Abstract

Deakin University in Australia is one of the leading providers of distance education in the South Pacific region. The School of Engineering offers four-year professional engineering-degree programs and three-year technologist programs. The over 600 total students studying engineering at Deakin fall into four categories:

- 18-19 year-old students fresh from high school, who largely study on-campus,
- older students in the technical workforce, seeking a university degree to upgrade their qualifications,
- industry-based students studying in university-industry partnership programs,
- overseas students studying either on-campus, or off-campus through education partners in Malaysia and Singapore.

Geographically these students form a very wide student base. The study programs are designed to produce multi-skilled, broadly focused engineers and technologists with multi-disciplinary technical competence, and the ability to take a systems approach to design and operational performance. A team of around 25 academic staff deliver courses in seven different majors in the general fields of manufacturing, environmental engineering, mechatronics, and computer-systems. We discuss here the history of the School, its teaching philosophy, and its unique methods in delivering engineering education to a widely scattered student body.

The case for distance education

Over the years the teaching profession has become increasingly aware of the need to bring quality education to people who previously could not access higher education. This has been accompanied by a marked increase in the number of students enrolling in college and university courses, first in two-year associate degree programs, followed by four-year bachelors programs, and more recently in post-graduate masters and doctoral programs. The general trend has been for longer periods of formal education prior to full-time employment in professional fields. More and more professionals are undertaking post-graduate courses to aid their career advancement.

* In Australia, the standard bachelor’s degree program (a “pass” degree) in arts and sciences is three years of full-time study, with the option of continuing into a fourth, “honours” year.

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Traditionally, a college or university course requires the student to attend scheduled classes at the local campus, usually during normal office hours. For those students who live near a college or university, and who have no full-time work commitments, this is not usually a problem. However there is a significant number of people who would benefit from higher education, but for various reasons are unable to take the traditional college course. Potential students in this class include those in full-time employment, those who travel abroad (interstate or overseas) regularly, those who are unable to leave their homes easily due to illness or disability, those who live in remote areas, and even those who are incarcerated.

To reach students such as these, some colleges run classes on weekends or in the evenings. This only partially satisfies the need for some people, as there are still some who have difficulty getting to a college campus. Many universities have responded by developing distance education, a means of delivering academically rigorous courses to students in their own homes. A good example of this is The Open University in the United Kingdom, which was established in the late 1960’s. Since then, distance education has gone through significant development. This includes delivering distance education in science and engineering.\(^1,2\)

Australia is a large continent with a population of around 20 million people. Although the vast majority live in one of the seven major cities of Brisbane, Sydney, Melbourne, Adelaide, Darwin, Hobart, and Perth, there is a significant population in country and remote areas (“the Bush”). The needs of some of these people are met by a small number of regional universities or colleges of advanced education. However the local courses offered to them are limited, especially in science and engineering. Thus Australia is a good example of where distance education has been sorely needed.

Australia has long known of this need to provide education, and indeed other services, to a widely scattered population. Distance education in engineering has become one means to satisfy this need.\(^3\) Delivering science and engineering education by distance learning has always been a challenge. Science and especially engineering are very practical fields. To become successful in either, the student needs “to get his hands dirty,” and he needs someone to show him how. Deakin University is one case of how students can be effectively trained in engineering by distance education.

**About Deakin University**

Deakin University was founded at Geelong, Victoria, Australia, in 1974, and teaching began in April, 1977. The original vision was that Deakin would specialize in distance education, following the model set by the Open University.\(^4\) Consequently, from the very beginning Deakin put into place the infrastructure, administration, and faculty necessary to offer a wide variety of majors by distance education. Over twenty-five years later, Deakin University operates on five campuses in Melbourne, Geelong, and Warrnambool, with a total of over 20000 equivalent full-time students and over 30000 enrolments. Over 40% of Deakin’s enrolments are off-campus. The University offers 313 degree and diploma programs.\(^5\) It has been nationally recognized for its use of technology in education and its practice of forming partnerships with industry for
education and training. Deakin University comprises five Faculties or Colleges: Arts, Business and Law, Education, Health and Behavioural Sciences, and Science and Technology.

Deakin University Engineering

The School of Engineering and Technology began in 1991 with a handful of staff. Teaching began for the School in 1992 when the Bachelor of Technology in manufacturing was first offered. This was followed in 1993 by the first offering of the Bachelor of Engineering in manufacturing. The original mission of the School was fourfold:
- to develop innovative programs in teaching and learning
- to become a leading provider of distance education in engineering
- to create pathways in career development for mature-age students
- to carry out applied, industry-based research.

Since then the School has grown to offering undergraduate majors in seven fields, both through distance education and conventional on-campus studies. It also offers postgraduate programs at both the Masters and Doctoral levels (on-campus and off-campus). This paper will focus on our undergraduate distance-education programs.

