A Fifteen Year Journey to A Unique Program in Engineering:- WIL, PBL, Professional Practice and e-Learning

Prue Howard, John Mark & David Jorgensen
Faculty of Sciences Engineering and Health
Central Queensland University
Bruce Highway
Rockhampton 4702, Queensland, Australia.

Prue Howard ph +61 7 49 309730
fax + 61 7 49 309382
email p.howard@cqu.edu.au

Abstract

The Faculty of Sciences Engineering and Health at Central Queensland University, Queensland, Australia is offering an innovative and, it is believed, unique Bachelor of Engineering program. This program integrates Work Integrated Learning, Project Based Learning, Professional Practice development and e-Learning for both internal and distance students. The program is offered over three campuses. In doing so the faculty has redefined the way in which engineering can, and it is believed, should be delivered.

In 1993 the faculty began reinventing its professional engineering degree programs with the implementation of co-operative education or Work Integrated Learning (WIL). The new program commenced in 1994. The program curricula was restructured to include two six month co-operative education work placement periods, with the first placement to be offered in the third year of the program in 1996. In the second placement, in the latter half of fourth year, students were provided with an opportunity to undertake their second six month work placement as an overseas placement.

In 1997 the on-campus elements of the program were reviewed, with a new program incorporating significant changes being introduced in 1998. This review was in response to a range of stimuli, including, a need to better prepare students for their work placements, a recognition of the fundamental problems with the old program structure, and a recognition of the need to respond to significant social changes. The changes incorporated affected both curriculum and pedagogy, and were characterised by the introduction of Project Based Learning (PBL) and the incorporation of an 'inverted curriculum'. PBL was incorporated in all years of the program with generic professional practice skills forming a significant explicit component in the early years, tapering off toward the end of the program, whilst the converse is the case for technical discipline knowledge and skills. The development of the combined PBL/WIL engineering program was the result of extensive national and international study. The combined program provided context for holistic student learning and practice, and an integrated learning environment.

In a later development in early 2004, the professional practice learning in the Bachelor of Engineering (Co-operative Education) program was explicitly and formally recognized. This was accomplished by a change to an integrated dual award program, the Bachelor of Engineering (Co-operative Education)/Diploma of Professional Practice (Engineering).

The latest developments within the program have been incorporated in 2007, with the offering of both the first and second year of the program on three campuses, and all years in distance mode. The further enhancement of e-Learning within the program has included webcam

conferencing between students and three campus locations i.e. Mackay, Rockhampton and Gladstone using "Click to Meet" and "Scopia". We have also introduced Citrix Main Frame Application Delivery via the web for Applications such as Matlab, Microsoft Office, Cad Applications, Strand 7 and Visual Studio.

This paper presents the history, issues, development and implementation of this unique engineering program.

Introduction

Situated on the Tropic of Capricorn, approximately 40 kilometres from the Central Queensland coast, and 650 kilometres north of Brisbane, the Queensland capital, Central Queensland University commenced operations in Rockhampton, Queensland, Australia as the Capricornia Institute of Technology in 1967. The School of Engineering was the major foundation on which the institution grew and diversified over the next 38 years. James Goldston, who was a Commissioner of Queensland Rail and an Engineer, was a founder of what was to become the University and the founder of the School, and later the Faculty of Engineering.

The focus for the engineering school, and later faculty, was the development and delivery of engineering programs to specifically meet the needs of the Central Queensland region, which covers an area of approximately 250,000 square kilometers. The state covers 1,723,936 square kilometres. This region was, and still is, the node for the operation and maintenance of the state rail system, and also a focal point for the region's power industry and (still) developing coal mining and other minerals extraction and processing heavy industries.

The then Capricornia Institute of Technology's School of Engineering commenced delivering a relatively narrow range of engineering programs in the late 1960's. Those programs evolved into offerings of Associate Diplomas of Engineering: 2 years full-time; Bachelors of Technology: 3 years full-time and Bachelors of Engineering: 4 years full-time, post secondary completion, by the early 1990's.

Central Queensland University's Bachelor of Engineering (Co-op) and from June 2004 its evolution into fully integrated Bachelor of Engineering (Co-op)/Diploma of Professional Practice (Engineering) is the faculty's 'Jewel in the Crown' in terms of its industry and community standing.

Table 1 outlines the history of the development of the Co-operative engineering programs at CQU.

Table 1. CQU Engineering Program Development Timeline

Year	Activity
1967	Establishment of Engineering programs at CQU's predecessor institution
1967 to 1992	Expansion of engineering program offerings to incorporate Associate Diplomas of Engineering; Bachelors of Technology and Bachelors of Engineering
1993	Faculty review of professional engineering programs to incorporate engineering co-operative education. Approval of BEng(Co-op) program by University
1994	Formal introduction of the BEng(Co-op) program with students enrolled - Brainstorming for new educational philosophy arising out of need to have students industry ready at end of 2nd year.
1995	Appointment of a Director, Co-operative Program and Industry Liaison in June 1995

	Major Australian Institution of Engineers review of professional engineering and educational philosophy underway. Teaching and learning of professional engineering programs under the microscope - instigated world-wide search by CQU for models for new teaching and learning strategy to integrate with co-operative education element
1996	Co-operative education BE program Australian placements commenced in 3rd year of BE (Co-op) program
	Proposal for incorporation of PBL and inverted curriculum following international review of PBL models in engineering education.
	Institution of Engineers, Australia (IEAust) review results published in "Changing the Culture" document
1997	Co-operative education BEng program Australian and international placements commenced in 4th year of BEng (Co-op) program
	IEAust accreditation of BEng (Co-op) programs – accreditation granted for the full five years allowed
	Re-structure of BEng programs (BE 2001 - Changing the Culture) to incorporate Project Based Learning (PBL) and integrate PBL with Co-operative education – development and university approval
1998	Introduction of new integrated PBL/Co-operative Education BEng program
2001	First graduates PBL BEng program
2002	First graduates PBL/BEng (Co-op) program (June 2002)
	Accreditation of all programs - Full Accreditation for five years (highest achievable) of BEng(Co-op) programs – under observance of international Washington Accord delegates
2004	Formal recognition of Professional Practice element – restructure of BEng(Co-op) into BEng (Co-op)/DipProfPrac
2005	Major Review of all Engineering Undergraduate Programs

