

STUDYING ENGINEERING BY DISTANCE EDUCATION: AN AUSTRALIAN CASE STUDY

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ABSTRACT

The University of Southern Queensland has offered undergraduate engineering programs by distance education since 1977. This paper describes the design, development and implementation of the distance education version of the professional level Bachelor of Engineering program, which was first offered in 1987 as a mixed-mode program. The fully external version of the program was first offered in 1997 and in 2002 it was granted full accreditation status by Engineers Australia. The program offers equality of educational opportunity to a large number of previously disenfranchised people. This is evidenced by the fact that to date almost 1000 students have benefited from its introduction.

BACKGROUND

The University of Southern Queensland (USQ) is one of Australia's leading regional universities and is noted for the excellence of its distance education programs and its flexible approach to learning. In 2003, the University had more than 25,000 enrolled students of whom over 19,500 were studying by distance education. The main campus of the University is located in Toowoomba, Queensland. The Faculty of Engineering and Surveying is one of five Faculties in the University and it offers a wide range of programs at both undergraduate and postgraduate level. Two, three and four-year undergraduate programs lead to Associate Degree, Bachelor of Engineering Technology and Bachelor of Engineering awards, in a variety of discipline areas. All of these programs are offered both on-campus and by distance education. They are also highly articulated to enable students to transfer between programs with maximum recognition of prior learning.

In 2003 there were approximately 2,500 students enrolled in programs offered by the Faculty, of which about 2,000 were studying by distance education. Approximately 810 of these students were enrolled in the Bachelor of Engineering program, each in one of the ten fields of study in the program. To date, more than 150 students have graduated from the program.

RATIONALE FOR THE PROGRAM

Traditionally, education has been face-to-face and classroom based. There were of course exceptions, particularly in large countries such as Australia [(1), p117].

The distance education offer of the Bachelor of Engineering program was developed to address the educational needs of people employed in the engineering workforce in the regional areas of Queensland, which is a highly decentralised state. People living in these regional areas now have the ability to enhance their career opportunities in the engineering industry without leaving their hometown.

Early experience with distance education for engineering technicians indicated that the commencing students in those programs had, on average, better tertiary entrance scores than the students entering the on-campus Bachelor of Engineering program. It was therefore obvious that there were a large number of highly qualified students who, for whatever reason, were unable to undertake full-time studies in professional engineering. It was also clear that the majority of these students were already working in the engineering industry, and that many of them had the potential to work at the professional level if they were given the opportunity to complete the required degree level studies. Although one Queensland institution offered part-time studies in professional engineering, this program was only available to those living within a reasonable travelling distance of that institution. Currently, in Queensland, there are no professional level engineering courses offered outside normal business hours for part-time students.

The introduction of the program has meant that for the first time there is an equality of educational opportunity for those wishing to pursue a career in the engineering industry. The majority of the students are drawn from local and regional communities. Whilst the majority are employed in the engineering workforce and are studying part-time there is a small but increasing trend for people to study full-time by distance education whilst remaining in their region. Interestingly, the program has also become popular with students

who live in metropolitan areas and prefer this mode of study.

The engineering industry has also benefited from the program as it allows companies to value add their existing workforce, particularly those who are committed to a career in professional engineering. There is strong support for the program in the wider engineering community as many employers offer cadetships, prizes and other awards for distance education students.

A BRIEF HISTORY OF THE PROGRAM

In January 2002 Engineers Australia (EA) granted full recognition status to the distance education offer of the Bachelor of Engineering program. This was the culmination of a process commenced in 1987. Throughout this fifteen-year period the Faculty played a major role in shaping EA's policy on the provision of professional engineering programs by distance education. The development of the program posed numerous challenges and resulted in many innovations. The key milestones in this process are discussed in the following sections.

1974: Introduction of the Program

USQ has offered a four-year professional level Bachelor of Engineering program by on-campus study since 1974. The Institution of Engineers, Australia (now Engineers Australia) granted full accreditation status to this program in 1980. This status is not available until EA has accredited a program after the first students have graduated from that program.

