UTS ENGINEERING INTERNSHIPS: A MODEL FOR ACTIVE WORK PLACE LEARNING

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Abstract *¾ This paper describes Engineering Internships, an innovative approach to work based education developed in the Faculty of Engineering at the University of Technology, Sydney (UTS). Each of the two Engineering Internships which students in the UTS program undertake comprises: a preparatory academic subject; a six month period of engineering experience; and an academic subject in which they review and reflect on their experience. The Faculty worked closely with the Institution of Engineers Australia and with an Industry Advisory Network of senior executives from local and international engineering organisations to develop the new model. It emphasises structured learning processes designed to support students in becoming active life-long learners. Recognition of student achievement is by a new Diploma of Engineering Practice. The paper locates the Engineering Internship program in the international, national and institutional context. It includes a perspective from an industry leader and excerpts from reflections prepared by students during the review process - excerpts that show the richness of Internships as learning processes.*

Index Terms ¾ ABET, cooperative education, Diploma of Engineering Practice, engineering education, Engineering Internships, Industry Advisory Network, Institution of Engineers Australia, National Competency Standards, reflective practice.

THE AUSTRALIAN CONTEXT

All Australian engineering undergraduate degree programs are accredited by our professional association, the Institution of Engineers, Australia (IEAust), the Australian signatory to the Washington Accord [which provides for mutual international recognition of engineering degrees]. The commonest Australian route to full professional status as an engineer has been a four year full-time engineering-science-focused degree, including a minimal period of work exposure (12 weeks), followed by three to five years practice in the workplace. The degree meets the requirements for Stage 1 or 'graduate' competency. The workplace experience is intended to provide the additional professional formation required for recognition as a Stage 2 or 'experienced' engineer.

The IEAust traditionally relied mainly on specification of educational process [prescribing various types and durations of subject offerings] as the main basis for accreditation. However, there was a major national Review of Engineering Education in Australia in 1994-96 [1]. As a direct result of that review the IEAust moved towards specifying graduate outcome requirements for program accreditation. The IEAust had reservations about relying solely on outcomes without any specification of the educational process that was intended to deliver them so, like ABET in the USA, it adopted a hydrid approach and continues to insist on some basic process requirements [2]. As the discussion below illustrates, the IEAust also applies this hybrid approach to recognition as 'experienced' engineer.

The IEAust provides learned society coverage for all areas of engineering in Australia, although its strongest focus is in civil and to a lesser extent mechanical and manufacturing engineering. Many graduates in the newer areas of electronics and computer-oriented technology see the UK-based Institution of Electrical Engineers (IEE) or the USA-based Institute of Electrical and Electronic Engineers (IEEE) as more relevant to their needs. This issue is so significant that the IEAust has negotiated formal agreements for mutual recognition of qualifications with the IEE and IEEE.

National Generic Competency Standards

During the late 1980s and early 1990s, many skilled migrants came to Australia from non-English speaking countries. In order to assess their often unfamiliar qualifications properly, the Australian Government supported the development of National Generic Competency Standards in a wide range of areas, including engineering. The engineering standards were developed by the IEAust in a process that included extensive consultation. Their relevance is increasingly accepted across the profession. The four year full-time equivalent degree, plus a minimum of three years of suitable experience, provides the experience base for recognition as a Stage 2 or 'experienced' engineer. Confirmation of Stage 2 status by the IEAust now requires successful completion of a process involving an Engineering Practice Report, framed in terms of the Competency Standards, followed by a Professional Interview. Stage 2

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status allows use of the postnominal 'CPEng' (Chartered Professional Engineer) [3].

Many educators around the world have an ongoing concern as to the appropriateness of a competency model for assessment of activity at a professional level. Certainly the original formulation of many of the National Standards left something to be desired, partly because of their strong bias towards the requirements of civil engineering. However, after a major revision that included the incorporation of significant systems content, in our view the model is now broad enough to provide valuable guidance for professional engineering development.

Stage 2 Competency Standards

The National Generic Competency Standards for Stage 2 Professional Engineers use a hierarchical structure. *Units* cover broad areas of professional performance; they are divided into *Elements* which describe what is done in the workplace within a Unit. Elements are further divided into *Performance Criteria* describing outcomes which can be assessed. There are three Compulsory Units and five Elective Units (as indicated below, two of the elective units include a pair of alternatives). Competency in written and oral communication, and the candidate's practical understanding of professional ethics, are assessed indirectly, through the evaluation process.

The three directly assessed *Compulsory Units* are:

- Engineering Practice;
- Engineering Planning and Design; and
- Self-Management in the Engineering Workplace.