The Faculty Review

In 1993, the James Goldston Faculty of Engineering (JGFE) decided to conduct a review of its Bachelor of Engineering (BEng) degree as part of a review of its strategic plan (JGFE 1993). The review was to address the concerns articulated by employers in general, that engineering graduates were not being properly prepared for the modern workforce. Graduates were deemed to be specifically lacking generic skills such as problem solving, creativity, communication and teamwork. The review was also to investigate the assertions of students and some staff that the program was overloaded with technical content, and contact hours, with for example, 29 hours of contact each week in the first year of the program.

While there was 100% employment of graduates, this was not taken as a guarantee that the program was delivering what employers needed. At the same time, the attrition rate, especially from the first year of the program was too high. In some years it was up to 50% in first year. The students in some cases burned out, and were lacking interest in the program particularly by the end of their first year. They had very little motivation or enthusiasm for their study with a further three years of 'grind' in front of them. It seemed to be accepted by the student population who stuck it out, that engineering was difficult, and they simply expected that it would come together in the long term. It was obvious something needed to be done.

The faculty review team was also concerned about the 'tick-a-box' perception of the degree that students were acquiring. Students were passing a course, and mentally 'ticking the box' that denoted 'completion' of that course, and then seemingly ignoring that material. The result was that once a course was passed, they failed to use the material in later courses. Consequently, material had to be taught, and retaught where it was needed at a later time. Effectively students could 'tick off' all the boxes, denoting individual course completion, and collect their degree. Very rarely, it seemed, were students required to integrate or utilise material from more than one course until they graduated and became employed. This style of learning was superficial, with little retention or understanding. Added to this was that material was taught in isolation and very rarely in context.

Vacation work experience allowed students to experience, albeit in a fairly superficial manner, the professional engineering environment. However, the 8 – 10 weeks time period of a typical vacation experience did not give students or employers enough time to have the students fit in to the environment and take on a role of importance within the organisation. Consequently students had very little opportunity to apply any of their academic learning in the workplace prior to graduation. This reinforced the 'tick a box' attitude to study.

The program issues that were specifically addressed by the review were:

- Overloaded program with technical content (as technology changed, material was simply added to the program, with very little being removed)
- Students were overloaded with excessive class contact hours (29 hours per week in first year)
- High student attrition rates (up to 50% attrition from first year)
- Repeat teaching (surface learning resulted in material being forgotten as soon as the course was passed, and consequently material had to be re-taught when it was next needed)
- Students were not properly learning or integrating material

Additionally, during the review process it became clear that the traditional CQU (and generally Australian) engineering curricula no longer adequately prepared graduates for professional life. The curricula were still heavily analytical, even though technology had automated many analytical tasks. Self-learning and sustained learning was not strongly encouraged, even though it was an obvious strategy for coping with rapid technological advances.

The grassroots recognition of these phenomena within the engineering community prompted a national review. This national review was undertaken by The Institution of Engineers Australia, (IEAust), the Australian Council of Engineering Deans and Australian Academy of Technological Sciences and Engineering. Several CQU engineering staff were actively involved in the national review.

Co-operative Education in Engineering

The result of the1993 review was a proposal to introduce Co-operative Education into the professional Bachelor of Engineering Program. As a bonus, it was expected that the introduction of the Co-operative education program would improve the attractiveness of the engineering program to potential students by providing a professional engineering program unique to Queensland. It was intended that the existing Bachelor of Engineering (BEng) would continue to run in parallel with the new BEng (Co-op) program, sharing almost all the academic components except specifically, the new work placement elements and their associated preparatory work for students.

After extensive investigation nationally and internationally, a co-operative education program was developed. The result was a general program structure as detailed in Table 2 below. While the two placements were nominally six months in duration, by working through the University Christmas holidays, students were able to undertake two placements of up to eight months.

Table 2 – General Structure of Co-operative Engineering program

March – June	July - October

Term 1	Term 2
Term 3	Term 4
Work Placement 1	Term 5
Term 6	Work Placement 2
Term 7	

This structure, it was expected, would address the issues identified above. The work placements would not only allow the students to use taught material outside of the courses, but it would be done in a real engineering environment early within their period of study. The change of focus that a paid co-operative education work placement following second year would give, with working (and income), was certain to be attractive for students and provide significant motivation for study continuance.

Co-operative Education Program

The Structure

An accredited Professional Engineering program in Australia is a nominal minimum four year full time program. For graduates to become members of the engineering professional body (then known as The Institution of Engineers, Australia (IEAust), now Engineers Australia), the program must be accredited by that body. The new co-operative education program needed to be accredited by the IEAust to continue to be a professionally recognised and accepted, and also a marketable, program. The general course structure for the program from 1994 to 1998 is shown in Table 3 below.

Table 3 – Initial Co-operative Bachelor of Engineering structure (1994- 1998)

YEAR	TERM 1	TERM 2
1	Eight (common) Lecture Based Courses	Eight (common) Lecture based courses
2	Six Discipline* Lecture Based Course	Six Discipline* Lecture Based Courses
3	Work Experience – Industry Placement & one External Study Course	Six Discipline* Lecture Based Courses
4	Seven Discipline* Lecture Based Courses	Work Experience – Industry Placement & one External Study Course
5	Seven Discipline* Lecture Based Courses	Graduation

* Disciplines – Electrical, Civil and Mechanical Engineering

Whilst it was accepted that there would be valuable student learning during the placements, it was not felt that accreditation would be achieved for a four year program with only three 'normal' years of academic component. It was considered that increasing the duration of the program by a year to incorporate the two six month work placements, simply on top of the existing program, would have a detrimental effect on the ability to market the program to potential students. The solution determined was to increase the duration to four and a half years and incorporate distance education during the two work placement periods. Upon reflection, the addition of distance education had additional benefits.

