Getting bench scientists to the workbench

Sharon Fraser, Centre for Professional Development, and **Elizabeth Deane**, Division of Environmental and Life Science, Macquarie University
sharon.fraser@mq.edu.au edeane@els.mq.edu.au

Introduction

In the Australian University sector today, the separation of the 'world of work' from formal education is becoming more artificial. Since the mid-eighties, the voices of Government and Employer bodies have combined to demand more workplace-relevant skills and attributes from university graduates (ACNielson, 1998, 1999; NBEET, 1992; Tomas, 1997). Variously referred to as generic skills, capabilities, key skills or graduate attributes, these include literacy, numeracy, computer skills, time management, written and oral communication, interpersonal skills, teamwork, leadership, creativity and problem solving (ACNielson, 1999) amongst others. Universities have responded, to a greater or lesser extent, by revisiting their curricula with the aim of integrating the development of such work-relevant skills and capabilities into their degree programs. A related response has been to establish or enhance already established industry-university linkages through research partnerships and work placement programs. A work integrated learning (WIL) program (cooperative education, work experience, internship) has the potential to assist students to develop these skills, and more. Student motivation, classroom learning and course completion are enhanced when a WIL program is implemented effectively, whilst at the same time students develop an awareness of the 'world of work', confirm or redirect career decision-making, and improve their job opportunities (NCCE, 2002). This paper explores the issues that need to be addressed in the sciences, before an effective WIL program can be developed so that all partners in the process can achieve useful outcomes.

WIL in the sciences

Faculties or disciplines that have firm ties to a profession, such as Law, Nursing, Medicine, and Education, traditionally have work placements as part of the learning experience, however, there is no reason why all university students should not have the opportunity of experiencing some form of work in their undergraduate program. In 1998, nearly 60% of university courses had some element of work experience, and learning of this type accounted for between 1/8 and 1/4 of total marks (Martin, 1998). Universities with strong industry ties, most notably the previous 'Institutes of Technology', are well placed to expand their programs with regard to WIL. Their ties with industry partners are strong, and a culture of commitment to work experience already exists amongst staff and students. Such understanding of, or support for WIL is also present in the professional degrees mentioned earlier, but how much of this commitment to, and understanding of WIL is present in the more traditional university offerings that include the bench, pure and 'enabling sciences' (such as chemistry, mathematics and physics) is open to question.

There are various forms of WIL already integrated into a small number of science programs in universities around the world, and the range and variation are represented in Table 1. Specific models include:

- **cooperative programs** – work experience integrated into the overall curriculum;
- **cooperative Education for Enterprise Development (CEED) programs** – which are university-industry partnerships assisting with the training of students in technological fields as they undertake industry-relevant projects (based on a program originally developed at RMIT); and
- **fieldwork** – from 1 to 4 days a week with the employer/agency, for a defined period.

University	Characteristics
University of British Columbia, Canada *BSc*	• 5 year cooperative education program (normally 4 years) – all disciplines • all basic subjects studied prior to work placement • students selected on basis of academic performance, enthusiasm and motivation • students hired and paid for their work • e.g. Biochemistry and Molecular Biology – terms 1 to 6 on campus; summer vacation and following year in work placement; terms 7 and 8 on campus
University of Waikato, NZ *BSc (Technology)*	• 4 year degree – BSc + 2 Management Papers (units of study) • 12 months paid work experience – 3 months at end of second year; 9 months at end of third year, return semester 2 in fourth year
The University of Adelaide, Australia *BSc (Physics)*	• *EPIC program* – Education in Physics with Industrial Cooperation: 4year degree • students apply after second year, with a credit average across the 2 years • paid work experience for 4-5 months: semester 2 year 3 plus semester 1 year 4 in work placement, return semester 2 • project jointly agreed to by academic staff and employer
The University of Adelaide, Australia *BSc (Honours)*	• *CEED program* – projects in conjunction with external organization • students apply in semester 1 of year preceding honours, if accepted students take a Science Industry Practicum subject in second semester as preparation • 8 weeks in summer vacation period with some financial recompense

Table 1. Examples of models of WIL in science and applied science programs within universities

Though the structure of these work experience programs differs, they do exhibit some commonalities – many of them are only available to the more able students who are then commonly paid whilst undertaking the WIL program. The benefits or otherwise of models such as these are discussed elsewhere (Martin, 1997; Davies and Hase, 1994), but the extent to which WIL science programs are 'quality' programs is not known. A careful consideration of each program, with regard to issues of quality, and the extent to which the rest of the curriculum is structured in order to prepare students to integrate the experience with the rest of their education experience (see later), is necessary before one or other variation of WIL could be considered more effective than another.

