Global J. of Engng. Educ., Vol.9, No.1
Published in Australia

From Graduate to Professional Engineer in a Knowledge Organisation: Does the Undergraduate Curriculum Provide the Basic Skills?*

George R. Burns
Department of Educational Studies, Glasgow University
20 Western Court, Glasgow G12 8SQ, Scotland, United Kingdom
Colin U. Chisholm
School of Engineering, Science and Design, Glasgow Caledonian University
Cowcaddens Road, Glasgow G4 0BA, Scotland, United Kingdom

Knowledge is recognised as a key element of organisational value. Some organisational models have been proposed in which the core headcount is concerned with the ability of the organisation to make effective use of its knowledge resources. The graduate Engineer has satisfied the academic standards of the appropriate institution for Chartered Engineer membership. The transition from graduate to professional engineer is marked by the development of skills that rely on the ability to integrate engineering knowledge with other skills, such as judgement, ethics, people skills and personal development. Two issues arise from these observations, namely that employers are looking for knowledge skills in addition to engineering knowledge, and professional development to meet standards for chartered engineer will be consistent with the knowledge focus of the organisation. In this article, the authors suggest that these two issues pose fundamental questions concerning the basic skills gained as undergraduates and how they influence employability and professional development. Further consideration is given to how curricular change might address these issues.

INTRODUCTION

Attaining the status of Chartered Engineer requires a practicing engineer to have obtained a first degree in engineering that has been approved by the appropriate engineering institution as meeting their academic requirements [1]. In addition to this evidence, it is required that it includes a period of practice to a satisfactory standard. A typical undergraduate programme will span three or four years of formal education, leading to the award of a degree that has been validated, ie meets the educational standards of a particular engineering institution.

Historically, this training in explicit knowledge was considered to provide the basis from which professional practice could then be undertaken. The emergence of knowledge and the ability of workers to be effective in their use of knowledge is now considered a key factor in the ability of an organisation to maintain a competitive advantage. Many organisations now recognise this and reflect these skills in their recruitment processes.

EDUCATION PROCESS

The education process or learning experience of students varies from one discipline to another but the objective is broadly to prepare them for their chosen career. The learning process or experience is usually described in terms of the mechanisms that are employed as part of the process, and these are usually lectures, tutorials, laboratories, etc.

In this mode, the learner is isolated with individuals, relying on the content of the material delivered to create ideas within his/her own mind. Ideas, concepts

*A revised and expanded version of a Keynote Address presented at the 8th *UICEE Annual Conference on Engineering Education*, held in Kingston, Jamaica, from 7 to 11 February 2005. This paper was awarded the UICEE bronze award (joint fifth grade with one other paper) by popular vote of Seminar participants for the most significant contribution to the field of engineering education.

and propositions form the content, and the internalisation of this material is demonstrated by the student being able to solve discipline related problems that rely on this knowledge.

This view is entirely consistent with the classical Greek notion of education and reinforced by Descartes. In line with this thinking is the idea that the mind is an individual property and, through acquiring knowledge, the mind is changed and, therefore, the individual is also changed. Thus, in the case of an approved engineering programme, the process delivers the *right* knowledge, that is knowledge considered essential so that the mind is appropriately equipped for its ultimate function of professional practice.

The demonstration of mastery of this knowledge is through formal examinations, presentations and oral examinations. The process outlined here is that followed by most institutions of higher education and certainly has an influence in many other forms of education practice. Ideas are supreme and stocking the mind of the individual with appropriate ideas is central to the practice of the process [2].

Assumptions and Consequences

Underlying this process are some assumptions related to the explicit nature of the knowledge being delivered, namely:

- Best learning resides in individual minds;
- Best learning is propositional (true/false; more certain, less certain);
- Best learning can be expressed formally and written down in books;
- The acquisition of best learning alters minds;
- Such learning via bodies can alter the external world.

Some consequences of these assumptions are as follows:

- Student selection is based on performance in written tests based on propositional knowledge;
- The curriculum is based on propositional knowledge reflecting disciplines;
- Non-propositional learning is driven by propositional knowledge, eg laboratory classes used to reinforce propositional knowledge;
- Teaching is based on lectures/tutorials, etc;
- Assessment is based on students demonstrating learning by reproducing answers verbally, or responding by written means, to questions that require the use of propositional learning, either singly or in combinations;
- Numbers or grades are used to demonstrate the amount of learning.