Distance Education

Offering some courses in distance education mode while on work placement allowed the requisite number of courses to be delivered within the four and half year period. This was the initial reason for their inclusion.

The introduction of distance education however delivered more advantages to the offering of the co-operative education program. It was recognised that it would encourage students to appreciate more the necessity for them to engage in lifelong learning skills and attitudes. It was also expected to keep students primed for study and to better integrate work and learning, to keep up with the rapid changes in engineering and technology, and further the development of students accepting the responsibility for their own learning progress and achievement (Jancauskas and Edwards 1997).

International Placements

The decision was taken from the beginning, to take a global approach to the education of CQU engineering students with the inclusion of opportunities for placements to be taken outside Australia. Many co-operative education programs in Australia limit themselves to local or state-based placements; however there were advantages for both students and the faculty in broadening the placements. From the student's point of view these included experiencing:

- the culture of a country by working in it
- cultural and religious differences
- sports
- society
- professional environment
- business ethics
- technology differences
- student mental maturity

Benefits for the faculty include leads to other areas of co-operation in partner universities as links based on co-operative education interaction are expanded into research and teaching (Edwards, Jancauskas 1997).

Recognised Need for Curriculum Review

Whilst the introduction of Co-operative Education addressed the major issues that had been identified in the faculty it also introduced its own problems. The problems were based around the fact that the new BEng(Co-op) program simply used the existing BEng program without any curriculum or pedagogical review. The need for a further formal review was recognised, however the faculty decided that the improvements in just introducing co-operative education were worthwhile in implementing immediately. Hence the BEng(Co-op) program was introduced in 1994 with the first work placement occurring at the start of 1996.

A major philosophical review of the professional engineering program was started in 1994 in parallel with the introduction of the Co-operative Education program. It was a philosophical review rather than simply a curriculum review, as one of the major issues arising from the introduction of co-operative education was the industry preparedness of the students for their first work placement at the conclusion of their second year of study. The goal of this review was to develop a professional engineering program based around the co-operative education concept, and addressing the issues that had been identified.

During this review period a national study was also being undertaken by the Institution of Engineers, Australia (IEAust 1996), culminating in a report calling for significant change in how engineering programs in Australia were expected to prepare students as professional engineers. This national review, along with local industry surveys, had shown that life long learning and other critical professional capabilities and attitudes, such as communication skills,

a commitment to sustainability, problem solving skills and team skills were not adequately developed.

The Institution of Engineers Australia was modifying its program accreditation process to have a strong focus on quality concepts. The demonstrable competencies of graduates would be the key to accreditation. There would no longer be any constraints on program structure.

The timing of the National Review, the movement to quality principles in accreditation, together with the inherent flexibility of a small institution, presented CQU with the opportunity to redefine engineering education in Australia. The Faculty made the best use of this opportunity by identifying the international best practices in engineering education. This process highlighted fundamental problems with the traditional program structures. These included:

- the promotion of rote or surface learning by excessive course workloads and a reliance on closed book examinations
- the development of a fragmented knowledge base in traditional course units; students find it extremely difficult to integrate knowledge in a design environment, and have poor problem solving skills
- very poor understanding of professional attitudes and values amongst students.

Problem-centred or project-based curricula were identified as providing the best solution. They provide an environment which reflects the professional workplace and a meaningful context in which the fundamentals of technology and design can be studied. The bulk of the international education literature had for at least twenty years, agreed that project-based learning had the following advantages:

- it takes account of the way in which students learn, the learning style is active, deep and contextual
- enormous improvements in student motivation have occurred elsewhere; first year attrition rates can be as low as a few percent
- it develops a high level of generic and self learning skills
- it supports the integrated view that most engineers have of their profession
- project-based learning produces highly valued engineers in the industrial setting

The outcome of the review proposed significant curriculum and pedagogical changes. While the review was driven by a desire to produce the best program, it was also a necessary response to significant social changes. These included a shift away from mathematics and sciences in high school education, the move to mass education and the automation of many analytical tasks in the engineering workplace. On a national level it had become clear that engineering curricula must evolve to remain relevant (JGFE 1997).

The outcome of the faculty review conducted in 1995/6 was the development in 1997 of a Project Based Learning philosophy to complement and enhance the co-operative education model already in place. The recommendations of the review report, *Changing the Culture: Engineering into the Future*, (IEAust 1996) aligned well with the objectives of this restructured program.

The PBL/Co-operative education Bachelor of Engineering program commenced operation in 1998. This program was then granted full accreditation by Engineers Australia (the Australian professional body previously known as IEAust) for the maximum possible five years in January 2003.

Program Objectives and Graduate Attributes

An outcome of the review was that a new set of program objectives was required. In the 1996 Review of Engineering Education in Australia, carried out by the Institution of Engineers, Australia (IEAust, 1996), a set of generic graduate attributes had been defined against which programs would be professionally accredited in the future. CQU took these IEAust Generic Attributes and adopted them without alteration as the new Bachelor of Engineering (Co-op) program objectives and hence CQU Bachelor of Engineering (Co-op) Graduate Attributes. These program objectives and Graduate Attributes are:

- ability to apply knowledge of basic science and engineering fundamentals
- ability to communicate effectively, not only with engineers but the community at large
- in-depth technical competence in at least one technical discipline
- ability to undertake problem identification, formulation and solution
- ability to utilise a systems approach to design and operational performance
- ability to function as an individual and in multi-discipline and multi-cultural teams, with the capacity to be a leader or a manager as well as an effective team member
- understanding the social, cultural, global and environmental responsibilities of a professional engineer and the need for sustainable development
- understanding the principles of sustainable design and development
- understanding of and commitment to professional and ethical responsibilities
- expectation and capacity to undertake life long learning.

