INDUSTRY/UNIVERSITY PARTNERSHIP IN THE POSTGRADUATE EDUCATION OF ELECTRICITY SUPPLY ENGINEERS

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Abstract *¾ This paper describes a postgraduate coursework program that was developed through a close partnership between a technological university and two electricity supply companies. The partnership commenced about a decade ago with an agreement for provision of postgraduate training by the university partner to the industry partners. Syllabi were developed from competency standards for professional electrical engineers in the electricity supply industry. The paper describes the process for the development of professional engineering competency standards as well as a technique for extracting syllabi from competency standards. Factors contributing to the success of the program are discussed and it shown that considerable benefits have accrued to all partners.*

INTRODUCTION

In recent years there have been many changes that lead to requirements for a fresh approach to the postgraduate education of engineers. In the electricity supply industry in Australia there has been an emphasis on downsizing and deregulation that has meant that numbers of engineers employed by some large organisations has steadily been reduced, whilst at the same time engineers have had to cope with significant changes in technology. Many organisations have now lost the capacity to provide on the job training for junior engineers and there is an increasing requirement that any off workplace training should be strictly directed towards providing engineers with improved expertise in value adding skills that can be directly applied in the workplace. Employers are increasingly less willing to release staff for prolonged periods of training and there is an increasing requirement on providers of postgraduate education for courses to be available at a time and place determined by student needs rather than a fixed calender or university location.

This paper describes a postgraduate program that has been developed to provide postgraduate education for electrical engineers in the electricity supply industry. A structured approach to the development of the educational program directly from industry competency standards has been pioneered and the methods developed to identify materials that need to be taught from competency standards are discussed in the paper. Student reaction to the course is discussed and benefits that have accrued, to the university and industry partners, from almost one decade of operation of the program are identified.

ESTABLISHMENT OF THE PARTNERSHIP

Needs of the Partners

In the early 1990s electrical power engineering staff at the Queensland University of Technology, who had maintained very close links with the electricity supply industry over many years, were facing government funding cuts, increasing general enrolements and declining interest by undergraduates in the disipline of electrical power engineering. A request was made to the electricity industry for direct financial assistance to the university but the economic rationalist culture that was strong within the industry precluded a direct grant.

An informal industry/university steering committee was established to explore ways that the indusy and the university might develop closer relationships that would produce mutual benefits. The pressing need that it was identified the university might meet was determined to be in the training of electrical engineers currently employed in industry. The committee determined that traditional methods of training young engineers in electricity supply companies (that mainly comprised on-the-job mentoring) were becoming more difficult to implement. Engineering staff numbers in industry had been greatly reduced. The services of many specialist engineers had been lost to the industry, and remaining staff were finding it difficult to fit in training of junior engineers into increasingly full workloads.

Some industry-specific training was available from the Electricity Supply Association of Australia (ESAA) which offered two main types of training programs: short courses and summer schools. The ESAA short courses were essentially stand-alone seminars covering a wide range of topics and were seen by the industry partners as not providing enough training in specific skills needed in the workplace by new graduates. The summer schools were seen as valuable but required attendance for one month at a remote location and were seen as not meeting industry needs for flexible, life-long training.

The industry represetatives suggested that a completely fresh approach to training was needed to with objectives of the

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training being unashamedly focussed on achieving the skills needed in industry. There was also felt to be a need for training outcomes to be rigorously assessed to provide evidence that desired performance levels had been attained.

The Initial Training Agreement

After prolonged discussions in 1992, Queensland University of Technology (QUT), the Queensland Electricity Commission (QEC) and South East Queensland Electricity Board (SEQEB) entered a collaborative arrangement under which QUT would provide electrical engineers in the corporations with 50,000 hours of targeted, industry-specific, postgraduate training at commercial rates over a period of not more than 5 years.

It was established as part of the intial discussions that much of the material that needed to be taught was extermely industry-specific and indeed many of the methods, procedures and some of the analytical techniques had been developed by practitioners in industry. This was recognised in the training agreement that gave the university partner access to and use of materials owned by the industry partners. Even more importantly it was agreed that industry specialists would be encouraged to participate in the training program as part-time lecturers since university lecturers did not have the level of practical experience that was needed to provide students with the necessary insights.