If curriculum change incorporating WIL is to become more extensive in the sciences in Australia, there could be no more opportune time for it to happen than now. The last two decades have seen a continued shrinkage in government funding for universities, which, coupled with rising HECS fees and student debt, contributes to student disinterest in the pure science disciplines, which attract high HECS (Level 2) and are potentially low income-generating careers. The sciences are faced with a fight for survival (Senate Report, 2001). The Government is demanding that universities become more responsive to society's needs, more relevant and 'applied' in nature. The quiet acquiescence of higher education to the corporate world has, however, raised considerable concern amongst educators in recent decades (Kolb, 1984; Boyer, 1987; Dewey as cited in Saltmarsh, 1992). Regardless of the government agenda or the debate it generated, there are good reasons why the sciences should consider integrating some experience of work into the curriculum.

The benefits of work experience

The benefits of work experience, as documented in a comprehensive study from the UK (Harvey, Geall and Moon, 1998), are outlined in Table 2. In this study, written feedback or interview data was collected from over 100 university academics, placement coordinators and employers, and used in conjunction with an extensive critique of the literature and re-analysis of empirical data collected from students by the Centre for Research in Quality in the UK. Though the benefits are impressive, the *'experience of work should not be regarded as something that is intrinsically beneficial: something that is somehow "good for the soul"'* (Harvey, Geall and Moon, 1998, chapter 2, page 1).

The establishment of an effective WIL program has implications for the development of content and skills in science courses, and the attitudes and understandings of academics, students and employers.

Student perspective	**Employer perspective**	**Academic perspective**
Working in a setting in which to put theory into practice *Developing an awareness of work-place culture* *An appreciation of the fluidity of a rapidly changing world of work* *An opportunity to develop a range of personal attributes* *The development of key interactive attributes (team-working, interpersonal skills and communication)* *Short-term financial benefits* *Enhanced employment prospects and the potential of commanding higher wages when starting employment after graduation* *Assistance in developing career strategies* *Working in another culture, learning other languages and contributing to the global community* *Encourages course completion*	*Extra workers at low cost* *The setting up of a new project* *The completion of specific tasks* *The opportunity to give a potential recruit a trial without obligation* *Using student's reflection on work as a recruitment criterion* *A pool of potential recruits with an awareness of workplace culture* *An injection of new ideas* *Developing links with higher education institutions* *Staff development opportunities that arise from employees mentoring students* *Improves workplace diversity* *Increases retention rates of employees hired through cooperative programs* *Enhances human resource flexibility within effective short-term employees*	*The opportunity for students to see their subject area in practice* *The satisfaction of seeing students develop and mature* *The enhancement of students' skills* *The establishment of links with a wider range of employers* *Using employer contacts to ensure that their teaching is up-to-date* *Using links to encourage employers to participate on course validation panels, participate in seminars* *The tailoring of innovative or more work experiences through collaboration with past employers of placement students* *Developing their expertise in assessment methods by working with employers who have experience in assessing 'employability skills'* *Enhances public support for the institution* *Access to state of the art equipment*

Table 2. Benefits of work experience – student, employer and academic perspectives (adapted from Harvey, Geall and Moon, 1998)

Harvey, Geall and Moon (1998) stress that in order for learning to come from the work experience, the program needs to address crucial areas (Table 3), including it being a **meaningful experience**, **intentional, organized** and **accredited**. An Australian study (Martin, 1997), in which eight university courses in four vocational areas (health science, engineering, business and social work) were investigated by way of interview and questionnaire data collected from students, academics and employers, supports these findings. The Martin study is of interest to science educators as it cites two Case Studies as exemplars of effective WIL programs, courses from Victorian Universities in Medical Laboratory Science and Electronic Engineering. Both include a variety of characteristics, which cohere with the framework suggested by Harvey, Geall and Moon (1998). The characteristics that make the courses effective learning experiences include:

- participating companies develop a tender for students to address a particular issue or problem;
- students often work in teams, and are always supervised by a member of academic staff, as they develop and submit a proposal which includes a statement addressing how they will develop as professionals through the exercise, as well as how they will address the problem;
- students submitting successful proposals work for a full year on the problem together with workplace and academic supervisors;
- the program involves regular reporting and monitoring of progress and problems; and
- each program is assessed and accredited by the university.