These then become part (with very minor modification) of the Engineers Australia Accreditation Board's 2005 Accreditation Management System (Engineers Australia, 2004)

Whilst the above were suitable for the explicit program objectives, the implicit objectives of preparing students for their work placements also existed. The co-operative education component of the program required that students would be able to function in a worthwhile manner in industry in an engineering role at the end of their second year. They then needed to 'ramp up' their generic professional skills for the second placement mid way through their fourth year. The explicit program objectives above would drive the curriculum review, while the implicit objectives would drive the pedagogical review.

Project Based Learning (PBL)

What is Project Based Learning (PBL)?

Project Based Learning is any learning environment in which the project drives the learning. While there are a number of interpretations of PBL, they all have the following points in common:

- The problem or project is posed so that the students discover that they need to learn new knowledge before they can solve the problem/project.
- Students learn by engaging in investigation.
- The problem/project is the context for the learning.

PBL is a curriculum design and teaching/learning strategy that simultaneously develops generic skills and a disciplinary knowledge base. It is ideally suited to professional practice oriented programs as it places students in a problem solving role as they would be in the workplace. PBL also purposefully confronts students with a situation that is ill structured, just as in "real world" problems.

The characteristics of PBL are:

- Student centred
- Small teams

- Lecturers become facilitators
- New information is acquired through self directed learning
- Collaborative learning.

PBL uses a cyclic approach to developing knowledge and skills. An important aspect is that the student must be confronted with the problem to be solved, and start on self directed learning, by identifying what they need to know, before any formal or traditional structured learning event is conducted. This is different to the traditional Taylorist approach of presenting material to be later used in a project, whether the project is "real world" or not. From an educational point of view, the PBL approach to learning is ideally suited to preparing students to hit the ground running in their work placements, in a co-operative education program. Figure 1 below shows the PBL learning cycle.

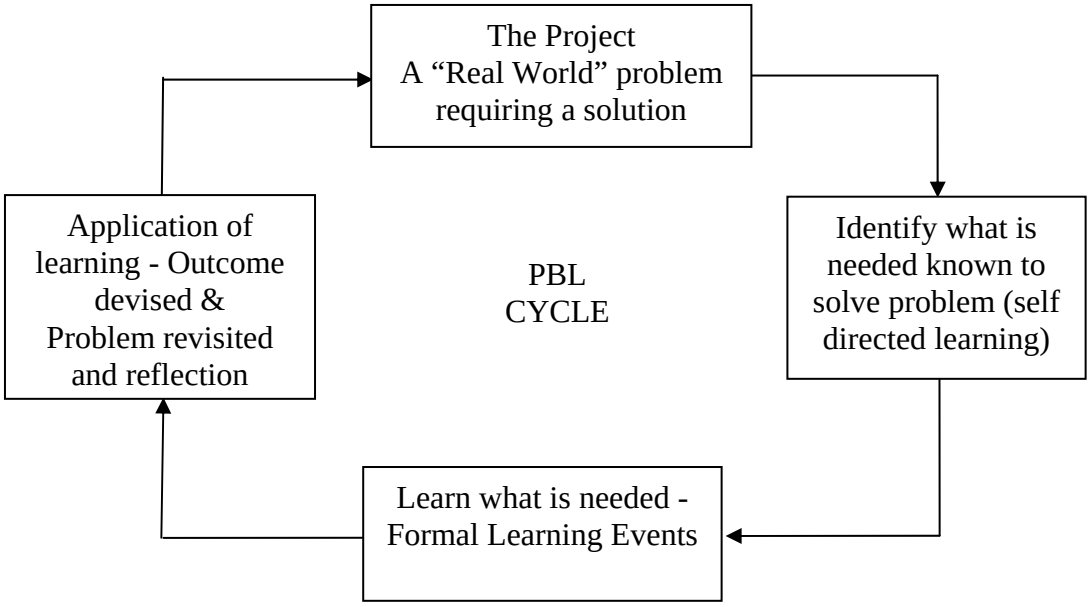

Figure 1 – Project Based Learning Cycle (adapted from Woods D.R.1994)

Why use PBL?

Traditional programs have been suitable for producing graduates whose requirements had not changed for many decades. However as the interface between technology and society has

evolved, the need for a different type of graduate has also evolved. Educators must be producing graduates for tomorrow, not today.

Today's World		Tomorrow's Graduate
• Rapid explosion of knowledge	⇨	• Self directed and lifelong learning
	⇨	• Problem solving/analytical and critical thinking skills
• Increased technology and social complexity	⇨	• Integration of interdisciplinary knowledge/skills
	⇨	• Teamwork and interpersonal skills

Many institutions claim to develop all the graduate attributes required without the use of PBL, so why use it? Both the faculty and the 1996 IEAust review (IEAust 1996) determined that students needed to be motivated, and a context given to their studies. It was expected that the context for the learning would bring enthusiasm. The following outcomes are what was expected would be achieved by engaging students in project based learning:

- Integration of knowledge and skills
- Motivation and enthusiasm
- Problem solving in context
- Teamwork
- Interpersonal skills
- Lifelong Learning Skills
- Proactive, critical, systems thinking
- Self directed learning skills
- Communication Skills
- Professional practice (make reasoned decisions in unfamiliar situations)

Problem and Project Based Learning in Engineering – Internationally

At the time of the faculty review, final year projects had been common in professional engineering programs at most universities in Australia. However, the concept of PBL was only occasionally utilised in the earlier years. As part of the review process, a search was conducted to determine world wide best practice in PBL in engineering education. The following summary describes the results of that search.

Aalborg University in Denmark had been delivering PBL programs in engineering for more than 30 years, producing approximately 500 graduates annually. Their programs had been independently evaluated, with positive outcomes. (Ostergaard, J. 1989, Kjersdam, F, Enemark, S. 1994).

McMaster University in Canada offered several PBL courses in Chemical Engineering. Don Woods developed a small group, self assessed and self directed approach to PBL. (Woods, DR, 1994)

Colorado School of Mines in the USA introduced in the late 1970's, "Engineering Practices Introductory Course Sequence" (EPICS) to teach in a PBL environment (Pavelich, MJ, Olds, BM & Miller, RL, 1995).