1978: The First Distance Education Programs

In 1977 a two-year Associate Diploma program in three branches of engineering was offered for the first time. In the same year the Faculty began the development of a distance education offer of these programs.

As academic staff developed their knowledge and skills in presenting technical subjects by distance education it was natural for them to consider offering the existing Bachelor of Engineering program by distance education. However, at the time the prevailing attitude to engineering studies by distance education, both in industry and academia, was discouraging. There was an entrenched view that attendance on-campus was a vital component of the program because it was during this period that students 'absorbed the ethos of professional engineering'. So, to propose an offer of the program by distance education would have been considered heretical, even for a

reputable university, let alone an Institute of Advanced Education (as USQ was at that time).

1987: The Mixed-mode Program Accredited

The Faculty therefore advanced a proposal in 1987 to introduce a Bachelor of Engineering program by mixed-mode study. This involved four years of part-time study by distance education, followed by two years of full-time on-campus study. In late 1987 both USQ and EA accredited this program. Its introduction prompted EA to review its policy on professional engineering programs utilising distance education. The revised policy reduced the time required for on-campus study to one year.

1988: The Revised Mixed-Mode Program

In 1988, the Bachelor of Engineering program by mixed-mode study was amended and the program then comprised six years of part-time, distance education study and one year of full-time, on-campus study. The revised program was reaccredited by the University, and granted provisional accreditation by EA.

1994: Full Accreditation Status Granted

EA granted full accreditation status to the mixed-mode program in 1994 following the graduation of the first students.

1995: EA Revised its Distance Education Policy

The implementation and effectiveness of the program was closely monitored by EA. Following its successful introduction EA revised its approach to distance education. For the first time EA's policy and guidelines on four-year professional engineering programs by distance education did not have a requirement for full-time, on-campus study. The only reference to on-campus attendance related to the need for students to undertake practical work and some other activities on-campus, and these could be completed during short-term residential schools

1996: The Distance Education Program.

The Faculty conducted a major review of its engineering programs during the latter part of 1995 and the early part of 1996. One result of the review was that the mixed-mode program was replaced by a full distance education version of the program. In late 1996 the University accredited the new program and EA granted preliminary accreditation status to it, which enabled the Faculty to introduce the program in 1997.

1997: EA Revised its Education Policy

During 1995-6 EA conducted an extensive review of engineering education, involving all sectors of the industry. The resulting report (2) set the scene for a new era in engineering education in Australia. In 1997 EA published a new Accreditation Manual, which placed the onus on engineering schools to demonstrate how they ensured that the graduates of a program could achieve the learning outcomes specified for the program. The Manual included a set of generic graduate attribute and capability statements, and it was expected that all graduates would have acquired these skills. Each engineering school was expected to contextualise these statements and add other statements defining the expected learning outcomes in the technical fields taught in the program.

The Manual also included a requirement that schools would be required to have in place a quality management system which covered, amongst other matters: program content, curriculum development and review, student assessment, monitoring graduate attributes, performance against the program objectives, and performance standards

Finally, the Manual specified the matters program accreditation documents must address, including: a description of the teaching and learning environment; an audit of the quality management system; program statistics; and the measures used to ensure graduates have acquired the defined attributes and capabilities.

The Accreditation Manual was reviewed and published on the Internet in 1999, (3).

1998-2000: A Faculty Response to the Policy

In late 1998 the Faculty established a working party that was charged with the task of reviewing its engineering programs to ensure that they would be re-accredited by both the University and EA in 2001. Initially, its focus was to identify the main issues that would have to be considered when reviewing the programs, and how the review could be conducted. The resulting report provided a detailed strategy that the Faculty could use to conduct a major review of its engineering programs. The paper outlined the objectives to be achieved by the review, the tasks to be completed and the review process.

2000-2001: Review 2000

The review commenced in April 2000, with the goal of developing a suite of undergraduate engineering programs and a teaching and learning environment that together would ensure that the service

provided to the Faculty's students would be representative of best practice in engineering education.