The *Elective Units* are:

- Engineering Business Management OR Engineering Project Management;
- Engineering Operations;
- Materials/Components/Systems;
- Environmental Management OR Investigation and Reporting; and
- Research, Development and Commercialisation.

Each Unit is made up of from five to eight Elements, and each Element is in turn made up of between two and ten Performance Criteria. To be credited with an Element it is necessary to satisfy a majority of the Performance Criteria. Range Statements and Evidence Guides are provided to help candidates assess and demonstrate the expected level of performance. To be successful in the process, candidates are required to address all the Elements in the three compulsory Units, and be credited with at least twenty-seven Elements.

The assessment process involves candidates completing a series of Career Episode Reports, each typically around 500 words and describing a 'project' undertaken over a work period of around four months. Each Report spells out the work situation, the task involved, the candidate's role, what they did, and the outcomes of their efforts. The Reports are written in the first person, with the focus on what candidates themselves did. The rule of thumb used is that the process of going from graduate with minimal experience of professional practice, to experienced engineer, should take a minimum of three years, so each Report of four effective months of work can reasonably demonstrate that a candidate meets another three Elements. Each Report is normally signed off by the candidate's supervisor, who should preferably be a professional engineer. Once Reports demonstrating twenty-seven Elements have been completed, they are assembled and submitted as the Engineering Practice Report. Candidates then apply for a Professional Interview to confirm that they meet the requirements. This one hour Interview, essentially a peer review of the competencies claimed, is conducted by an experienced Assessor from the IEAust, assisted by two professionals from the candidate's field of professional practice [3].

THE INSTITUTIONAL CONTEXT

The undergraduate program in the Faculty of Engineering at the University of Technology, Sydney (UTS) has been fully cooperative since its establishment in the 1960s. With around 2500 students, it is the largest such program in the Southern Hemisphere, and the second largest in the world. The cooperative education program is seen as a three-way developmental partnership between students, academic staff and experience providers. The requirement for significant engineering experience has always been an important part of the UTS program, indeed the original model saw students alternating between semesters of work and semesters of study, and completing at least 144 weeks (three years) of engineering experience [4].

Following a comprehensive review in 1996, the UTS Engineering Faculty decided to restructure, moving from a School (or Department) based model to a matrix organisation. A systems model was used to completely redesign the undergraduate program. In a approach that significantly anticipated the findings of the national Review of Enginering Education mentioned earlier, the engineering practice focus was strengthened and a great deal of effort was put into building a more integrated program that did justice to the social as well as the technical aspects of engineering practice [5,6].

Work based learning is an essential aspect of the developmental process that allows aspiring professional engineers to become part of their professional communities of practice. Academic staff in the Education and Engineering Faculties at UTS have a long history of action research aimed at enriching students' experience in the workplace, including participation in industry-based projects [7]. During the program redesign process it was agreed that if students were given additional academic support for the learning that took place during their periods of engineering experience, the minimum experience period could be significantly

reduced. It was also agreed that an specific additional qualification should be introduced to give formal recognition of the learning involved.

After they graduate, students will need to take personal responsibility for their ongoing professional development. Some initial familiarity with and awareness of the possibilities of work based learning can help students and graduates to make the most of the opportunities that arise and to take control of their learning, if necessary generating their own opportunities.

The Diploma of Engineering Practice (DipEngPrac)

The Faculty has many years of experience of exploring and contextualising engineering practice at both an Australian and a global level [8,9]. At UTS we have now moved away from a model of student work experience seen in terms of exposure, and towards one which is conceptualised as a structured learning process which will help to prepare students to be active and reflective life-long learners. In terms of certification to reflect these changes, we have adopted a two level Engineering Internship model, leading to a Diploma of Engineering Practice (abbreviated as DipEngPrac and awarded in addition to the basic degree, but not separately). At each of the two levels there is a three-part cycle, made up of a 'Preview' subject, a minimum of 22 weeks of Engineering Experience, and a 'Review' subject.

The 'Preview' subject is designed to help students to prepare themselves for the experience and to encourage them to be active learners during it. An important challenge is getting them to think about what they want to learn, and where and how they might be able to learn it. A well-received exercise in the first level Preview subject is for small groups of students to arrange to interview an engineer in his or her place of work. The interview focus is on what they might expect and what they might learn in their first formal experience of work based learning. Each student writes an individual report on the interview and each group gives a brief presentation to the tutorial class. Students commonly express surprise at the extent to which the engineers they interview emphasise the importance of practice skills like communication and teamwork.