Kotka Polytechnic in Finland, introduced a PBL system in the early 1990's to address socio-technical issues (Letho,S 1995).

Drexel University in the USA, as part of a University Coalition developed the E^4 curriculum (Quinn, R. 1993).

Project Based Learning at CQU

The CQU interpretation of PBL is "Project" Based Learning, which provides a longer term, and multi-faceted "problem" to allow an exploration of the breadth and depth of the stimulus material. When a project is defined by students there is an expectation that they will holistically consider all variables, parameters, and constraints including technical, social, environmental and cultural. The term project based learning was also used to focus the staff and students on a systems approach to potential outcomes, rather than a series of discrete problems to be solved in isolation.

The Engineering Faculty at CQU developed, and introduced in 1998, a new Project Based Learning (PBL) Bachelor of Engineering (BE), re- incorporating Co-operative Education Learning from the previous program. The educational and theoretical issues surrounding this program have been discussed (Wolfs, PJ, Howard, P, Vann, A, Edwards, R, 1997). The introduction of this program, as previously mentioned, was in response to the recognised shortcomings in the old program. The new PBL/Co-op Bachelor of Engineering program was established with 50% of each term of study designated as a single course incorporating Project Based Learning.

The Revised 1998 Program
The CQU BE program was established on an overall 50% PBL basis, where half of each term's student load is a single project based course. This structure can be seen in Table 4 below. Each project based subject is worth 12 units of credit, while the lecture based subjects are each worth 6 credit points, making the project based subject 50% of the term's offering (24 units of credit – in each of two terms a year).

The curriculum was vertically integrated and partially inverted to allow the generic skills to be developed throughout the entire program. It also allowed content to be delivered as it was needed, rather than as parcels of information presented in the first year or two, to be utilised in the last two years.

It was recognised that the students would need to learn how to learn in both a team environment and the project based mode. To this end, an induction program was developed, and the first term project based subject, centred on learning how to learn, and developing a propensity for life long learning.

Table 4 1998 PBL/Co-op Program Structure

YEAR	TERM 1	TERM 2
1	Lecture Based Course	Lecture Based Course
	Lecture Based Course	Lecture Based Course

	Project Based Course	Project Based Course
2	Lecture Based Course	Lecture Based Course
	Lecture Based Course	Lecture Based Course
	Project Based Course	Project Based Course
3	Industry Placement	Lecture Based Course
		Lecture Based Course
		Project Based Course
4	Lecture Based Course	Industry Placement
	Lecture Based Course	
	Project Based Course	
5	Lecture Based Course	
	Lecture Based Course	
	Project Based Course	

The following characteristics were those that all projects within the project based courses were to include:

- Student centred learning
- Small teams
- Lecturers become facilitators
- Project is the context for learning
- New information is acquired through self directed learning
- Collaborative learning is required

The Common First Year

The program was established with a common first year, encompassing a mathematics and a physics course in each term, plus the project based courses, which concentrate on professional engineering skills, common to all disciplines. These two courses, Engineering Skills I and II, are designed to introduce students to the profession of engineering, and to represent a normal engineering environment. All projects are team based, where students are assigned to teams using various methods.

The Later Years

At the start of the second year of the program, students must select a specialist discipline. From that point, each discipline develops a technical skill and knowledge base, based on the concepts developed in the first year, as well as further developing the generic skills imparted in the study of Engineering Skills I and II.

An important aspect in the development and delivery of many of the technically based project subjects has been the involvement of practicing engineers. This allows current practice to be displayed, and real projects to be used.

Industry placements

The program places students in a co-operative industry placement for a period of six months at the end of their second year, and middle of their fourth year. These placements, which are an academic component of the program, allow students to apply their already learned skills and knowledge. At the start of 2000, the first cohort of students from the PBL program began their first placement. The faculty considered that the feedback from the employers would be a valuable interim assessment of the effectiveness of the new PBL program.

Reactions

The feedback from employers of co-op students in their work placements has been overwhelmingly positive. In formal interviews with the employers, towards the end of each placement, employers have commented on the quality and value of the students. Employers are particularly enthusiastic about the ability of, what are in actual fact second and third year students to:

- Function independently
- Work in a team
- Communicate articulately
- Problem solve
- Have confidence in their ability
- Know their limitations, and are prepared to ask for help

The co-operative program has been in operation for several years, and a number of employers remarked that the students in the PBL/Co-operative education cohorts are the best they have encountered.

The feedback for the introduction of PBL into the Co-operative Education engineering program has been positive. The student evaluation is positive, and their reflective journals show mostly an acceptance of the philosophy of PBL. They have become independent active learners, and motivated enthusiastic students. This is reflected in the attrition rate, which has dropped significantly to approximately 15%.

In 2002 the IEAust assessed the CQU submission for the Accreditation of all Bachelor of Engineering programs which constituted review of a complete set of documentation and a two day visit to the faculty in August by a panel of national experts in engineering education under the observance of international Washington Accord delegates. Full Accreditation for five years of the Bachelor of Engineering (Co-operative education) programs was granted – the highest level of achievement possible.

The engineering faculty of at CQU established a new paradigm with the PBL Bachelor of Engineering degree. It was apparent that it would (and did) supply graduates who are better prepared for professional engineering practice than graduates from the traditional program offered at CQU. Feedback from students and employers of co-operative industry placement and graduating students indicated that many of the goals of the program are being explicitly realised (Jorgensen & Howard, 2000).

As previously discussed, in 1996, co-incident with the faculty review of its Bachelor of Engineering programs, the Institution of Engineers, Australia (IEAust 1996) published a review of Australian engineering education. This claimed that the future accreditation of engineering courses would depend upon the demonstrated development of the attributes then deemed as lacking, specifically in the areas of teamwork, communication, sustainability and cultural and community responsibilities in addition to the technical knowledge and skills. As a result of both reviews, CQU's Engineering faculty developed a Project Based Learning Bachelor of Engineering (Co-op) program.