The Medical Laboratory Science program also requires students to maintain a journal, which serves as the basis for regular reflection and discussion with both workplace and academic supervisors.

Meaningful Experience – for all stakeholders	• *For academics* – linked to subject specialisms • *For employers* – enabling students to make a positive contribution, and gain an appreciation of the organization • *For students* – to provide a practical context for their study and to develop the skills and maturity they need for the workplace

Intentional and Recognized	• Learning is 'deliberate' (Tough, 1971) with specific goals and identifiable learning outcomes
	• The experience:
	  • is well organized, planned and prepared
	  • has ongoing and built-in reflection about what and how they are learning

Reflection and Articulation	• Students need to be able to articulate their learning – to reflect on it, identify what has been learned, and critically review their progress both at regular intervals and retrospectively
Assessment and Accreditation	• Assessment shapes students' experience learning – to be valued, it should be assessed • To be taken seriously, the experience should be accredited

Quality Issues	• The *quality process* is tied to its relevance, structure, organization and intentionality
	• Employers are committed to it, and aware of its implications, involved in the planning and provide adequate support, training and workplace supervision
	• Academics have ongoing responsibility to monitor and support the students whilst on work placement, including:
	  • prior induction and briefing of all concerned
	  • facilitation of ongoing reflection
	  • debriefing and identification of outcomes

Table 3. The crucial areas requiring consideration for WIL in undergraduate programs (adapted from Harvey, Geall and Moon, 1998)

Integrating WIL into science programs 'from scratch'

Issues that need to be considered when implementing WIL – problems to avoid, structures and resources to develop, are too numerous to discuss in this paper, and are better dealt with elsewhere (Davies and Hase, 1994; Gardiner and Singh, 1991; Martin, 1997), however what it means for those interested in developing WIL, warrants further exploration. It is usually the institution's responsibility for accrediting the work placement experience, hence much of the responsibility for developing and organizing the program will fall on the shoulders of academics involved in it. It is essential that academics understand its goals and are committed to developing, implementing and monitoring the program. There are clear links between the way academics think about learning in work placements, how they plan and support the placements, their student's perceptions of their own learning during the experience, and the satisfaction they and their employers feel with the placement (Martin, 1997). Staff who view workplace learning as in need of careful planning and collaboration with employers are more likely to produce students and employers who perceive considerable benefits from the work experience. The study also suggests that the opposite is true – if it is assumed students will learn simply because they are in the workplace, and hence there is little attention paid to learning outcomes and supervision, the least effective learning outcomes will ensue (Martin, 1997). So how do proponents of WIL engage academic scientists with their notions? Is it simply a matter of elucidating its benefits, or are the issues more complex than that?

It is not unusual for traditional science courses to be highly structured and teacher-directed, with infrequent opportunities for student interaction and discussion at a high cognitive level. Learners of science at university are rarely given the opportunity to reflect on their own learning needs and skills development, or negotiate learning contracts to enable them to pursue learning of real personal interest and relevance to them. Without a commitment to learner-centred pedagogies whereby students' concerns, interests and problems leading to their active engagement with the culture of scientific thinking and doing (Gardiner and Singh, 1991) is the starting point, combined with a critical reflection upon the pedagogical practices and assessment procedures present in the existing curriculum, there is little base from which to move into the world of work.

There is abundant research literature to assist academics in their thinking about the curriculum. The work of Kolb (1984) in experiential learning, taking the learner from 'knowing what' to 'knowing how' (through the four stages of learning – concrete experience, reflective observation, abstract conceptualization and active experimentation), provides a pathway for a conceptualization of the curriculum as 'delivered' on-campus through to the integration of WIL into the learning program. Boyer (1990) initiated the process of reconceptualizing scholarship in academia, moving away from one dominated by the scholarship of **Discovery**, towards one in which other forms of scholarship – **Application**, (whereby theory and practice in the scholar's special field of knowledge are connected), **Integration**, (making connections across the fields, disciplines and professions) and **Teaching** (wherein the work of academics becomes significant only as it is understood by others), are valued and rewarded. This too provides academics with a framework within which to consider the links between their own research, teaching, community outreach and the professional world. In order to address such complex curricular issues and understandings however, it may be necessary for academics to first reflect upon their own conceptions of teaching and learning.