Degree programs

At the undergraduate level, Deakin offers two kinds of engineering bachelor’s degrees:
- the three-year Bachelor of Technology (BTech)
- the four-year Bachelor of Engineering (BE).

Both degrees are accredited by the Institution of Engineers, Australia. The BE allows graduates to become qualified, professional engineers in Australia and the South Pacific region. Within both degrees are seven specialist major fields:
1. Computer systems
2. Electronics
3. Robotics
4. Environmental
5. Mechatronics
6. Manufacturing
7. Mechanical.

The School also offers a 2-year, non-accredited, Associate Degree of Technology, offered through industry partnerships, and a number of 5-year, double-degree programs, such as Engineering-Science, or Engineering-Commerce.

All degree programs are taught in both on-campus and off-campus mode. The individual courses are the same in either, but the methods of delivery for each is, of course, different. The actual degree (BE or BTech) makes no distinction between campus and mode of study. During their time at Deakin, students can (and often do) study on-campus in some semesters and off-campus in others.

Student profiles and demographics

In general, Deakin Engineering students fall into one of four categories:
1. 18-19 year-old students fresh from high school. These students study mainly on-campus. However, in their final years, many switch to off-campus studies, especially those who take up employment prior to graduation.

2. Mature-age students in the technical workforce or trades, who take up a university degree program to upgrade their qualifications. These students are mainly off-campus and part-time, although a few become on-campus students, and they are typical of the sort of students who take up a course by distance education.

3. Industry-based students studying through Deakin-industry partnership programs. These students work for companies such as Ford Australia, Holden, and Ansett Airlines. They study off-campus, initially for an associate degree. Some articulate into the BTech or BE.

4. Overseas students. A small number of overseas students study on-campus in Australia. The majority study off-campus through education partners in Singapore and Malaysia. In addition, a handful of overseas students are native Australians living abroad, studying off-campus. The latter students are posted to countries including Indonesia, Saudi Arabia, South Africa, Canada, and, even Mongolia. One or two students of the authors have taken courses while at sea in the merchant marine.

In 2003, Deakin University had total of around 1130 enrolments in Engineering and related technologies. In the School of Engineering, this translated to an effective full-time load of 465 student-units, of which 133 effective full-time students were international, paying full tuition, and the remainder were government-subsidized. Over the years, the vast majority of on-campus students beginning their degree program has been under 24 years old, whereas the majority of off-campus commencing students has been 25-40 years old. For commencing off-campus students in their first year, the majority comes either from metropolitan Melbourne or interstate Australia. With approximately 85 off-campus enrolments, 2003 marked the start of a twinning partnership between Deakin Engineering and Kolej Damansara Utama (KDU College) at Kuala Lumpur and Penang, Malaysia. A similar, smaller program exists for off-campus students in Singapore.

**Partnerships for teaching**

Many of the School’s off-campus (including international) students study through partnership programs between Deakin, industry, and overseas colleges. Associate degree programs currently operate with Ford Australia and General Motors - Holden for engineering and management training of students employed with the automotive industry. These programs typically involve students taking courses at first-year and second-year. Although the study mode is off-campus, since both Ford and Holden have local plants, Deakin teaching staff deliver tutorials at the plants in select subjects. For instance, in 2003, tutorials were given at the local Holden-Melbourne plant in first-year mathematics, materials science, electronics, and management. Deakin also offers BE and BTech programs to off-campus students through the educational arm of the Institution of Engineers Australia.

In the off-shore programs, students from Malaysia and Singapore study for both the BTech and the BE in selected majors by taking the final one or two years as Deakin off-campus students. Deakin is responsible for admission of students, credit transfer from a student’s previous studies, delivery of courses, and assessment. The students are usually enrolled full-time. The local
college provides local administrative and academic support. In their final year, BE students in these programs attend a two-week residential school on-campus to complete laboratory requirements, give oral presentations for their final projects, and gain exposure to Australian professional engineering practice by means of industry site visits and guest lectures. Students in these programs are often employed in industry, and their final-year projects are often related to engineering problems in their workplaces.

**Specifications of off-campus delivery**

The key to delivering a successful and complete off-campus program in engineering lies in giving each student a flexible program that is available where and when it is needed, at an affordable cost. Flexibility includes the ability of each student to study on-campus, off-campus, or a mixture of the two at different times in the course of a degree. Flexibility also extends to the curriculum design, articulation and credit-transfer practices, university administration, and infrastructure.