The Engineering Faculty at CQU has taken a liberal interpretation of PBL, perhaps more generally accepted as 'Problem' Based Learning. The aim of introducing project based learning into the co-operative education degree was to allow as much integration as possible of content within the program, while adding a context to encourage the acquisition of understanding and skills. The faculty's interpretation of PBL is "Project" Based Learning, which provides a longer term, and multi-faceted "problem" to allow an exploration of the breadth and depth of the stimulus material. When a project is defined by students, there is an expectation that they will holistically consider all variables, parameters, and constraints including technical, social, environmental and cultural. The term, project based learning, was

also used to focus the staff and students on a systems approach to potential outcomes, rather than a series of discrete problems to be solved in isolation (Jorgensen, Howard 2001).

One advantage of PBL within the Co-operative Education context is that it develops the student's ability to learn how to learn. Each student will be going into a different environment and industry, and cannot hope to be prepared for all eventualities. However the students can be prepared to identify what they need to know to solve a problem, (identify what they don't know), and then go about sourcing the knowledge, internalising it, and using it to solve the problem. This, in a nutshell, means develop problem solving skills. These are the skills that will be needed on their two work placements as well as obviously on graduation.

Engineering PBL/Co-op Program Structures

The CQU BEng (Co-op) program was established initially on an overall 50% PBL basis, where half of each term's student load is a single project based course. This structure can be seen in the Table 5 below.

Table 5. Bachelor of Engineering (Co-op) Program Structure (1998 to June 2004)

<table>
<tr><th>YEAR</th><th>TERM 1</th><th>TERM 2</th></tr>
<tr><td rowspan="3">1</td><td>Lecture Based Course</td><td>Lecture Based Course</td></tr>
<tr><td>Lecture Based Course</td><td>Lecture Based Course</td></tr>
<tr><td>Project Based Course</td><td>Project Based Course</td></tr>
<tr><td rowspan="3">2</td><td>Lecture Based Course</td><td>Lecture Based Course</td></tr>
<tr><td>Lecture Based Course</td><td>Lecture Based Course</td></tr>
<tr><td>Project Based Course</td><td>Project Based Course</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Work Experience – Industry Placement & one External Study course</td><td>Lecture Based Course</td></tr>
<tr><td>Lecture Based Course</td></tr>
<tr><td>Project Based Course</td></tr>
<tr><td rowspan="3">4</td><td>Lecture Based Course</td><td rowspan="3">Work Experience – Industry Placement & one External Study course</td></tr>
<tr><td>Lecture Based Course</td></tr>
<tr><td>Project Based Course</td></tr>
<tr><td rowspan="3">5</td><td>Lecture Based Course</td><td rowspan="3">Graduation</td></tr>
<tr><td>Lecture Based Course</td></tr>
<tr><td>Project Based Course</td></tr>
</table>

Each project based course is worth 12 units of credit, while the lecture based courses are each worth 6 units of credit, making the project based course 50% of the term's offering and twice the 'value' of 'normal' courses.

The curriculum is vertically integrated and partially inverted to allow the generic skills to be developed throughout the entire program. It also allowed content to be delivered as it was needed, rather than as parcels of information presented in the first year or two, to be utilised in the last two years.

Professional Practice - Philosophy and implementation

Educators need to develop graduates with attributes and abilities previously not considered core to their professional practice. According to a review of Australian engineering education

steered by the Institution of Engineers, Australia (IEAust 1996) future accreditation of engineering courses will depend upon demonstrated development of attributes including effective communication, the ability to work in multi-disciplinary teams, utilisation of a systems approach to design, and an understanding of the social, cultural and ethical responsibilities of the professional engineer (Howard, Jorgensen & Toft 2000)

Partially as a result of this, moves have been made to redefine professional engineering practice (Thom 1998). Global conferences have called for the development of generic attributes in engineers, which encompass the multi-faceted concepts of engineering practice (Boeing Company and Rensselaer Polytechnic Institute 1997). As the concept of sustainability stands on the three legs of economic, environmental and social sustainability, engineering as a profession, in order to embrace the concept of holistic practice, must first develop an understanding of individual and societal needs (Crofton, 1998). Students need to not only be aware of, but have the opportunity to prepare, practice, and reflect upon these issues.

Since the inception of the BEng(Co-op) program by the faculty graduates had demonstrated good professional practice skills. These had resulted from professional practice skills training, delivered by the faculty, and the opportunity to work in industry where they can use and develop these skills. Upon their return to the academic environment, they were encouraged through reporting requirements for their work placement, to reflect upon how those issues had impacted their placement. These learning opportunities however were not formally recognised by the university (except in the assessment of the work placement report) and was not credited towards their degree. This lack of recognition and credit was the motivation for the development of a Professional Practice program. This program replaces and extends material currently provided in the Work Placement courses of the Engineering Co-op Program.

The Diploma of Professional Practice, integrated with the PBL Bachelor of Engineering (Co-operative Education), aims to explicitly equip graduates with the knowledge, skills and attributes needed in professional practice and for professional leadership. The combined program is designed around the triple themes of intellectual, social and professional development. (JGFEPS 2004a)

A feature of the professional practice program is its incorporation with the periods of work placement in a professional environment that provides the opportunity to learn and put into practice, professional practice skills. The existing work placements are highly regarded by employers, and this program provides students with the training and education to maximise the learning occurring in the professional environment. The program is structured with internal courses delivered before and after work placement periods to provide necessary preparation and review of skills, which will be put into practice in the work place. They also require reflection on the learning.

The new program separates the professional development components previously combined with the BEng(Co-op) work placement courses and presents them in an explicit program. This explicit program provides students with due recognition of their professional practice skills. This program is now integrated with the BEng(Co-op) program to form a dual award program known as Bachelor of Engineering (Co-op)/Diploma of Professional Practice (BEng(Co-op)/DipProfPrac(Eng)). With the introduction of this dual award, the BEng(Co-op) is no longer offered as a stand alone program.

