more on digital communication techniques rather than analogue communication techniques. This resulted in a skewing of the laboratory difficulty to the point that material covered in the initial laboratory (necessary to understand the laboratory infrastructure) was no longer part of the laboratory experiments. This was a major cause of the dissatisfaction expressed by recent student cohorts in and outside the laboratory.

The other third-year laboratories in computer engineering and control engineering both had supplementary material available on well-organised websites. In 2009 the control laboratory was modified so that experiments were demonstrated using web-based video instructions and background lectures which students could access from their own computers at any time. No such material had been previously available for this telecommunication courses laboratory component.

Considering the success of other courses in the school that used online laboratory notes with multimedia modules, it was decided to redesign this course in a similar fashion. The extra multimedia material would assist both students and demonstrators to better understand the laboratory concepts.
3 THE TELECOMMUNICATIONS LABORATORY

The telecommunications instructional modelling system (TIMS) is used to allow undergraduate students to inter-connect a variety of different interchangeable boards that simulate telecommunication signals and system. This includes digital modulation and de-modulation systems. TIMS can also be used to simulate analogue communication systems. The initial laboratory implemented in the 1990s included both types of experiments. TIMS is used in many tertiary institutions throughout the world. A software simulator for TIMS is also available for institutions that cannot afford to provide a physical TIMS laboratory for their students (EMONA, 2013; Sadat & Nasabi, 2008). The TIMS system also provides documentation showing example experiments for student activities using the equipment.

4 MINOR LABORATORY CHANGES

The primary author was an academic demonstrator at the University of Wollongong in autumn 2010. Having developed material for the original laboratory in the mid-1990s, he was concerned that the students were confused by many aspects of the laboratory procedures. His observations were that students had little of understanding of what was required, how they were meant to complete the experiments, and what the learning objective were. In addition, the students were taking a long time to complete experiments, and only making progress with significant help from the demonstrator.

The laboratory also suffered from having no initial tutorial experiments, before students had to undertake the digital experiments, required by the new experiments. Students had access to TIMS reference booklets, available during laboratory sessions, which outlined the operating characteristics of each module. When students arrived at the laboratory, they were provided with an initial introduction from the demonstrator, and then were expected to perform the experiments outlined in the laboratory notes (studying either in groups or alone). Examination of the experimental procedures outlined in the laboratory notes provided by TIMS, revealed that these notes were accurate and sufficiently descriptive. However, the authors of these notes indicated that they had the expectation that preliminary experiments would be conducted before more technically complex material was attempted. Due to the change in experiments over the years (from analogue to digital) scaffolded learning was no longer in place.

Problems with the subject were further identified by a survey instrument deployed in the school to measure the students’ laboratory experience (details of the instrument can be found in Nikolic et al, 2014b). The survey results of this third year telecommunications laboratory were 67% in 2009 and 71% in 2010. These results were poor compared to other third year laboratories.

The feedback showed that students of all backgrounds, even when successfully conducting the experiments, were not demonstrating that they had gained any understanding of telecommunication system design. Even students who had got the TIMS equipment to function correctly admitted that they were not sure of why it functioned from an engineering perspective.

In consultation with students, demonstrators, literature and other staff, a number of changes were agreed. These included developing extra multimedia educational material for both the demonstrators and students. A laboratory website was created, that could showcase the resources. For the demonstrators a training DVD was created to improve training on the TIMS equipment and experiments.

5 DEVELOPMENT OF THE MULTIMEDIA WEBSITE

One of the primary areas of focus in the development materials was the need for students to gain familiarity with the TIMS and grasp the fundamentals of operation. Despite students being in their third year of an undergraduate engineering program, they had not previously used the TIMS units.

First, a TIMS video tutorial was created to introduce the setup, operation, and manipulation of the TIMS equipment. The tutorial also included specifics on how to use measuring equipment, such as an oscilloscope, to read the signals being produced throughout the TIMS equipment. The basis of the tutorial was to reinsert the scaffolded learning removed from the transition from analogue to digital experiments. The tutorial was made available via the newly created laboratory website, seen in figure 1. The students were required to view the tutorial video before entering the first laboratory session. To ensure that the students spent the extra time preparing for the first laboratory, an e-learning quiz was developed. Out of a database of 28 questions, the students were asked eight questions. They were permitted only one attempt and the results contributed to their laboratory assessment.