This set of assumptions and consequences are mutually reinforcing in that the selection of students pre-determines their aptitude for this type of learning. Also, the process reinforces the learning of propositional knowledge and their skills in this form of learning.

This brief picture of learning as a process bears many resemblances to that described by Gibbons as mode1 or traditional education, and is most commonly the mode for instruction in engineering programmes [3].

Learning Environments

Over the past decade, new learning environments have developed and, in particular, Work-Based Learning (WBL) environments have shown progressive growth as an alternative environment for the education of engineers [4]. Alongside, technology has provided Web-based learning, which also has the focus of being an off-campus learning environment.

Within each learning environment, there are a number of factors that need to be considered as to the relevance of the learning environment in providing for the achievement of the required outcomes of a given programme. For example, it seems unlikely that a work-based environment will underpin and sustain the study of the fundamentals of engineering for students at the beginning of their programmes. Alternatively, it is questionable if the knowledge-based skills related to output competence within a programme can be best achieved in an on-campus, classroom-based environment, where little correlation can be developed to a *real world* situation. In this case, a Work-Based Learning environment would underpin this type of requirement.

With a number of learning environments available, with each capable of supporting different forms of learning, consideration needs to be given as to what environment or environments can be used most effectively for undergraduate, postgraduate and post-experience learning.

The same critical consideration needs to be given to modes of learning. A part-time programme may achieve outcomes in quite a different way from a full-time programme. Thus, learning environments need to be considered carefully in terms of the learning that can be supported in each individual environment, as well as the factors within each environment that need to be considered in relation to desired programme outputs.

PROFESSIONAL DEVELOPMENT

In following this thinking, it would appear that all knowledge of any value starts as theoretical and may eventually become practice. Professional development is a complex issue, but most writers, Eraut for example, agree that experience from actual situations is an essential ingredient to developing professional skills [5]. Experience is the opportunity to use propositional knowledge in real situations so as to develop real solutions. Thus, a simple notion of practice is one in which propositional knowledge and experience come together to enable the practitioner to identify a problem, and then formulate a solution. The development of this ability is not based solely on propositional knowledge or simply the addition of some experiential knowledge driven by an essential propositional requirement. Thus, the question forms: what constitutes a preparation for practice?

The preparation for practice of students in other professional groups is undertaken in different ways, depending on the profession. Two groups, teachers and nurses, adopt a process whereby academic development and professional development are part of the undergraduate training. Student teachers spend a proportion of their time in the classroom, teaching children. Nurses spend a significant proportion of their undergraduate programme on wards in hospitals nursing. In each of these professions, satisfactory performance of the professional activity is a required part of the programme before graduation.

Perhaps the most significant difference between these groups and engineers lies in presenting students with the reality of practice. Students have to come to terms with the reality that not all situations fit neatly into the boxes that theory establishes and that they are required to develop solutions based on theory but which address a specific problem. In employing this approach, these professional groups are actively developing the link between propositional knowledge and experience to equip graduates with a basic professional competence before they enter practice. It may be argued that these professions have always used these approaches, but this does not mean that they do not have value for other communities of practice.

The Case for Engineering

Engineering as a profession is largely concerned with economic development in one form or another. What has changed so that employers of engineers are looking for skills beyond the academic performance of obtaining a degree? Perhaps a clue to this might be found in considering the impact of the knowledge revolution on national economies [6][7]. It is self evident that, in today's world, economic survival is about maintaining a competitive advantage in a marketplace that is fast changing and knowledge driven.

A common theme of economic management is the need to be competitive through having a smarter workforce who work smarter and produce goods more cheaply than the competition [8][9]. At the same time, organisations have been assessing the value of their knowledge. Many papers, books and articles have been written about the development of organisational knowledge, all emphasising the importance of understanding its nature, generation, capture and eventual codification [10][11]. Much of the literature on this recognises that not all organisational knowledge can be written down. A not entirely apocryphal story illustrates this:

> *An engineer retires and the company call him back to investigate a problem. He returns to the plant and, after a short time, places a cross at a particular point on a machine casing and advises hitting that point with a hammer. His bill of £5000 is questioned by the plant authorities and he responds by saying £500 is for the time spent on the job £4500 is for having the knowledge to know where to place the cross.*

This is really an elegant demonstration of the difference between purely propositional knowledge and practice knowledge, which has evolved as a result of experience.