All the courses in the BE and the BTech are offered off-campus. The assessment tasks, including assignments, lab exercises, reports, and exams are identical in on-campus and off-campus mode. In a given course, on-campus students attend lectures, lab classes and tutorials in the usual way according to the university timetable. In the same semester, off-campus students follow the same syllabus and schedule. Each off-campus student receives a study package containing a text, one or more study guides, a lab manual (if applicable), a *Unit Guide*, and supplementary material such as videos, computer software, or instructional lab kits. The study guides typically contain lecture notes and guide the student step-by-step through the material to be studied. They also often contain readings from selected sources relevant to the individual topics. The *Unit Guide* contains administrative information, including a course schedule, list of texts, assignments, and details on how to contact the lecturers. The study guides are professionally edited and revised every 3-5 years. The *Unit Guide* is updated each time the course is offered. Each course has a dedicated website, which serves as a course noticeboard, and to which is posted additional material that in previous years was delivered to students by conventional mail (for example, lecture notes, tutorial notes, and solutions to assignments). More recently the School has been posting *Unit Guides* and sometimes lab manuals to the course websites.

As they study and learn the course material, off-campus students receive individual assistance from their lecturers by telephone, email, and fax. Presently most assignments are mailed into the University, but increasingly students are allowed to send in assignments by email. At the end of semester off-campus students take their exams at designated, supervised, off-campus exam centers, pre-arranged by the University. The Library maintains a mail-order service, as does the University Bookshop. Following a worldwide trend in education, Deakin is increasingly relying on the use of modern computer and Internet technology in the delivery of its courses.

**Lab classes**

One of the more challenging aspects of delivering engineering education by distance learning is allowing off-campus students to gain the same practical knowledge and experience through laboratory courses as their on-campus counterparts. Teaching lab has always been a problem in
Some courses, such as physics, materials science, statics and dynamics, instrumentation, and fluid mechanics, run weekend lab sessions that off-campus students attend. Lab work is completed in one or two intensive days.

Other courses employ a mixture of kits and computer simulations to deliver lab experience to off-campus students. The use of kits and simulators is especially prevalent in teaching electronics and microprocessors. First year electronics employs a kit of electronic components and a breadboard, with which students perform a series of exercises in digital and analog electronics. The School has also developed a micro-controller kit that is used in courses on basic and intermediate microprocessors, and a simulation program for teaching programmable logic controllers.

Final-year mechatronics students work an at-home project in building a simple robot for their lab work. The robots are designed to perform simple tasks, such as run through a maze or follow a curved path along a white line.

Deakin has made some progress in providing lab exercises that can be controlled remotely over the Internet.

One remote-controlled, Internet, exercise involves the flow of water over a weir, and measuring the height of the waterfall. This simple experiment (figure 1) employs a computer-controlled water pump to vary the flow rate of water in the channel and a digital camera to take still images of the weir. The entire apparatus is operated by the student via the Internet. A reservation program ensures that only one student runs the experiment at a time. The entire exercise can be placed in the context of a dedicated website, complete with procedures, notes, and hints to the student.

Figure 1: Outline of the remotely controlled exercise “Flow over a Weir” for first-year physics off-campus students.
Most lab programs delivered off-campus are flexible. Sometimes the individual experiments can be performed entirely at home. Such experiments include measuring fatigue in thin copper wire and creep of lead-tin solder (second-year materials science). Again flexibility is the key, with lecturers often allowing students to change procedures slightly to suit their own circumstances.

**Case study – first-year materials science**

A common Deakin course with significant numbers of off-campus students is SEM111, Materials 1. Required of all first-year engineering students, it is an introductory course in materials science, designed to introduce the student to the basic concepts of materials, metallurgy, ceramics, polymers, composites, and mechanical testing. Table 1 shows the content of the off-campus study package for this course. Typical off-campus enrolments per semester are 30-60 students. The lecturer has also given tutorials for this course at local automotive manufacturing plants. Most announcements and supplementary material are delivered through the SEM111 website (figure 2).

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<tr>
<td>Textbook</td>
<td>Callister, W.D. <em>Materials Science and Engineering, an Introduction</em> (Wiley)</td>
<td>mail</td>
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<tr>
<td>Study guide and reader</td>
<td>Long, J.M., <em>Introduction to Materials Science</em></td>
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<td>Fox, B.L., <em>Ceramics, Polymers, and Composites</em></td>
<td>mail</td>
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<tr>
<td>Video</td>
<td>Bathgate, R., <em>Materials-Mechanical Testing of Properties</em></td>
<td>mail</td>
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<tr>
<td>List of email addresses of other off-campus students</td>
<td>Self-help list</td>
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<td>Assignment acknowledgment cards</td>
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<td>Administrative information and assignments</td>
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Table 1: Off-campus course materials for SEM111, materials 1.

This course also contains lab exercises in mechanical testing and metallographic observation of several samples of heat-treated steel. Off-campus students attend a full-day lab session on a Saturday during semester. At the session students perform tensile tests, hardness tests, and optical metallography on real samples. A final exercise draws all the experiments together so that students gain an appreciation for how the specific mechanical properties of steel (and other
metals in general) may be changed and manipulated through heat treatment. The “Virtual Microscope” website (figure 3) assists the students with observing specific microstructures, at different magnifications, in the steel samples.