Video introductions for the experiments, that students had to undertake, were then created. This took about 10 hours of filming and about 20 hours of editing. The assistance the videos provided, in how to undertake the experiment, was gradually reduced as the students developed competencies in each experiment.

In addition to the introductory video, resources that explained the operating characteristics of the different TIMS interchangeable cards (known as modules) were also created. Previously this
information was available only in the laboratory via a limited number of resource books. This information was now available for students to view before entering the laboratory, allowing students to prepare in advance. This information was also hyper-linked within the laboratory instructions of each experiment for quick reference.

Additional online resources were created for the other electronic equipment in the lab, used in conjunction with TIMS. This included instructions on how to use the equipment, equipment instruction manuals, and troubleshooting guides. These resources were latter integrated into a shared online resource called the “Training Laboratory” (Nikolic, 2014).

The order of the experiments was changed to ensure that the more technically difficult laboratory experiments were performed after the easier experiments. The first experiment was the only analogue experiment and covered FM. The following experiments were digital, covering topics such as PRBS, line coding, eye patterns, and noise.

6 DEMONSTRATORS RESOURCES

A DVD resource was developed for laboratory demonstrators. This was created from the hours of raw video developed for the introductory videos. The DVD enables the laboratory demonstrators to gain an understanding of the learning outcomes, as determined by the design, and not by their own interpretation. The goal was that the demonstrators would be better trained, and be able to provide more effective support to students.

7 METHODS

The evaluation of the success or failure of the multimedia resources was via a three pronged approach. The first approach was conducted by requiring the demonstrators to keep a log of their experiences for each experiment. As a part of the log, the demonstrators had to answer 12 questions that explored the student experience. The second approach was to observe the impact, the changes had, on the school laboratory survey instrument. The third approach was to assess any impact the changes had on assessment.

8 DEMONSTRATORS OBSERVATIONS

The questions and a summary of results from the demonstrator log are shown in table 1.

The responses from the demonstrators indicated that the students attempted to prepare for the laboratory, especially the first laboratory, as the preparation for this was an assessment task. In some cases, the students did not complete all the preparation, but they all had, at least, begun it. They also took advantage of the new videos provided both before and during the laboratory session.

In order to improve time management, the demonstrators monitored the time taken for each laboratory. For most students, Experiment 1, the FM modulator, required between 120 and 150 minutes to complete. Experiment 2 required all three hours, with many students not completing the laboratory. Even with the laboratory videos, this experiment...
was difficult to understand and took much more time to complete. This will be examined further in the discussion section of this paper.

For Experiment 3, the demonstrators reported that the students had no difficulty and that it was completed within 90 to 150 minutes. Experiment 4 took between 90 to 180 minutes. According to the demonstrators, Experiment 5 took a minimum of 90 minutes. Experiment 6 was also long, with the demonstrators indicating it took the full three hours. The demonstrators indicated that by the time the students reached this experiment, some students were concerned with the laboratory exam and were also reviewing/practicing earlier experiments, spending an hour on that activity. No students attempted Experiment 7.

The demonstrators reported that they had found no obvious mistakes in the videos or the revised laboratory notes (with one very minor exception in the initial laboratory). With the exception of Experiment 2, they found the laboratory material satisfactory and indicated that in all cases, they felt that the students were learning relevant material. They felt, on the whole, that the videos were well targeted.

9 THE STUDENT EXPERIENCE

Student surveys had been conducted on the telecommunications laboratory from 2009 to 2013. All questions were rated on a Likert scale, ranging from Strongly Agree (5) to Strongly Disagree (1). Table 2 shows the survey questions, and the responses.

The survey responses show that the ratings correlate with the changes made to the laboratory. The data can be divided up into three different stages. In 2011, the redeveloped laboratory was deployed with the new online multimedia resources. The majority of the experiments remained the same, compared to 2009 and 2010. All the equipment and instruments used in the laboratory also remained the same. However, in 2011 a substantial uplift was noticed on all survey questions, except for the...
suitability of the computers. In part, the recorded improvement could be the impact of the multimedia resources used for learning. The DVD training resource could also have played a part in providing more effective demonstrators.

Of interest, was the 18% increase in student ratings of the electronics equipment. The TIMS unit, the modules used, as well as the measuring instruments remained the same. This suggests that by having a better understanding of what the equipment does, and how it operates, students gain a better appreciation of the laboratory environment.