As organisations began to understand this difference and the value it represents, they identified different employment criteria for core staff. The skill set sought from today's graduates involves attributes that go beyond simply the possession of a degree. Attributes include the following:

- The ability to appreciate that knowledge is an ever-expanding domain and personal knowledge is an ever-changing domain;
- The importance of working in teams with colleagues from other disciplines;
- Understanding the significance of their propositional knowledge in relation to solving a particular problem.

The traditional education process briefly described earlier conceives education and knowledge in terms of explicit knowledge, as well as a skill set to support the acquisition, storage and application of such knowledge.

Polanyi has suggested that the difference between knowing *what* and knowing *how* is related to experience [12]. Know what describes the explicit knowledge that a traditional education process provides. Know how describes the ability to actually generate and implement a solution, a skill that relies on having the ability to relate know what and the problem to generate know how.

In the 20th Century, know what was about using the means of production, machinery and resources to generate products and hence income. In the 21st Century, know what is in itself of limited value, since it is not the means of production that are rapidly changing, but rather the knowledge upon which they are based. In this post-modern situation know how has to be supported by know what that is current, so that a solution makes use of the most recent knowledge. In terms of the new graduate, this is a sometimes bewildering situation when their know what may already be out of date and they have yet to develop the know how. In some senses, this represents the basic dichotomy between the traditional education system preparation for engineering practice and the perceived skills requirements of a 21st Century economy labour market.

DEVELOPING PROFESSIONAL PRACTICE

In the UK, recognition as a professional engineer is regulated by engineering institutions and the Engineering Council. Essentially, graduate engineers have to demonstrate that they have met the criteria set by the Engineering Council in relation to professional practice. In order to achieve this, a minimum time of two years is usually required. The examples of teaching and nursing noted earlier illustrate how two professional groups have addressed the issue of incorporating practice and academic development; would such arrangements be possible and beneficial for engineering?

It has been suggested that experience is the catalyst in developing the ability to recognise problems and implement solutions, ie professional practice. Organisations are seeking to recruit graduates who can demonstrate the ability to recognise and solve problems without the need for long training periods. Looking at these two statements, it seems clear that the opportunity to develop these skills would achieve the following:

- Provide graduate engineers with the skills appropriate to modern practice;
- Enhance engineering graduates' employability in a modern 21st Century labour market.

Having recognised the problem, is a solution available? Some options include the following:

- Change the curriculum;
- Recognise skills derived from part-time employment;
- Devise alternative degree structures.

Current Curriculum

The current curriculum requirements for undergraduate programmes in engineering are heavily biased towards traditional educational processes. A major influence on curriculum content is that provided by accrediting institutions; thus, any change to accommodate practice would need their approval. Two issues are involved in this, namely:

- A recognition that some reduction in actual propositional knowledge does not invalidate the academic content;
- The inclusion of practice is a recognition of 21st Century employability trends.

In order to incorporate practice, a number of obvious difficulties arise, such as:

- The opportunity for practice (nurses and teachers have a clear resource for this);
- A change in the structure awards to recognise the successful completion of practice.

UNDERGRADUATE LEARNING ENVIRONMENTS

Work-Based Learning (WBL) environments support the mode 2 approach to educating engineers, wherein learning is driven through an environment that is transdisciplinary [2][13]. Fundamental to this is the availability of tacit knowledge and its integration with explicit or codified knowledge. However, what is probably not available are learning environments that facilitate the teaching of the fundamentals of engineering needed within an undergraduate programme. While a typical environment might facilitate the understanding of a few fundamentals, it is highly unlikely to provide the ideal environment. Thus, it can be concluded that a work-based environment is not the optimum learning environment for the early years of undergraduate programmes, where the main outputs are associated with establishing the fundamentals of engineering and the required mathematics.

However, other aspects of the programme could be suitably developed using a workplace learning environment, where the student could be introduced to experience-led learning as opposed to instruction-led learning. Introducing the student to the two different learning environments at the start of a programme will facilitate the student developing a balanced view of the validity of the environments. Many programmes contain professional development planning that involves the development of a range of practical and personal skills, which could be developed through a Work-Based Learning (WBL) environment more effectively.