This holistic approach was adopted so that all of the many components of the educational process were properly considered. A top-down program design process was used to develop, in turn, the program aim, the program objectives, the graduate attribute and capability statements, and, finally, the curriculum for the individual courses. The review process was completed in April 2001, Dowling (4), (5).

2001: Distance Education Program Accredited

The University accredited the revised program in July 2001.

An EA Accreditation Panel visited the Faculty for three days during September 2001. Following the visit the distance education program was accredited for a five-year period from January 2002. This was the first time EA had granted full accreditation status to a Bachelor of Engineering program offered by distance education.

"Even with a somewhat longer visit schedule than usual, it was not possible to explore every detail of every program. However, in terms of educational philosophy, delivery modes, assessment systems, and quality assurance, the Panel raised every question it could devise. In every instance it was not only satisfied with the answer but impressed by the depth of thought and experience behind it. The Panel can state with confidence it's finding that the depth and quality of educational thinking, debate and commitment at USQ should withstand any scrutiny, national or international." [(6) Page 20].

STUDENT DEMAND FOR THE PROGRAM

The popularity of the program can be gauged from the number of students who have enrolled since it was first offered. The data for the twelve-year period 1992 – 2003 are shown in Table 1. There has been a particularly significant rise in the number of commencing students since the introduction of the fully external program in 1997.

The Bachelor of Engineering program attracts students from a wide range of backgrounds and experiences. This diversity is demonstrated in the following statistics.

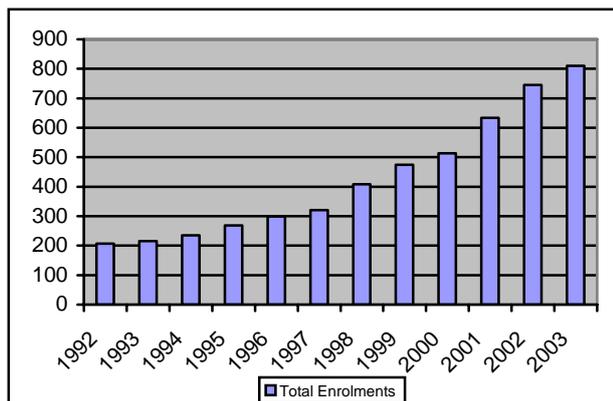
Whilst approximately 60% of on-campus commencing students are under 20 years of age, the majority of the distance education students are between 20 and 29 years of age when they enter the program. More than sixty students over the

age of 40 have entered the distance education program since 1995.

Approximately 62% of on-campus students, and 55% of distance education students, are drawn from rural areas.

Twelve percent of the on-campus students, and 8% of distance education students are female.

TABLE 1: The Growth of Student Enrolments in the Bachelor of Engineering by Distance Education



CURRICULUM DESIGN

The development and implementation of this program spanned fifteen years and has seen the introduction of many innovative and practical solutions to overcome the numerous obstacles that were encountered.

The highly flexible program has been designed to cater for the specific needs of distance education students who often have to fit study into a busy schedule of work and family commitments. The students who enrol in the program normally study part-time and therefore take at least eight years to complete the four-year, full-time equivalent program. The only on-campus experience these students have is when they attend a residential school for one week in each year of their program.

Throughout the development and implementation phases of the program the Faculty has consulted widely with members of the regional communities, including students and employers. Over the years many people approached the University and EA independently, requesting them to support the Faculty in developing the distance education program.

The Faculty employs a wide range of teaching methodologies for distance education students. These include traditional printed study materials, audiotapes, videos, interactive teletutorials (with

both audio and video links), computer-based systems (simulations, compact disks, etc.), and internet based systems (content delivery, assignment submission, marking, and return, discussion groups, etc.). Distance education students also have access to study centres located throughout Australia and South East Asia, each equipped with library and computing facilities.

The development of this program demonstrates an innovative and practical approach to the delivery of professional engineering education by distance education. Traditionally there has been no provision of such programs in regional Queensland and other non-metropolitan areas because of the challenges associated with their implementation and with achieving professional accreditation. These difficulties have included the ability of students to undertake practical work, to work in teams, to study an academically demanding and conceptually difficult curriculum, and to absorb the ethos of the engineering discipline.