For ten years, the James Goldston Faculty of Engineering and Physical Systems at CQU delivered the BEng (Co-op) which was and is highly regarded by industry. Graduates had well developed professional practice skills, which resulted from specific professional practice skills training, delivered by the faculty, and the opportunity to work in industry where they could use

and develop these skills. The training that the students were required to undergo was however not formally recognised by the university and was not credited towards their degree.

The Diploma of Professional Practice program was developed to separately formulate, recognise and extend the professional development components previously implicitly combined with the work placement courses and presents them in an explicit program. The program is a generic program designed to provide students with the necessary professional practice skills to go into the placement and the opportunity to reflect upon their experiences in the workplace. It is through this reflective process that the implicit learning from the work placement becomes explicit assessable learning.

As of 2005 the BEng(Co-op) has been replaced by the new integrated dual award program the Bachelor of Engineering (Co-op)/Diploma of Professional Practice (Engineering) BEng(Co-op)/DipProfPrac(Eng). The new structure is shown in Table 6 below.

Table 6. Bachelor of Engineering (Co-op)/Diploma of Professional Practice (Engineering) Program Structure (Post June 2004)

YEAR	TERM 1	TERM 2
1	Lecture Based Course	Lecture Based Course
	Lecture Based Course	Lecture Based Course
	Project Based Course	Project Based Course
2	Lecture Based Course	Lecture Based Course
	Lecture Based Course	Lecture Based Course
	Project Based Course	Professional Practice Course
		Project Based Course
3	Work Experience – Industry Placement External Study Course	Lecture Based Course
		Lecture Based Course
		Professional Practice Course
		Project Based Course
4	Lecture Based Course	Work Experience – Industry Placement External Study Course
	Lecture Based Course	
	Professional Practice Course	
	Project Based Course	
5	Lecture Based Course	Graduation
	Lecture Based Course	
	Professional Practice Course	
	Project Based Course	

Whilst this appears to be an increased load for students, as to some extent it is, it formally recognises additional learning that students were, to a large extent, already undertaking previously in preparation for, and reflection after completion, of their work placements.

Professional Practice Program Structure
The structure of the Diploma of Professional Practice program element of the dual award program is as shown in Table 2 below.

Table 2 Professional Practice Element of an integrated Co-operative Education Engineering Program

Course	Units of Credit	Comments
Professional Practice Preparation 1 (PPP1)	6	Covers resume writing, interview skills, ethics, health and safety, industrial relations– prior to 1st work experience
Professional Practice Review 1 (PPR1)	6	Covers documentation of actual work experience using competency framework, formal presentation of work experiences, shared reflection workshops.– following 1st work experience
Professional Practice Preparation 2 (PPP2)	6	Covers additional engineering workplace skills similar to first line supervisors course.– prior to 2nd work experience
Professional Practice Review 2 (PPR2)	6	Covers documentation of actual work experience using competency framework, formal presentation of work experiences, shared reflection workshops.– following 2nd work experience
Work Experience 1 (WE1)	6	Formal course structure to match work experience period. Each course of nominal 12 weeks duration. Assessment limited to weekly activity and reflection journals and self-established job objectives.

Continuing Innovation with Information Technology

Information Technology (IT) plays a very large part in the delivery of Project Based Learning (PBL). IT is the backboard on which we are able to ensure that students regardless of location are able to be part of a larger team environment. IT is able to facilitate some characteristics of PBL :

- Small teams
- Lecturers become facilitators
- Collaborative learning

Small Teams
With the use of Software Tools such as;

- CMAPS (http://cmap.ihmc.us/) Conceptual Web Based Mapping
- Citrix Web Based Applications (http://studcitrix.cqu.edu.au/) application such as AutoCAD, MatLAB, Microsoft Office including Project etc
- SCOPIA, Web Based Video Conferencing and Desktop and Application Sharing (Copyright © 2007 RADVISION Ltd. All Rights Reserved, http://www.radvision.com/Products/Network/)

we are able to empower the students within these small teams to work from any location and share any type of information in a virtual sense. Students are not limited due geographical isolation, because all of the tools available to them are web based. This also means that the students are not limited to the University IT Network.

Lecturers become facilitators
Lecturers are able to lead and or participate with the teams using the tools shown above,and therefore they become part of the team. Geographically, this means that any academic

anywhere can be part of this process. Lectures can also be contacted via web cam and/or telephone to offer advice and direction to teams as they may require it. The only issue is time zones as it is with students. However within Australia there are only four times zones with no more than 3 hours difference. Additionally this gives the students the opportunity to work in a real world environment, as it is the same as the global environment that professional engineers work within.

Collaborative learning
Collaborate Learning is used with a number of meanings, eg:

- Collaborative learning is a process to enhance decision-making through shared understanding. Collaborative Learning uses ideas from soft systems ...
  www.mgrush.com/content/view/70/33/
- A more radical departure from "cooperative learning". It involves learners working together in small groups to develop their own answer through interaction and reaching consensus, not necessarily a known answer. ...
  www.neiu.edu/~dbehrlic/hrd408/glossary.htm
- Learning through the exchange and sharing of information and opinions among a peer group. Computers excel in mediating collaborative learning for geographically dispersed groups.
  www.conferzone.com/resource/glossarycd.html
- when learners work in groups on the same task simultaneously, thinking together over demands and tackling complexities. Collaboration is here seen as the act of shared creation and/or discovery. ...
  www.unesco.org/education/educprog/lwf/doc/portfolio/definitions.htm
- Collaborative learning (CL) is a personal philosophy, not just a classroom technique. In all situations where people come together in groups, it suggests a way of dealing with people which respects and highlights individual group members' abilities and contributions. ...
  esb.ode.state.oh.us/Word/GLOSSARY%20FOR%20DRAFT%20STANDARDS_10_18_05_FINAL.doc
- Collaborative learning is an umbrella term for a variety of approaches in education that involve joint intellectual effort by students or students and teachers. ...
  en.wikipedia.org/wiki/Collaborative learning

Computer-supported collaborative learning (CSCL) has emerged as a new educational paradigm among researchers and practitioners in several fields, including cognitive sciences, sociology, computer engineering. It thus constitutes a new trans-disciplinary field. **Collaborative Learning** also has a particular meaning in the context of Learning Management Systems. In this context, collaborative learning refers to a collection of tools which learners can use to assist, or be assisted by others. Such tools include Virtual Classrooms, Web Cams, chat, discussion threads, application sharing.