Thus, for an undergraduate programme, a mixture of the on-campus learning environment with the WBL environment may provide the optimum balance. However, the combination of the environments can vary significantly – both at levels within a programme and across programmes overall. Placement in a WBL environment needs to consider how functional the environment will be to the necessary outcomes. While the on-campus environment is very much within the control of teachers and lecturers, the use of a WBL environment requires negotiation and agreement with the management in control of the workplace.

The workplace environment is not designed as a learning environment and to use it effectively means that educators need to work closely with the management of the workplace to specify and define what learning is required. Negotiation is essential and a constructivist approach needs to be taken with the desired outcomes clearly articulated to the supervisors, the managers of the workplace environment and the student.

Essential to success is the need to determine that the workplace chosen can provide a learning environment wherein the outcomes can be achieved. This means that a suitable WBL environment can only be achieved after discussion with the managers of the environment, and an inspection by supervisory academic staff; indeed, this aspect is critical regardless of whether a four-week period or a one-year period is used [14]. The intrinsic value of this environment is its transdisciplinary nature where outcomes can be effectively realised that would not otherwise be possible in the single discipline approach of the on-campus learning environment.

CHANGING THE PROCESS

The basic content of the programme is normally delivered by a series of blocks of study referred to as modules. These modules are arranged such that the progression leads to a named award. In the process of designing a curriculum of this type, the major knowledge element is normally explicit (see Figure 1). The

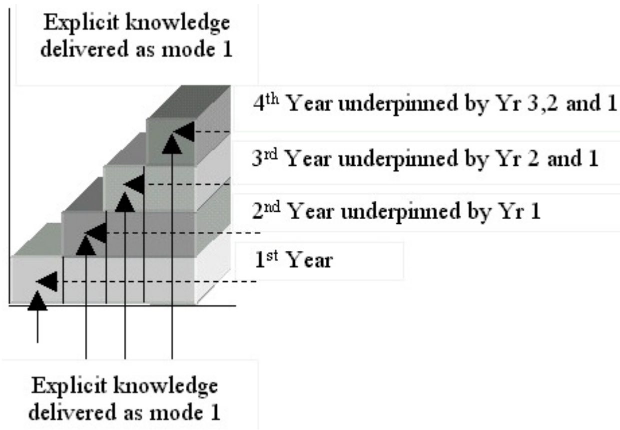

Figure 1: Explicit knowledge content in a curriculum.

knowledge base is provided by traditional means, as is assessment and qualification. Hills and Tedford summarise this as the professor being the *sage on the stage* [14].

One difficulty with this model is the amount of time that is spent on developing the knowledge base. Currently, engineering programmes at a Scottish university typically involve studying six modules or the equivalent per year for four years, involving a total of 24 modules or 480 credit points for the award of an honours degree. Using this model, it is mainly explicit knowledge that generates the credits.

The model in Figure 2 attempts to make provision for the development of knowledge skills as part of the undergraduate curriculum by providing space to devote to practice. A proportion of the student effort is devoted to practice. The impact on the curriculum in terms of mode 1 study can be assessed as follows. If the original model requires six modules, then reducing this by one has the impact reducing direct teaching by approximately 17% in any one year. Even a casual analysis of most curricula currently used by engineering

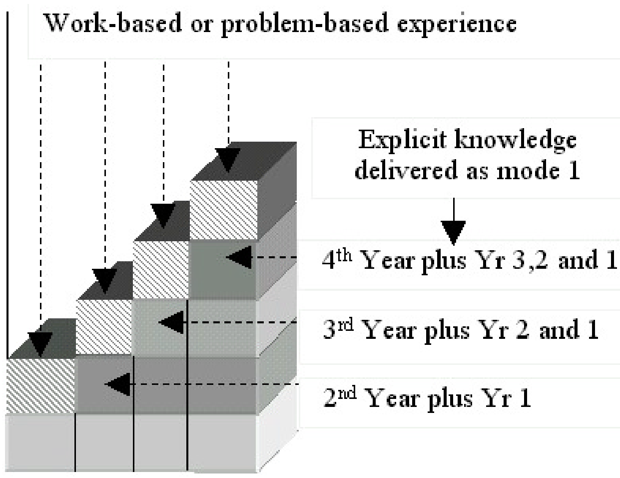

Figure 2: Incorporating knowledge skills in the curriculum.

programmes will show that the prerequisite modules for successive years of study do not address all modules in the succeeding year. In these circumstances, does the loss of one module create a serious reduction in the explicit knowledge base? On this basis, it might be more realistic to make provision for experience of engineering problems in the form of work-based placements [15][16]. Another option is a highly focused Problem-Based Learning (PBL) approach [17].