Challenges

Attrition Rates. Many engineering schools in Australia have been changing their programs to try to improve attrition rates, particularly first year attrition rates. In most cases these changes have been aimed at addressing two factors that are believed to have a strong influence on attrition rates, motivation and a lack of understanding of the engineering profession. Two studies were undertaken by the Faculty to gain a better understanding of the factors that contribute to the attrition rate for first year students, particularly distance education students. This resulted in twenty-seven recommendations being made to the Faculty Board to improve attrition rates.

Articulation. The highly articulated nature of the Faculty's undergraduate programs impacts on the design of those programs. Any proposed changes to the programs were evaluated to see whether they would maintain or enhance the articulation pathways, as well as teaching efficiency.

The Primacy of Distance Education. For many years the majority of the Faculty's students have been enrolled in the distance education mode of study. In recent years this group has accounted for approximately 75% of the total undergraduate enrolment. Throughout the curriculum design process the primacy of distance education students is recognised and this meant that when decisions had to be made they favoured this cohort rather than the on-campus cohort. The EA Accreditation Panel recognised the uniqueness of the USQ approach: "*The arrangements at USQ are very different from those at conventional universities. The culture of external studies and*

student-centred learning is all-pervasive." [(6)
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Practical Work. The need to accommodate practical work has always posed special problems for the Faculty in presenting its distance education programs. Initially this was resolved by the introduction of compulsory residential schools, but attendance at course-based residential schools often proved difficult and expensive for external students. The Faculty therefore sought ways to reduce the number of visits and the amount of time that must be spent on-campus by distance education students. This led to the development of home experiment kits, simulated experiments, and the introduction of Practice courses.

Innovations

The curriculum for the Bachelor of Engineering program has been reviewed and modified on several occasions to enable the Faculty to achieve the many accreditation milestones previously listed. The development and implementation of the distance education program has resulted in several major innovations.

Graduate Attributes Embedded in Curriculum.

The program was one of the first programs to include in its design a systematic and quality-assured approach to the introduction and development of graduate attributes and capabilities throughout the entire program.

Problem Based Learning at a Distance. The introduction of the first of four engineering problem solving courses in 2002 marks the first time that Problem Based Learning techniques involving teams of students have been successfully implemented in a distance education program.

The first course to utilise this innovative pedagogy was offered in semester 1, 2002. Initial comments from both students and staff indicate that this approach was highly successful in achieving the objectives of the course. The following comments from an external student are typical. *"...I have enjoyed Engineering Problem Solving 1 quite a lot and found the study path different to conventional study in many ways and more immersed in real life experiences and abilities. As a team (we) evolved throughout the semester to become a cohesive unit by the end with many character traits and talents becoming evident as we came to know each other...It was an interesting experience and it certainly holds merit in the academic process for engineering study. I look forward to enrolling and studying Problem Solving 2..."*

Practice Courses. Traditionally a residential school offered by the Faculty consisted of five days

of practical work from the courses being studied that year, although lectures and tutorials were sometimes conducted on advanced topics to help students with any problems they may be having with the content of a course.

As the residential schools were course based, the exact period of time spent at a residential school depended upon the requirements of the particular courses in which the student was enrolled. It was often difficult to justify student attendance at a residential school on a course-by-course basis. This problem was often exacerbated for students who entered a program with advanced standing, as they were often not able to follow a normal enrolment pattern.

Another problem was that students who were unable to attend a residential school for illness, employment or family related reasons received an incomplete grade in the courses that had compulsory residential school components. This meant their progress in the program could be delayed for at least a year.

Because the residential schools were course-based rather than program-based, opportunities for students to acquire generic skills had been provided within the residential school component of individual courses. This ad hoc approach often led to scheduling difficulties and inconsistent outcomes.