Analysis from the feedback obtained in 2011, was that experiment two was too advanced, and experiment five was easy. As a result, in 2012 experiments two and five were swapped, to provide better scaffolding. Between 2011 and 2012, the three experiment based questions (Q1, Q2 and Q3) was the source of further improvement in the survey instrument. This provides further indication, of the importance of correctly scaffolding learning in the laboratory, and the impact this has on student evaluations.

No changes were made to the laboratory for 2013. As would be expected, many of the student responses remained close to those obtained in 2012. Overall the data suggests, that by having laboratory notes and resources that provide scaffolded learning, and greater understanding of the equipment being used, a greater student experience can be achieved. This supports the findings suggested by Nikolic et al (2014b).

### Table 2: Student survey responses 2009 through 2013.

<table>
<thead>
<tr>
<th>Survey question</th>
<th>2009 (n = 34)</th>
<th>2010 (n = 15)</th>
<th>2011 (n = 42)</th>
<th>2012 (n = 43)</th>
<th>2013 (n = 33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1) I have a great overall impression of the laboratory component for this subject?</td>
<td>57.65%</td>
<td>49.33%</td>
<td>77.14%</td>
<td>84.65%</td>
<td>84.85%</td>
</tr>
<tr>
<td>Q2) The contents of the laboratory notes provide me with enough information to successfully complete the required exercises?</td>
<td>60.59%</td>
<td>45.33%</td>
<td>76.67%</td>
<td>86.51%</td>
<td>83.64%</td>
</tr>
<tr>
<td>Q3) The experiments undertaken in this laboratory are worthwhile learning experiences?</td>
<td>67.06%</td>
<td>65.33%</td>
<td>76.19%</td>
<td>83.26%</td>
<td>85.45%</td>
</tr>
<tr>
<td>Q4) The computers in the laboratory are suitable for the work required?</td>
<td>87.65%</td>
<td>89.33%</td>
<td>88.57%</td>
<td>86.51%</td>
<td>92.12%</td>
</tr>
<tr>
<td>Q5) The electronic equipment other than the computers in the lab are suitable for the work required?</td>
<td>74.12%</td>
<td>74.67%</td>
<td>84.10%</td>
<td>84.19%</td>
<td>88.48%</td>
</tr>
<tr>
<td>Q6) The laboratory is in good condition?</td>
<td>77.65%</td>
<td>80.00%</td>
<td>88.10%</td>
<td>86.51%</td>
<td>90.91%</td>
</tr>
<tr>
<td>Average score</td>
<td>70.78%</td>
<td>67.33%</td>
<td>82.46%</td>
<td>85.27%</td>
<td>87.58%</td>
</tr>
</tbody>
</table>

### Table 3: Student final grades 2010 and 2011.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
<th>SD</th>
<th>Students</th>
<th>HD</th>
<th>D</th>
<th>C</th>
<th>P</th>
<th>PC</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>64.40</td>
<td>14.25</td>
<td>95</td>
<td>13%</td>
<td>15%</td>
<td>22%</td>
<td>41%</td>
<td>2%</td>
<td>7%</td>
</tr>
<tr>
<td>2011</td>
<td>69.11</td>
<td>12.32</td>
<td>83</td>
<td>14%</td>
<td>27%</td>
<td>22%</td>
<td>33%</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

### 10 STUDENT ASSESSMENT

The impact of the new multimedia resource was also analysed via student assessment. Firstly, this was done via the laboratory exam. The exam required students to draw a block diagram of a telecommunications system, build the system using the TIMS hardware, and conduct measurements. The students then had to analyse the difference between the measured values and theoretical values of the system.

The logs from the laboratory demonstrators reported that, in autumn 2011, it appeared during the laboratory exam that the students knew how to connect the modules and were observing appropriate signals on the oscilloscopes. That is, they observed an increase in cognitive and psychomotor skills. This alone was a large improvement on 2009 and 2010 where many students were highly confused using the TIMS systems.

The assessment marks from the laboratory exam in 2011 also showed an improvement compared to 2010. However, the authors no longer have access to the marks, and no accurate analysis or commentary can be provided. Final assessment marks for the subject, are available, and are shown in table 3. In 2011, the laboratory component was worth 25% of ECTE363. Many factors play a role in determining the final grade. The improvement in grades between 2010 and 2011, may suggest that improvements to the laboratory played some role.

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11 CONCLUSION

In 2011 and 2012 the telecommunications laboratory was enhanced by:
- developing an online laboratory resource
- creating a video tutorial
- producing video introductions for each experiment
- producing a training DVD for the laboratory demonstrators
- providing TIMS datasheets online
- providing resources to help understand and use the equipment and resources used in the laboratory
- providing scaffolded learning.