The model proposed in Figure 2 offers at least an option. However, it is dependant on engineering institutions accepting a reduction in propositional knowledge content.

ASSESSMENT ISSUES

What is critical for the assessment function is the capability of those assessing the outcomes in work-based environments. Some educators argue that only staff in the higher education establishment, which gives the final award, can undertake the assessment, while other published work claims that company staff can act as assessors, replacing or complementing the assessment by academic staff [13]. It can be argued that workplace supervisors and assessors would understand the outcomes more effectively than academics not familiar with the workplace. To date, this aspect remains unresolved, although this is already happening in some organisations with appropriate training for staff.

Critical consideration needs to be given to what assessment methods have transferability and applicability in the workplace learning environment. In order to be effective, methods need to be evaluated on the basis of validity, reliability, relevance and efficiency. Formative assessment techniques should transfer to the workplace and are an essential component, as often an engineering student may be studying in relative isolation. Summative assessment by traditional written examination paper has little transferability to the work-based environment and new, novel methods that are compatible with the environment need to be developed. Whatever processes and methods are decided to be suitable for this environment, they will need to include a summative element to authenticate student achievement in an environment that is less controlled than that on-campus.

Normally, high validity and high reliability go together when assessing simple, determinate outcomes; however, reliability is often achieved using essentially artificial techniques that correlate very poorly to life-like performances. The basic tenet of workplace learning is achievement in transdisciplinary environments and, on this basis, seeking high reliability is not liable to provide answers to summative assessment of Work-Based Learning (WBL). The workplace mode would necessarily have to be based on validity, so satisfying quality assurance processes, and the reliability element, not appropriate to this type of learning, will be reduced, ie because validity needs to be preserved, there are, consequently, higher reliability costs. In addition, what might be considered an *acceptable cost* might need to be investigated. Some difficult aspects need to be given consideration, since aspects of workplace learning may resist any form of reliable assessment and other aspects may be marginally reliably assessed, but only at a high cost.

The main problem in achieving credibility for the WBL environment is related to the high cost of acceptable reliability levels. To have successful recognition of workplace learning means to accept the reduction of reliability, but not of validity. However, while overall, the cost of reliable and valid assessment may be higher than in on-campus environments, the overall mode of workplace learning may be much less costly to operate. The case for continuous formative assessment is high in relation to the workplace environment. It is accepted that for conventional on-campus programmes, not all outcomes require to be summatively assessed. On this basis, formative assessment is an acceptable alternative for outcomes that are beyond the potential reach of reliable summative assessment. It is proposed that many of the outcomes and skills requirements should be formally assessed in a WBL nvironment.

This would integrate well with this form of learning where continuous feedback is desirable because of the off-campus environment. This approach will facilitate not only the negotiation of the leaning but will underpin moving students through their studies. For example, if the learner felt, at some point, that the judgement of the supervisor was in question, then dialogue could take place between the supervisor and student leading to resolution and, hopefully, a reduction in the concerns of the learner in relation to the formative assessment. Workplace learning will also lend itself to self-assessment as the engineering student has already negotiated their learning and should thus be motivated to give an accurate self-assessment. So the balance of summative to formative has to be shifted significantly towards the formative for workplace, but more research needs to be completed in order to identify suitable alternatives summative processes.

One way forward could be by using learning portfolios that would provide summative evidence of any outcomes achieved, based on continuous formative assessment. The off-campus workplace environment is more suited to an achievement of complex outcomes from transdisciplinary environments, rather than simply an examination of the ability to reprocess explicit knowledge in an examination script. So, most important for the student, will be collating evidence of achievement of agreed outcomes in a portfolio. In this respect, the tutorial concept will assume much greater importance, as the student will require validation of their judgements through formative oral sessions with tutors and peers. Claims for achievement of outcomes will need to be substantiated in the portfolio. There is also the potential for oral assessment. The nature of the learning and the off-campus environment supports the use of this, which could also be combined with the learning portfolio.