With the increasingly commercial focus in the electricity industry it was necessary that the investment in training should improve the skills of engineers in specific professional activities that would add value in the workplace. There was consequently a considerable challenge for the university partner in designing training programs that would satisfy the needs of a large industry where engineers carry out a wide range of high-level activities.

Research showed that other professional groups had used the competency approach to identify tasks carried out in the workplace [1],[2] and indeed the Australian Government had commissioned a study that provided guidelines for the development of competency standards for the professions. [3]. In the engineering profession the Intitution of Engineers, Australia was in the process of developing generic competency standards [4] that described the general attributes of engineering graduates but which, were not intended to define detailed competencies required by groups of professional engineers employed in different industries.

It was seen that competency standards that described the work done by electrical engineers in the electricity supply industry could provide a database of material from which syllabii of industry-specific training courses might be developed. The commitment was therefore was made [5] by the partners to endevour to jointly undertake the systematic development of competency standards for professional engineers. The first step in this process was to write units and elements of competencies for all value-adding activities carried out by professional electrical engineers in electricity supply. This process was made possible by an industry interest at the time in relating salaries to achievement of industrial competencies and by a government grant to the university partner to facilitate development of a novel approach to postgraduate training.

Development of Competency Standards for Professional Electrical Engineers

An analysis of professional knowledge, skills and abilities in the context of performance of professional tasks forms the basis of competency standards development. The methodology which was applied in the development of competency standards for engineers in the electricity supply industry was based on the technique of “functional analysis” [2],[3] whereby selected groups of engineers were led through a structured process in which they documented the essential tasks performed in industry.

The starting point of the process was the identification of Key Purpose Statements (KPSs) which describe the main functions of the electricity supply industry. The KPSs were formulated and validated by senior officers from throughout the industry. After refinement twenty KPSs were derived that ranged from “plan generation augmentation” to “operate/maintain distribution systems”.

Groups of engineers in facilitated workshops identified the Units of Competency (UoC) required in each KPS. The UoC consisted of a number of Elements of Competency (EoC), each of which represented the smallest definable stand-alone activity. Associated with each EoC were one or more Performance Criteria which indicated the level to which the competency was to be performed and gave the expected outcome when the task was completed. The background knowledge required for each UoC was defined as Knowledge and the range over which the UoC was to be performed was defined as the Range of Variables (RoV). Data contained in the RoV could be simply “operating voltage of equipment” or could indicate that the competency had to be carried out under certain emergency operating conditions. Copies of the proposed competency standards were circulated to electrical engineers in the industry partner organisations and validation meetings, convened by the KPS teams who drafted the initial outlines, sought constructive feedback from other electrical engineers with an interest or involvement in a particular KPS field.

The final competency standards [6] for engineers in the electricity supply industry were over 600 pages in length and showed that extensive knowledge is required on a very wide range of topics ranging from management to economics and law as well as technical specialisation. Activities such as

"research new technologies" or "improve systems" appear in many parts of the standards and serve to highlight the non-routine, innovative aspects of an engineer's work.

Extraction of Syllabi from Competency Standards

The identification of course modules to be developed to provide underpinning skills and knowledge for the units of competency was a complex exercise. In order to adapt courses to competencies, a detailed analysis of the competency standards was undertaken which resulted in the listing of 172 "Primary Fields of Knowledge" each containing up to 6 "Secondary Fields of Knowledge". Titles of the preliminary training modules, or units in university parlance, were identified that supported the fields of knowledge, and a list of units was refined after further discussions with representatives of the electricity supply industry regarding high priority areas for training.

After the training unit title was identified, computer key-word searches were made of the competency standards and lists were compiled of material from the standards that was related to the unit. Unit objectives were taken directly from the performance criteria in the standards and described the things that the student would be able to do on completion of the unit. Unit content was determined by the logical grouping and rearrangement of material extracted from the standards, and when a draft curriculum was produced it was circulated to industry specialists for comment and further refinement.