This was after many years of anecdotal evidence and survey results indicating that undergraduate students were having serious difficulty undertaking telecommunications experiments. As a solution, online multimedia material and teaching instructions for students and staff/demonstrators was then developed and introduced. The undergraduate students were then surveyed again, and observed by the laboratory demonstrators.

The addition of this extra online multimedia teaching material in early 2011 appears to have significantly improved the student learning experience within the telecommunications laboratory. This is inferred through the demonstrator logs, the improved student experience surveys, and the improvements in the assessment outcomes shown in table 3, for the student cohort between 2010 and 2011. More importantly, this infers that the students have, at least, appeared to have experienced improved learning experiences and probably outcomes.

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Dr Peter James Vial is currently a Lecturer at the School of Electrical, Computer and Telecommunications Engineering at Wollongong University. Peter completed his Bachelor of Electrical Engineering in 1986, and worked as an Electrical Engineer at the Port Kembla Steelworks in Wollongong until 1991. In 1992 he became a Teaching Fellow at University of Wollongong, which was reclassified to Associate Lecturer. In 1996 he received his Masters in Telecommunications from University of Wollongong, and in 2000 he received a Diploma in Education (Mathematics). In 2004 he was promoted to Lecturer and in 2009 he received his PhD from University of Wollongong. He has been involved in developing and teaching both postgraduate and undergraduate engineering laboratories. His main research interest is in wireless communications systems, especially related to ultra-wideband systems. He maintains a keen interest in engineering education and is a senior member of the Institute of Electrical and Electronic Engineers (IEEE) based on his contribution to engineering education at the University of Wollongong since 1992. Peter is a member of the ARC Communications Research Network. He has been nominated twice for the Vice-Chancellor’s Awards for Outstanding Contribution to Teaching and Learning at the University of Wollongong by his students.

SASHA NIKOLIC

Sasha Nikolic received his BE degree in telecommunications from the University of Wollongong in 2001. Since commencing as Laboratory Manager in 2006, he has been involved in improving and developing the teaching laboratories and sessional teaching staff with the University of Wollongong. In 2014, he became an Associate Lecturer in engineering education. Sasha became Chair of the NSW IEEE Education Chapter in 2014. He won a university Outstanding Contribution to Teaching and Learning Award in 2011. In 2012, he was awarded a Citation for Outstanding Contributions to Student Learning as part of the Australian Awards for University Teaching.

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Dr Montserrat Ros received her BE (Hons1)/BSs double degree with majors in Computer Systems Engineering and Mathematics (2000), and the PhD degree in Computer Engineering (2007) from the University of Queensland in Brisbane. Between the years of 1998-2004, she worked as a tutor, research assistant and tutorial fellow at University of Queensland. In 2005, she lectured in the School of Mathematics, Statistics and Computer Science at the University of New England in Armidale, NSW. In 2006, she became a permanent Lecturer in Computer Engineering in the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong, NSW, where she is currently a Senior Lecturer. Her research interests include embedded systems, sensor systems, microcontrollers, computer architecture and code compression. Montserrat is a member of the ARC Communications Research Network and Engineers Without Borders. She has won two University of Wollongong Vice-Chancellors awards for Teaching and Community Engagement.
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Dr Parviz Doulai was Senior Lecturer at the School of Electrical, Computer and Telecommunications Engineering at Wollongong University up to the start of 2013. He received his BSc (Eng) degree in Electrical Engineering in 1977 (Iran), his MSc degree in Power Electronics Engineering in 1981 (England), and his PhD degree in 1991 (Australia). He began his career as a lecturer in Electrical and Computer Engineering. In 1994, Parviz established a research and development setup that aimed to incorporate state-of-art internet and web-related technologies into dynamic and interactive processes for educational and industrial applications. Parviz has published over 50 papers in the area of the educational effectiveness and student acceptance of internet/web-based learning resources. He has presented keynote talks in a number of local, regional and international conferences, was selected as an IEEE Sponsored Speaker, organised and chaired panel discussions on educational technologies, conducted a number of workshops at international conferences, and presented over 50 seminars and demonstrations in Australia and overseas on the topic of internet/web technology and applications and technology-enhanced tertiary education and cooperative training. Parviz’s main research interests include multimedia and streaming technologies, applied engineering education, Internet embedded systems, energy systems and electric power quality, neural networks and intelligent agent technology.