The proposed support model is thus one of maximising the formative process in the workplace integrated with a carefully evidenced learning portfolio related to the desired outcomes. The WBL environment is primarily about authenticity and corresponding complex learning outcomes in a real world environment and, as such, the assessment practices must reflect this regardless of the potential cost. This seems as realistic an approach as is possible in taking account of the essential need for valid assessments of the complex outcomes.

Such forms of assessment can be much more realistically sustained in the off-campus environment where students can negotiate when to deliver the evidence-based portfolio. The work-based environment should not have to be a system that obeys on-campus rules, such as semesters and set examination dates. Indeed, the value of this form of learning and the assessment depends on the workplace environments being regarded quite differently to that operating for conventional programmes.

Perhaps the main contribution to establishing relevant assessment will be convincing staff of the need for an approach that is supportive of learning in a workplace environment. Academics will need to be prepared for a mindset shift to think about and implement quality assurance and assessment in workplace environments. There is no need for the assessment methods to be overly complex, costly and/or time consuming, and staff should enjoy the challenge of new and novel methods operating in a new type of learning environment. What is important is that staff must be prepared to go beyond traditional assessment methods that relate to on-campus learning.

Recognition and Assessment Skills

The skills sought by employers are associated with work environments and many students undertake part-time work. If changes to curriculum are not possible, then recognising the skills that are developed as a result of part-time employment can, at least, provide a record of workplace skills, eg teamworking, adaptation to the work environment, etc. These skills are elements of practice.

A possible approach to this would be the inclusion of an optional module that would address workplace experience. Assessment of this would be though a reflective analysis on the experience enabling the student to demonstrate their learning. This would at least provide some evidence to potential employers of the student's basic workplace skills. This option has the merit (?) of not requiring changes in the curriculum, yet still enabling a demonstration of experience – albeit somewhat limited.

Finally, it must be emphasised that assessment should be a negotiated process with the student, thereby keeping harmony with the philosophy of workplace learning. This means students and tutors first detail a descriptor of what assessment is being put in place, and only then can effective and reliable processes be negotiated and agreed, as well as practices achieved to the required output standard in the environment. However, although feasible, for some time this approach will remain controversial, as it is novel and evidence-led. Awards deriving from Work-Based Learning are practice-based achievements in complex situations, rather than subject specific knowledge.

Other Degree Structures

Finally, if curricular change is not possible, then the reintroduction of degree structures that enable periods of industrial placement (so-called *sandwich* degrees) would achieve the same end. This type of programme does have two drawbacks: firstly, the availability of suitable placements and secondly, the additional time required to complete the degree programme. One modification that might alleviate the second issue would be the recognition of this practice towards the experience required for Chartered Engineer status.

SUMMARY

Current engineering programmes are presented in a very traditional mode and focus on explicit knowledge delivery. Modern skill demands have a profile that this type of programme in the learning environment of higher education institutions has difficulty in addressing adequately. Competence with explicit knowledge – or *know what* – is no longer sufficient, an element of *know how* is necessary. *Know how* is developed through experience, but current programme structures are poorly equipped to accommodate periods of practice; as such, engineering graduates lack many of the skills employers now consider essential in a knowledge-driven organisation. Engineering degree programmes are crowded and so making room for new developments is difficult, yet it would seem that there will be increasing pressure to do so. Other professional groups who would argue that their corpus of knowledge is no less have practice as part of the undergraduate preparation for practice.

A model of engineering programmes has been presented in this article that would reduce formal contact, or *know what* delivery, by 17% allowing this time to be utilised for experience-based learning. Such learning could be approved WBL or highly focused PBL. Either would encourage the integration of *know what* and *know how* features that employers would welcome. Alternatively, degree structures that involved placement in an organisation could be used. Previously, these were known as sandwich degrees. The major drawback with these is the extended time to graduate and thus gain paid employment, a problem made more acute in the UK by the introduction of additional fees. A third option suggests recognising that, through part-time employment, students do achieve some of the characteristics associated with practice.

Any of these processes would enable the recognition of a practice element in undergraduate engineering students' experiences, thus enhancing their skills profile and employability, and, ultimately, their progress to Chartered Engineer status.