The range of IT support described above is now allowing students to enrol and study from any location, and to develop the skills necessary to work in a global environment.

Conclusion
A fifteen year reflective, developmental, period for the Bachelor of Engineering program at Central Queensland University has resulted in a unique program. The program has emerged from a traditional standardised format to an innovative program formally incorporating three philosophies. Project based learning, professional practice development and co-operative education are combined in an engineering program that is believed to be a world first. The result is the dual award program Bachelor of Engineering (Co-operative Education)/Diploma of Professional Practice(Engineering). The program is expected to produce world class professional engineers that are industry ready and highly sought after.

It is well recognised that co-operative education, even if only simply exposure in a work environment, is capable of informing, or even to some extent, enhancing the development of a graduate's generic skills. However, incorporating and integrating project based learning and explicit professional practice skills development, enables a significant integration, broadening, deepening, retention and internalisation of professional generic and technical knowledge, skills and attitudes. This is through identifiable preparation for, application in, and considered reflection of, learning experiences.

CQU has developed an integrated Bachelor of Engineering program, incorporating project based learning, co-operative education and specific development and recognition of professional practice skills. Along with the support of IT innovations, this program is believed to be unique in the world with its interpretation and combination of these learning paradigms. It has taken fifteen years of development within the university to reach this stage with parallel developments nationally and internationally informing and shaping its structure. Whilst a significant achievement in its own right, the program as it now stands, should be considered but a staged step in the engineering program's development continuum. As information technology innovations develop, the program is poised to take advantage of any developments to improve the opportunities for it's students.

References

Boeing Company and Rensselaer Polytechnic Institute 1997, *'A manifesto for global engineering education'*, Summary Report of the Engineering Futures Conference. January 22 – 23

Crofton, F. 1998, *'Sustainable development and engineering'*, Keynote Address at the Waves of Change: 10th Australasian Conference on Engineering Education, 28 – 30 September, 1998, Gladstone

Edwards R., & Jancauskas E. 1997, *Using Distance Education During Industry Work Placements To Develop Lifelong Learning Skills,* Conference Proceedings of the 10th World Conference on Co-operative Education Cape Town, South Africa p 78-84

Engineers Australia, 2004, *Accreditation Management System – Education Programs at the level of Professional Engineer*, Engineers Australia, Canberra, Australia PO2 p3

Howard R.P., Jorgensen D.O., & Toft, Y.M., 2000 *Using PBL to Develop Multidiscipline Teams* Paper presented at 2nd Asia Pacific Conference on Problem Based Learning, Singapore

IEAust, 1996, *Changing the Culture: Engineering Education into the Future*, Institution of Engineers, Australia, Canberra, Australia

JGFE 1993, *Course Proposal: Bachelor of Engineering, Co-operative Program,* James Goldston Faculty of Engineering, University of Central Queensland, Rockhampton Queensland Australia p5

JGFE 1997 *Course Proposal - BE 2001: Changing the Culture A Restructured Bachelor of Engineering Degree* James Goldston Faculty of Engineering, Central Queensland University, Rockhampton Australia

JGFEPS 2004a *Business Plan - Diploma of Professional Practice,* James Goldston Faculty of Engineering and Physical Systems, Central Queensland University, Rockhampton, Australia

Jancauskas E., & Edwards R. 1997, *Using Distance Education During Industry Work Placements To Develop Lifelong Learning Skills,* Conference Proceedings of the 10th World Conference on Co-operative Education Cape Town South Africa p159-164

Jorgensen D., Howard P. 2001, *A Professional Engineering Practitioner Learning Paradigm,* Proceedings of the 12th Annual Convention and Conference of the Australasian Association for Engineering Education, AAEE 2001 Queensland University of Technology, Brisbane, Australia, September 2001 p169-174

Jorgensen D.O., Howard R.P. 2000, *Project Based Learning – A Professional Engineering Practitioner Learning Paradigm* Paper presented at 2nd Asia-Pacific Problem Based learning Conference Singapore

Kjersdam, F., Enemark, S., 1994, *The Aalborg Experiment – Project Innovation in University Education*, Aalborg University Press, Denmark

Letho S., 1995, *New Solution for World Engineering Education in the 1990's – Towards an Efficient Learning Process by means of Integrated Learning Projects,* Fourth World Conference on Engineering education, Saint Paul, Minnesota, USA

Ostergaard J. 1989, *Experience with Project Based Problem Centred Engineering Education,* World Conference on Engineering Education for Advancing Technology, Sydney, Australia p730-732

Pavelich, M.J., Olds, B.M. & Miller, R.L., 1995, *Real World Problem Solving in Freshman-Sophomore Engineering*, New Directions for Teaching and Learning, No 61, Spring, p45-54

Quinn R., 1993, *Drexel's Experiment takes Hold,* ASEE Prism, December p14-15

Thom, D. (1998), *'Engineering education and the new industrial revolution'*, International Journal of Engineering Education, 14 (2). p89 – 94

Wolfs P.J., Howard P., Vann A., Edwards R., 1997, *Balancing project based and lecture centric education in a restructured engineering degree,* Proceedings of 9th Annual AAEE Convention and Conference, Ballarat, Australia, p260-264

Woods, D.R., 1994, *Problem Based Learning – How to Gain the Most from PBL,* Griffin Printing Ltd, Hamilton, Canada