The development of two units will be considered in more detail to illustrate the approach taken to syllabus design. In the design of a unit on *Power System Earthing* word searches identified many paragraphs containing key words such as grounding or earthing. From these paragraphs particular tasks that are done in the power supply industry were identified and listed. For earthing an abbreviated list was: calculate resistance of earth electrodes; make an assessment of safety of earthing systems; interpret tests results made on earth electrode systems and evaluate earth currents in complex earth networks. These activities were taken as the competencies that participants should be taught and were made the unit objectives. Further examination of material extracted from the competency standards revealed more details of the tasks and the range of equipment for which they were to be carried out was found from associated RoVs. Grouping of this material and logical listing after elimination of similar items provided most of the basic information for the syllabus, which was further refined by discussion with subject experts. In the design of a unit on Maintenance of Electricity Supply Systems, the main objectives of the unit were established as being: to enable participants to take part in the establishment of maintenance policies; to plan maintenance activities using computer data bases; to develop maintenance instructions and to be aware of important acts and legislation. Logical grouping of detailed material extracted from the competency standards enabled the main sub-headings in the syllabus to be determined as: establishment of maintenance policies; maintenance planning; data recording and analysis; maintenance operations and maintenance program evaluation.

The EoCs supported by particular training units were identified from the references found during word searches of the competency standards that were used in definition of the training units. A matrix was finally produced from this information relating training units to EoC that they support.

COURSE STRUCTURE

Design of Units of Training

The design of the training units was made with the needs of the industry partners in mind. Some of the factors that had be be considered included:

- One of the partners operated a transmission network that covered the whole state of Queensland, an area larger than Europe, and staff needing training were scattered throughout the state.
- There was a need for updating and reskilling of engineers throughout their careers and hence training would be needed from time to time over a very long period. This was not recognised in existing university postgradaute programs that were generally full-time for six months or one year.
- Whilst the industry partners had placed the initial contract with the university, it was felt that it was desirable to make training available to other industry organisations throughout Australia on a full-cost basis.
- The industry partners expressed a strong desire that all training outcomes should be examinable but were not concerned about their staff receiving a university award qualification. Prospective students in the partner organisations were, however, keenly interested in awards.

Units were consequently made as short as practicable so that they could be delivered at the university and remote locations as short courses. A common unit length of 15 hours contact time was established: this contrasts with the standard QUT one-semester unit of 42 hours

With a 15 contact-hour unit it was recognised that it would not be possible to cover many of the more complex topics in the presentation time available. In other short-courses, the response to this problem has often been to provide voluminous amounts of material for participants and hope that they ingest something useful. The competency approach

is different because units are designed to facilitate teaching of material so that participants gain demonstrable skills with which they will be able to add value to their organisations.

A pre-requisite structure was established between units through which participants can start to develop their skills and knowledge by studying some of the more basic and generic units first and build on these studies with more advanced units later. It is not mandatory that participants follow the prerequisite structure since some students have considerable knowledge and experience in industry (prior learning) and often attend only the more advanced units.

In the units the emphasis is generally on design rather than on development of detailed analytical methods but theoretical underpinning principles are strongly emphasised. To reinforce this approach all assessment of the coursework modules involves completion of assignments that are based on further imparting and examining industry competencies.

Award Courses

The prerequisite requirements and general approach to teaching and learning in the training program has meant that it has been possible to accredit the program for academic awards of QUT and students may gain a series of articulated awards including a. Graduate Certificate, a Graduate Diploma and Master of Engineering Science[7].

To gain the Graduate Certificate (Electricity Supply) students must accumulate 48 credit points by completing 12 units with a total of 180 hours of formal contact time. Award of the Graduate Diploma (Electricity Supply) requires completion of 24 units with a total of 360 contact hours. Students may aggregate credit towards a qualification over several years, taking the training units as they are needed in their professional development in the workplace rather than being driven by arbitrary university-imposed time limits.