REFERENCES

1. Engineering Council (UK), Standards and Routes to Registration (SARTOR). London: Engineering Council, UK (2004), http://www.engc.org.uk/
2. Beckett, D. and Hager, P., *Life Work and Learning: Practice in Postmodernity*. London: Routledge (2002).
3. Gibbons, M., Higher education relevance in the 21st Century. *Proc. UNESCO World Conf. on Higher Educ.*, Paris, France (1998).
4. Burns, G.R. and Marshall, I.H., Supporting postgraduate engineering education in South Africa through the learnership initiative and Work-Based Learning. *World Trans. on Engng. and Technology Educ.*, 3, **2**, 185-190 (2004).
5. Eraut, M., *Developing Professional Knowledge and Competence.* London: Taylor & Francis (1994).
6. Drucker, P., The age of social transformation. *The Atlantic Monthly*, November (1994).
7. Drucker, P., The next workforce. *The Economist*, 1 November (2001).
8. Brown, P., Green, A. and Lauder, H., *High Skills Globalization, Competitiveness, and Skill Formation*. Oxford: Oxford University Press (2001).
9. Department for Education and Skills, Skills: Getting On in Business, Getting On at Work. White Paper, London: Department for Education and Skills (2005).
10. McKenzie, J. and van Winkelen, C., *Understanding the Knowledgeable Organisation*. London: Thomson (2002).
11. Burton Jones, A., *Knowledge Capitalism*. Oxford: Oxford University Press (1999).
12. Polanyi, M., *The Tacit Dimension*. London: Routledge & Kegan Paul (1966).
13. Jacob, M. and Hellstrom, T. (Eds), The Future of Knowledge Production in the Academy. Society for Research into Higher Education (2000).
14. Robertson, C., *Work-Based Learning Contracts*. In: Stephenson, J. and Laycock, M. (Eds), Using Learning Contracts in Higher Education. London: Kogan Page (1993).
15. Hills, G. and Tedford, D., Innovation in engineering education: the uneasy relationship between science, technology and engineering. *Proc. 3rd Global Congress on Engng. Educ.*, Glasgow, Scotland, UK, 43-48 (2002).
16. Burns, G.R. and Chisholm, C.U., An assessment how Work-Based Learning methodologies may contribute to the development of engineering education in the 21st Century. *Proc. 6th UICEE Annual Conf. on Engng. Educ.*, Cairns, Australia, 29-33 (2003).
17. Burns, G.R. and Chisholm, C.U., The role of structured workplace learning studies for engineering undergraduate and postgraduate programmes. *Proc. 4th UICEE Annual Conf. on Engng. Educ*, Bangkok, Thailand, 191-195 (2001).
18. Savin-Baden, M., Facilitating Problem Based Learning. London: Society for Research into Higher Education (2003).

BIOGRAPHIES

George R. Burns has a first degree in Applied Physics from Strathclyde University and a Doctor of Philosophy from the Department of Electrical and Electronic Engineering at Strathclyde University gained for thesis-based research into low frequency conduction properties of insulating liquids. Since leaving University, he has followed a career in education starting by teaching physics and mathematics in high school, then physics in the Life Sciences Department of a local College. He left there to take up a lectureship at The Scottish School of Non-Destructive Testing (SSNDT) at Paisley University where he stayed for six years. During this period, his research interests were in computer data management systems. He left there to become senior lecturer in the Department of Engineering at Glasgow Caledonian University, where he continued with his research interests in computer-based data management and the use of artificial intelligence software (neural networks and genetic algorithms) to model business and manufacturing systems, as well as developing an interest in work based learning. During the same period, he was the University Project Manager responsible for establishing the Caledonian College of Engineering in the Sultanate of Oman.

The interest in engineering education and work based learning led to him being appointed Coordinator of the Caledonian Centre for Engineering Education (CCEE), the first satellite centre of the UNESCO International Centre for Engineering Education (UICEE). He left Glasgow Caledonian University in May 2000 after 14 years to take up an appointment as Director of the Executive Doctoral Programme at the University of Glasgow Business School. As Director, he is responsible for the development and operation of this postgraduate work based learning programme on a local, national and global scale. His current research interests are related to quality assurance and knowledge management processes associated with Work-Based Learning (WBL).

During his career, he has had over 80 papers published in conference proceedings and journals, as well as two books.