We believe that significant engineering experience during the undergraduate program can help to take students beyond a concentration on engineering science and open up the practice dimension of engineering. As one student commented recently: 'It makes you think differently about engineering – there's not just one aspect, analysis, but a whole range of processes.' Student feedback at UTS after the first six month period of engineering practice highlights the extent to which their experience differed from their expectations. For this reason we commonly ask a few of the Review students to make presentations about their experience to the next Preview group, and this input is clearly valued.

Students report that engineering experience, integrated with their undergraduate academic program, can provide very significant motivation. It helps them to direct their studies towards areas they discover to be of particular interest. Their greater maturity and focus, and the experience returning students bring from the workplace, are the basis for a more collegial atmosphere in the classroom, which makes teaching more effective and rewarding.

At the senior level, as well as a series of exercises designed to encourage students to think about the opportunities and options offered by their next engineering experience period, Preview students enjoy a series of high-level presentations on:

- National Competency Standards (as discussed above), presented by a representative of the IEAust;
- Industrial relations, presented by a representative of the professional union, APESMA (Association of Professional Engineers, Scientists and Managers);
- Presenting oneself professionally, presented by one or two of our graduates who specialise in professional placements; and
- The engineering profession, presented by a senior engineer, usually drawn from the Faculty's Industrial Advisory Network (made up of senior industry representatives).

Students are supported in applying for work, but it is their responsibility to find suitable experience. While they are in the engineering workplace they enrol in a zero load (and therefore zero fee) 'Engineering Experience' subject to hold their place in the University system. The experience normally involves paid employment in a regular job where students can use the knowledge and skills they have developed so far.

Our feedback is that students are good value for employers – bright, interested, with strong, up-to-date IT skills and keen to learn, and their attitudes are commonly appreciated and respected. Many students take the opportunity to work overseas, some are self-employed. Some do volunteer work in developing countries. The structured and active approach that students are encouraged to take means that even potentially unsatisfactory positions can often be turned into effective experience, provided the students can recognise the learning opportunities and seize them.

Each Engineering Internship stage closes with a 'Review' subject. Students write an assessment of their experience, organised under specified headings. These reports are marked by an academic and the students then share their experiences in a small tutorial group. In the first review subject, in classes of ten to sixteen, pairs of students exchange their reports and interview each other, then tell the rest of the group about their partner's experience.

In the senior subject, the review is based on a reflection on key highlights of their experience so far, plus a collection of Career Episode Reports based broadly on the IEAust model described above. This gives students an introduction to the IEAust Stage 2 process, without their necessarily

following it to the letter. The review presentations at this level are commonly given in groups of six to ten, and the sharing of experience and discussion of the associated learning makes this a very rich and stimulating subject for the academic staff and the students involved. Student membership of the IEAust is free, and students can join the IEAust and submit Career Episode Reports for assessment as they complete them.

UTS is moving towards more on-line support for teaching and learning. Through 'UTSOnline', every subject now has a web site where resources can be provided and announcements posted. It uses a proprietry interface provided by Blackboard Inc (www.blackboard.com). Out-of-class contact with students is generally by email or through the two Faculty Learning and Design Centres (LDCs), around which tutorial support is organised. Every academic is rostered for one or two hours in an LDC during each teaching week.

The UTS enthusiasm for a competency approach for Stage 2 reflects the needs of our students. Our current students typically have around eighteen months of engineering experience when they graduate, with a range from a minimum of one year to a maximum of ten years or more. Until the IEAust introduced the competency model, the most recognition our students could get was for one of the three years of experience that are the expected minimum for Stage 2 recognition.

Benchmarking the Engineering Internship process

When we introduced the Diploma of Engineering Practice, and the Internship process that underpins it, we went through a benchmarking process with the IEAust. The IEAust's most senior reviewer worked closely with one of the authors to set up interviews for a total of 98 students. Of these, 25 were told that their performance was at a level where they were eligible for corporate membership, immediately they graduated. Another 50 were advised that they already met a significant number of the competencies. On their graduation day, the members of these two groups were handed letters from the IEAust confirming their status. The remaining students failed to demonstrate any professional competencies. The process made them sharply aware of their need to adopt a much more active and critical role in managing their experience. As this last group of students demonstrated, unmoderated and unsupported student exposure to the work place, in positions with minimal responsibility and authority, can a very mixed blessing. Students can learn to react to situations, rather than anticipating and taking control of them.

The benchmarking process highlighted the importance of encouraging students to become active learners and to take control of their own development. There was always a concern that some of our graduates from the old program, while certainly 'work ready', were perhaps too biddable, too ready to accept the situations in which they found themselves, and insufficiently aware of their need for continuing professional and personal development.