In the Master of Engineering Science (Electricity Supply) students complete 18 units and in addition are required to undertake 100 days of supervised industry practice in the electricity supply industry or an industry that can provide the necessary specialised experience. During this time they must work in an established position as an electrical engineer and must undertake the normal range of duties. A practitioner's thesis is required to be submitted that demonstrates that advanced technical skills and a detailed understanding of the specific area of industry involvement have been acquired. In addition the thesis must demonstrate that students can apply a wide range of knowledge to solve complex engineering problems and, most importantly, that they have made improvements to engineering practice. A thesis supervisor from the university and a supervisor from industry who has regular work-place contact with the student, liaise to ensure that the nature of the project work performed by the student is appropriate and that the standard of the thesis is satisfactory. The M.Eng.Sc. (Electricity Supply) is different from a traditional masters with a narrow research-based focus because it is intended to educate professional engineers in application areas requiring a combination of high level skills from engineering and other disciplines.

M.Eng.Sc. theses have been produced on wide range of topics. A thesis on the development of insulation cocrdination procedures was close to a traditional M.Eng.Sc. in electrical engineering. A thesis dealing with design of by-passing arrangements for 11 kV regulators incorporated laboratory testing, required staff interviewing by structured process and risk analysis on the basis of limited data. A thesis on procurement of 275 kV disconnectors included legal and contractual material as well as improved procedures for appraisal of type test reports. A thesis on the development of a asset register for a distribution company required wide organisation knowledge and interaction as well as data base knowledge.

PROGRAM OPERATION

Delivery modes

The need for flexible delivery arrangements was recognised from the outset of the program as potential participants in the units were located throughout Queensland—and indeed, throughout Australiasia. Training units were, therefore, made available in the following modes:

- 3-hour classes conducted over 5 weeks in either day-time or evening on campus at QUT. *(Weekly mode)*,
- 2½-day short course at QUT annually or more frequently depending on demand. *(Short-course mode)*.
- Professionally-developed material for individual study including all software and reference material. *(Distance education mode)*.

In 1993, units were only available in short-course mode and weekly mode-units were introduced in 1994. Distance education units have been gradually developed over time with one or two units being introduced annually depending on available resources: currently there are thirty three short-course units and thirteen distance education units available. The % of total students taking the three modes are shown in Figure 1. From this figure it can be seen that the popularity of weekly units quickly declined and currently course units are presented only in the distance education and short-course modes

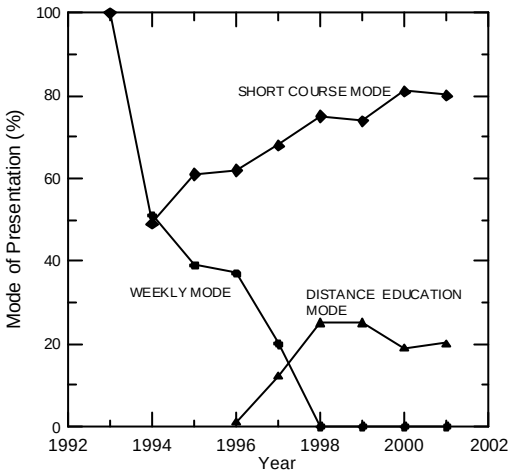

FIGURE 1.
ENROLMENTS IN THE THREE MODES OF PRESENTATION

Short course programs are offered bi-annually at QUT in Brisbane. This mode of education is very popular with students from industry who derive benefits from not only the formal lectures, but also from informal discussions with fellow students who are employed by a range of companies. Short courses are also presented on request at a number of venues throughout Australia and presentations have also been made in China, Singapore and New Zealand.

Distance education units are popular with people working in remote locations but there is also demand for this type of education from local students who need immediate training

Competency-based Teaching

In this program it has been found to be essential to have access to materials developed in industry and to have a large proportion of lecturing staff (75%) who are currently industry-based practitioners of engineering. Universities, however, possess skills in program design and operation, educational methodology and design of instructional materials, deep expertise in engineering fundamentals and have access to a wide range of professional expertise beyond engineering. The competency-based approach at the professional level, therefore, requires a close partnership between universities and industry.