Figure 2: the SEM111 Home Page.

Figure 3: One view from the SEM111 website, “The Virtual Microscope.”
The on-campus lab session also gives off-campus students direct contact with their instructors and fellow students. In addition to leading the lab classes, the instructors answer questions, discuss problems related to real materials engineering, and demonstrate real test equipment. At the end of semester the students submit lab reports for grading.

The course is essentially identical for on-campus and off-campus students. Students submit the same assignments, perform the same experiments and are given the same exam. Deakin runs a large number of supervised off-campus examination centers throughout Australia and overseas. Thus off-campus students take their exams at the same scheduled time as the on-campus students, in a supervised environment. Completed exam scripts are securely returned, by courier, to the home campus and the lecturer for grading.

The overall student grades for off-campus and on-campus students have been comparable over the entire 10-year history of the course. The lecturer responsible corresponds with the off-campus students indirectly by the course website and directly by telephone, email, and fax. The email addresses of the off-campus students are also published so that they may correspond with each other. An independent review of this course was recently conducted by an American engineering educator. The review found it to be complete, interesting, and at a level appropriate to first-year engineering.31

Infrastructure

The successful delivery of a complete off-campus study program requires certain support services to deliver and administer the courses. Deakin University has put in place some extensive infrastructure for this purpose:

- A dedicated mail center to package, track and deliver off-campus materials to any location in the world. The mail center also handles the delivery and collection of exams.
- A team of professional editors and publishers to ensure that all course material for distance education is of an academically and educationally appropriate standard.
- An efficient mail-order service in the Library and the Bookshop.
- A central university center to track all off-campus assignments as they arrive at the university, are passed onto the lecturers for grading, and are returned to the students.
- Examination centers placed throughout Australia and overseas, managed by a central team of administrators who monitor the production, delivery, and return of exams.
- Sufficient administrative staff to manage the non-academic activities associated with local and off-shore partnerships.
- Well-managed university and school websites for each course offered off-campus.

Having these services in place university-wide helps to alleviate some of the difficulties encountered by other universities delivering courses by distance education.32

The Future of Deakin Engineering

The School of Engineering and Technology has gone through enormous growth in its 13-year history, from offering the first year of a single undergraduate major to its present operation of delivering over 100 undergraduate and postgraduate courses by a team of around 30 academics
and additional support staff. Current developments in the School include the phasing out of the School’s web-server and collection of course websites, and the introduction of *Deakin Studies Online*, the University-wide course management system, based on WEBCT/VISTA. The goal of the new system is to further increase on-line teaching for off-campus students. Through on-line bulletin boards and chat groups, it will make communication easier between lecturer and students, and among the students themselves. By allowing on-line submissions, it will also streamline some administrative procedures and speed up the submission and returning of assignments.

Future developments include week-long residential schools for all off-campus students. These residential schools will comprise lab classes, industry site visits, and lectures to better provide education in professional engineering practice. They will also increase personal contact both between lecturers and off-campus students, and between on-campus and off-campus students. The longer-term plans of the School include re-aligning both the undergraduate and postgraduate programs with the research strengths of the School.

**Conclusion**

Since 1991, The School of Engineering and Technology, Deakin University, in Victoria, Australia, has delivered complete undergraduate degree programs by distance education. Current offerings include the three-year Bachelor of Technology and the four-year Bachelor of Engineering, in seven major fields of specialization. Deakin is one of two universities in Australia to offer complete engineering degrees in off-campus mode.

**References**

2. Peters, O. *Learning and Teaching in Distance Education* (London: Kogan Page), 1998.
5. See the Deakin University website: [www.deakin.edu.au](http://www.deakin.edu.au).
7. See the Deakin University, Engineering and Technology website: [www.et.deakin.edu.au](http://www.et.deakin.edu.au).
11. See the website for KDU College: [www.kdu.edu.my](http://www.kdu.edu.my).

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32. Edmonson, C.P. and Summers, D.C.S. “Distance Learning: Things to be Aware of or Wary of When Combining a Resident Course With a Distance Learning Course,” Proceedings of the 2003 American Society for Engineering Education Annual Conference, session 1647.

33. The website for Deakin Studies Online is www.deakin.edu.au/dso/.

Biography

DR. JOHN M. LONG completed his undergraduate degree in Physics at the University of Michigan (Flint) in 1987. In 1995 he graduated with a PhD from Monash University (Australia) in Physics. He previously worked for AC Spark Plug Division, General Motors Corporation, in Michigan. He is now a lecturer in the School of Engineering, Deakin University, teaching physics, materials science and electronics.

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