Something of the same problem can arise with the around 20% of UTS students who come into the engineering degree program with significant work experience at a trade or para-professional level. This experience can provide a solid foundation that valuably underpins their future academic and professional work, but only if they can change their view of themselves. A key challenge for us is to support them in making the substantial attitudinal changes associated with seeing themselves as professionals and with taking deliberate control of their own professional development.

AN INDUSTRY PERSPECTIVE

The value to local industry of the UTS Internship program is widely recognised. This is demonstrated by the large number and diversity of employers who repeatedly employ the students during the engineering experience periods and in the years following graduation. The commitment to the program by employers is shown by the fact that a number of senior executives have been prepared to put a good deal of their own time into the Industry Advisory Network and to developing a range of initiatives associated with the program.

The UTS program provides employers with an understanding of student needs, their aspirations and their ability to fit into particular working environments. The opportunity presented in the senior Preview subject for senior professional engineers to reflect on their own experience with a group of senior students is particularly beneficial and challenging. The UTS program, including its Engineering Internships, gives these students an advantage in the graduate development programs in many organisations. It also helps us to meet the demand for new types of engineering professionals who have reflected on their roles and responsibilities in society and are well prepared to communicate effectively with the community.

A new type of practice paradigm is emerging, in which projects are to an increasing extent defined through consultation with the community and a broad range of other stakeholders. To make this paradigm work we need professional engineers who can listen, recognise the validity of community concerns, views and requirements, and are able to set up a genuine dialogue. This represents a substantial change from professionals who saw themselves as the only legitimate authorities, or were not capable, or in some cases not permitted, to take into account the requirements of other stakeholders. We recognise the important contribution that the UTS style of program can make to the changing profession.

SOME STUDENT PERSPECTIVES

The new emphasis on student-focussed learning processes within the workplace has been strongly endorsed by the

students. Although the students have always considered the engineering experience itself to be a valuable component of their education, we have often been conscious that unreflective workplace experiences could and did lead to unquestioning acceptance of sometime questionable workplace norms.

The new UTS Engineering Internship expectation of visible planning for, and reflection on, workplace experiences has led to different outcomes for students. The sophistication of students' analysis of workplace experiences has greatly increased and they are aware of this increased capability for analysis. Some examples of students' reflections from the most recent Senior Review subject (March 2001) are as follows:

Understanding engineering practice: 'I can truly say that my experience was invaluable...I believe that the communcation and behavioural skills I learnt at work are things I would never have learnt at University. I feel that I am equipped to acquire technical knowledge with ease due to my university background. Yet being an engineer demands skills far beyond that and I've taken it upon myself to learn those skills in order to be a better engineer.'

Long term career planning: 'I believe this experience has set me in the right direction for achieving professional status at a later date. I now understand the requirements for professional status and therefore will look for work that fits the criteria more closely and also meets my personal needs.'

Personal responsibility for professional development: 'My superiors didn't always provide feedback and I incorrectly assumed that meant that everything was progressing as it should. I realised that if I didn't receive feedback then I should ask for it to improve my performance. I plan to improve on all the mentioned points in my next engineering experience by treating the last experience as a great learning opportunity.'

Understanding workplace culture: 'I found that all of my colleagues were always sharing the workload and not leaving anything for someone else to do, even though no one was checked for the amount of work that they completed. This sort of attitude, especially from my supervisor, was a very good example for everyone else to follow. I ... realised that it makes the day more enjoyable when the atmosphere is free of tension.'

Using the UTS Engineering Internship to support the workplace experience: 'In this respect having a learning proposal there, with objectives clearly written down, helped me a great deal. It provided focus at times when not many things seemed to be stable. It enabled me to push on through my job requirements but with a different approach to what I had previously had. I wasn't just trying to get a job done to meet a deadline, I was trying to get the jobs done properly, with an engineering approach and hopefully with some learning involved.'

CONCLUSION

The benchmarking process carried out in cooperation with the IEAust highlighted two issues: the need to encourage students to be active learners, seeking out opportunities and making the most of them, and the need to support structured reflection on their experience. The UTS Engineering Internship model is designed to respond to these needs through the formal academic Preview subject which precedes each period of Engineering Experience, and the Review subject which follows it.

Although our experience so far is extremely encouraging, we are still in the process of making the transition to the new degree program. The undergraduate programs designed to include the Diploma of Engineering Practice only started in 1998, so the first graduates of the new programs will not finish until the end of 2002. The academic subjects in the Internship program are also still being fine-tuned. Until we do more detailed testing and analysis we obviously cannot draw definitive conclusions. Even so, the feedback we are getting from students and employers is increasingly positive, and we are confident that the UTS Engineering Internship will continue to develop as a worthy model of work based learning.

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