The Faculty recognised these and other problems associated with the existing residential school policy and in 1997 adopted the concept of non-course specific residential schools. More than 30 Practice courses were developed, each designed to enable students to acquire both the practical skills and generic competencies appropriate to a particular level of a program. Thus, a Practice course may involve activities ranging from laboratory skills through to activities related to ethical responsibility and commercial reality.

For external students a Practice course may be regarded as a one week residential school as it involves between 30 and 40 hours of integrated activities spread over five days spent at the Toowoomba campus of the University. Allowing for report writing and other off campus activities the total workload required for a student to complete a Practice course is approximately 50 hours. Students in the program would normally complete at least seven Practice courses, each involving a week of on-campus work. Students may enrol in a Practice course at any time after they have completed any prerequisite courses. Thus, they can choose which year they will complete a Practice course.

Project Conference

The Project Conference is held during the last two days of the week long residential school for the final two Practice courses in the program. The event consists of two plenary sessions and up to seven technical sessions in which three or four parallel programs are scheduled. All of the final year on-campus and distance education students in the program present the second and final seminar on their final year project topic. In 2003, 117 students presented seminars during these sessions.

Penultimate year students attend the Conference to experience the technical conference environment and to gain some appreciation of the breadth of projects that may be pursued, and the standards that will be expected of them in the following year.

STUDENT FEEDBACK ABOUT THE PROGRAM

Both the Faculty and the University undertake surveys of both the student body as well as the graduates of the program. The resulting data is used to improve the curriculum as well as the teaching and learning environment.

Review of Courses by Students

At the end of each semester all students in the Faculty are requested to complete a standard USQ survey instrument for each of the courses in which they are enrolled. Students provide comments on the study materials, content, presentation, staff support, assessment and value of a course.

The Program Experience Forum

Since 1998 a Program Experience Forum has been held annually for graduating distance education students during the Project Conference week. These students are generally very complimentary about the program and they are supportive of the Faculty's efforts to improve courses. They have commented on the high quality of the study materials provided for each course, and note their usefulness as future reference material. Many have commented that the programs suited the needs of mature-age students. Typically, students report high levels of satisfaction with the program, indicating that its strengths are: "*the ability to study externally*"; "*the flexibility of studying and working at the same time allowing greater experience than studying full time*"; and "*the quality of the study materials.*"

Graduate and Employer Responses to the Program

The Student Services section of the University conducts annual surveys of both graduates and their employers. The data from these surveys is analysed by staff in Student Services and annual reports are issued to senior managers in the Faculties, and to other key stakeholders. These reports, together with those published by the Graduate Careers Council of Australia, are used by senior staff in the Faculty to inform decisions about programs, majors, teaching, assessment and student workloads.

CONCLUSION

The introduction of the distance education Bachelor of Engineering program has meant that for the first time there is an equality of educational opportunity for those wishing to pursue a career in the engineering industry, particularly for many previously disadvantaged members of the community.

The accreditation of the program by EA in 2002 was the culmination of more than fifteen years of innovative curriculum design and implementation by the Faculty. It was the first distance education program to be accredited by EA, and was recognised by this body as being representative of World's best practice. It also represents one of the most significant educational achievements in Australia over the last 20 years. The author acknowledges the important contributions made by many staff to the development of the program, especially Dr. Michael Morgan who initiated and then facilitated the development of the program until 1995.

REFERENCES

1. Jarvis, P. et al, 2003, "The Theory and Practice of Learning." Second ed., Kogan page, London.
2. EA, 1996, "Changing the Culture: Engineering Education into the Future", Institution of Engineers, Australia, Canberra.
3. EA, 1999, "Manual for the Accreditation of Professional Engineering Programs", Institution of Engineers, Australia, Canberra, www.ieaust.org.au/membership/accreditation.html#downloads
4. Dowling, D. G., 2001, Proceedings of SEFI Annual Conference, 114.
5. Dowling, D. G., 2001, Proceedings of 12th Australasian Association of Engineering Education Conference, pp 309- 314.
6. EA, 2001, Report of Accreditation Visit to the Faculty of Engineering and Surveying, USQ, 24-26th September 2001, Institution of Engineers, Australia,.