When the program was originally designed the partners were interested in the possibility of applying the full competency approach in which learning outcomes are demonstrated to workplace assessors of competency. This proved to be too difficult to implement with the resources available. Learning outcomes are examined in assignment work that is designed to be representative of tasks that are carried out in industry and this constitutes the main form of assessment in the program. The masters thesis provides evidence that graduate of the program can successfully apply the knowledge and skills developed in the taught units in a professional engineering job. An improvement of current engineering methods is embodied in the masters thesis which fully documents engineering processes and describes alternatives on which decisions are made: currently this information is often lost.

Response to the Program

The competency-based program has received strong support from employers and engineers throughout Australia. The initial traing contract was fulfillied in less than 18 months. At this time in excess of 30,000 student-hours of training have been provided to over 750 industry participants from electricity supply companies, manufacturers, mining companies and consultants from throughout Australasia. The level of student satifaction from surveys made at the end of each unit is very high as can be seen in Figure 2.

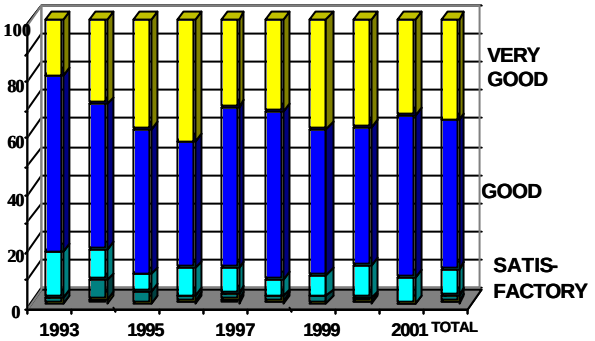

FIGURE 2.
OVERALL STUDENT SATISFACTION

The program is widely acknowledged as the leading coursework program in Australiasis for electrical power engineers. This is evidence by strong continuing support from industry, including requests from companies in other states for QUT units.

BENEFITS TO THE PARTNERS

There have been considerable benefits for all partners including:

The program is fully funded from income external to the university which coveres costs of: accommodation, administration staff, lecturer's salaries, production of materials, and software purchases. It is one of the few university engineering postgraduate programs in Australia fully supported by external earnings.

Undergraduate students have been given the opportunity to take some postgraduate units as part of final year electives and the program has provided support for laboratory development and research student bursaries at QUT.

The program has improved the university image with industry and other universities. The industry partners have subsequently funded a Chair at the university.

A number of research students have been attarcted to the university both from within Australia and overseas by the prospect of taking coursework as part of industry-focussed research degrees.

Presenters from in the program have developed very high profiles throughout Australia and overseas through lecturing. They have also developed their knowledge through repeated exposure to groups of peers from a wide range of organisations.

University presenters have taught in teams with industry presenters and this has inproved knowledge of university staff about industry and lead to greater collaboration between industry and the university.

Industry partners have been able to train young engineers and retrain existing staff through the program without having to set up significant traniing infrastructures within the companies. At a time when few power engineers have graduated from universities the industry partners have been able to recruit the most able students available and ensure, by training through the program, that recruits attain competency in electric power engineering.

When the industry partners have bid for large consulting contracts within Australia and overseas they have been able to incorporate relevant university training courses when training is required as part of the contract.

Through the masters thesis industry partners have had important aspects of their businesses thoroughly documented.

CONCLUSIONS

The industry-focussed postgraduate postgradauate program described in this paper has bean has achieved a remarkable level of acceptance within the Australian electricity supply industry and related industries. It is currently one of the main university-provided educational programs for the industry in Australia and after about ten yearts of operation it is still one of the few programs that are sustainably self-funding.

The success of the progam is based on very close patnership between the industry and two industry partner companies. At the core of this partnership is the initial training agreement which spelt out the obligations of each party in business terms. The main feature that has differentiated the training provided through this program from other postgraduate programs has been the clear emphasis on imparting knowledge that is needed in the work place as opposed to imparting knowledge that is a speciality of university staff. It has been found that industry competency standards for professional electrical engineers in electricity saupply provide a very useful starting point for the identification of training needed in industry and a methodology for developing syllabi for university courses from competency standards has been pioneered. As well as providing the university partner with income and training industry staff, the program has lead to a wide range contininig.of benefits to all partners.

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