Colin Urquhart Chisholm graduated with a BSc Hons in Metallurgy from Strathclyde University and with a Doctor of Philosophy from St Andrews/Dundee University in 1962 and 1968 respectively. From 1963 to 1965, he was a lecturer at Wolverhampton and Staffordshire College of Technology (now Wolverhampton University). From 1965 to 1971, he was a lecturer in materials science at Dundee Institute of Art and Technology (now Abertay University) where he researched in processes for alloy electrodeposition and the study of the structure of the deposited alloys. After spending a period as a senior lecturer at Robert Gordons Institute of Technology (now Robert Gordons University), he became Associate Head of Engineering at Paisley College of Technology (now Paisley University) and thereafter Head of School of Engineering at Glasgow College of Technology (now Glasgow Caledonian University) where he was awarded a professorship. He was Dean of the Faculty of Science and Technology at Glasgow Caledonian University (GCU) from 1993 to 2002, and, since 2002, he has taken up the position of Dean of Development. He has also been a member of the Executive Management team and is the Professor of Research and Development in the Scottish Centre for Work-Based Learning (SCWBL), a satellite centre of the UICEE.

Prof. Chisholm is also a Deputy Chairman of the UICEE Academic Advisory Committee.

Prof. Chisholm is an acknowledged international researcher in the field of electrodeposition of alloys and leads collaboration as Chairman of Surface Technology International, which involves a group of European universities. Since 1985, he has maintained a major collaboration with a team of researchers at Eotvos Lorand University in Budapest, Hungary.

For the last decade, he has led action research and development relating to work-based learning and, at GCU, has developed an innovative Postgraduate Learning Contract Framework for work-based learning, which has been operational since 1992.

More recently, he negotiated on behalf of GCU with the UNESCO International Centre for Engineering Education (UICEE) leading to the establishment in 1998 of the first satellite centre of the UICEE, named the Caledonian Centre for Engineering Education (CCEE) at the GCU.

He was awarded the UICEE Silver Badge of Honour for Distinguished Contributions to Engineering Education at the *Global Congress on Engineering Education* in Krakow, Poland, in September 1998, and more recently at the *2nd Global Congress on Engineering Education* in Wismar, Germany, in July 2000, he was also awarded the UICEE Gold Badge of Honour.

He has published over 250 scientific papers in refereed journals and conference proceedings and supervised over 40 PhD/ProfD students. More recently, Professor Chisholm, in collaboration with the team for Surface Technology International, published the first paper regarding the successful deposition of tin-chromium and tin-zinc chromium alloys. Prof. Chisholm has also received a number of awards for published papers presented at international conferences.

This form is also available on the Web at
http://www.eng.monash.edu.au/uicee/member/MembershipForm.html

UNESCO INTERNATIONAL CENTRE FOR ENGINEERING EDUCATION UICEE

MEMBERSHIP FORM - 2005

Yes, I/we would like to become a member of the UICEE. Please register me/us as:

i.	Partner (industrial or academic) ($A10,000 p.a.)	
ii.	Sponsor (A$5,000 p.a.)	
iii.	Supporter (A$2,000 p.a.)	
iv.	Contributing Member (A$500 p.a.)	
v.	Individual Member (A$100 p.a.)	
vi	Library Subscription (multiple readers) (A$200 p.a.)	

(i-iv) Institution /Company Name: ....

(i-v) Individual/Contact Surname: ....

First Name: .... Title: .... Position: ....

University/Company Address: ....

....

Country: .... Postcode: ....

Phone (B): .... (H): ....

Fax: .... E-mail: ....

Method of Payment:

| | Cheque | for $................... made payable to: **Monash University - UICEE**

| | Visa | | | Mastercard | | | Bankcard |

Card Number: __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

Cardholder s Name: ....

Expiry Date: __ __ / __ __ Signature: ....

	Electronic Funds Transfers (EFT)
BSB	033 289
Bank Account Number	630 759
Name of Bank	WESTPAC - Monash University
Address of Bank	Melbourne, VIC 3800, Australia
Please fax us a copy of the EFT for our record.	

Please copy this form and return to:
UICEE, Building 70, Monash University, Wellington Rd, Melbourne, VIC 3800, Australia
Tel: +61 3 990-54977, Fax: +61 3 990-51547, E-mail: uicee@eng.monash.edu.au

Visit the UICEE Web-site at: http://www.eng.monash.edu.au/uicee/