A study by Prosser, Trigwell and Taylor (1994) that looked at how 24 university science teachers view their role as teachers, identified 6 conceptions of teaching:

Conception A: Teaching as transmitting concepts of the syllabus;
Conception B: Teaching as transmitting the teacher's knowledge;
Conception C: Teaching as helping students acquire concepts of the syllabus;
Conception D: Teaching as helping students acquire teachers' knowledge;
Conception E: Teaching as helping students develop conceptions; and
Conception E: Teaching as helping students change conceptions.

The earlier conceptions (A-D) focus only on the teacher or context, with little focus on students, whilst the more complete understandings consider the students as centrally important. The study also found there to be a strong empirical relation between university science teachers' conceptions of teaching and their conceptions of the learning undertaken by their students. Those who hold conceptions of teaching as being the transmission of knowledge, talk about learning as being about students accumulating more information, rather than developing and changing their conceptions and understandings (Prosser, Trigwell and Taylor, 1994). Without coming to terms with our own views of teaching and what it means for students to learn, it is hard to understand why it is necessary, let alone to actually change teaching practices from teacher-directed to learner-centred pedagogies. Academics with the less sophisticated understanding of teaching would find it difficult to engage with the philosophy of WIL, at least at the level required to implement an effective program.

Future directions

It is possible to integrate quality WIL programs into science curricula, however to do so requires that the understanding of individual teachers, employers, students, and institutional bureaucrats be challenged, as the older paradigms of education, training and work are dispelled. A WIL program that is contextualised in the classroom by teachers who can facilitate student comprehension of the intellectual basis and meaning of the work experience, will be an experiential program that enhances student learning (Katula and Threnhauser, 1999). Participating employers and academics need to engage in a 'transactional dialogue' (Brookfield, 1986) aimed at understanding each other's workplace culture and dominant language, and sharing differing interpretations and viewpoints, in order that a common vision and real partnership can develop (Davies and Hase, 1994). As far as possible, there should be shared curriculum development and program delivery using methods suited to the needs of the workplace and reflecting the distinctive strengths of the WIL partners (Davies and Hase, 1994). Students will certainly take their lead from the academics that teach them, the learning environment within which they are immersed and the mentoring they receive from their supervisor and colleagues in the workplace. University policy makers must support teaching staff and their workplace partners, as they grapple with complex curricula issues and understandings, through the provision of specialist expertise, professional development and funding. University workload formulae and promotions structures should value and reward academics engaging in the development, implementation and support of WIL programs, or similar changes which require a substantive paradigm shift. The success or otherwise of such programs lies in the commitment and involvement of academic staff (Martin, 1997), and the establishment of an effective partnership between the learner, the university and the employer wherein the desires and perspectives of each stakeholder are reconciled (Foster and Stephenson, 1998).

References

ACNielson Research Services (1998) *Research on employer satisfaction with graduate skills – Interim report.* Canberra: DETYA, EIP.

ACNielson Research Services (1999) *Employer satisfaction with graduate skills: Research report.* Canberra: DETYA, EIP.

Boyer, E. L. (1987) *College: The undergraduate experience in America.* New York: Harper & Row.

Boyer, E. L. (1990) *Scholarship reconsidered: priorities of the professoriate.* Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Brookfield, S. D. (1986) *Understanding and facilitating adult learning: A comprehensive analysis of principles and effective practice.* San Francisco: Jossey-Bass.

Davies, A. T. and Hase, S. (1994) *The conditions for fostering cooperative education between higher education and industry.* Department of Employment, Education and Training. Canberra: Australian Government Publishing Service.

Foster, E. and Stephenson, J. (1998) Work-based learning and universities in the UK: a review of current practice and trends. *Higher Education Research and Development*, **17**(2), 155-170.

Gardiner, R. and Singh, P. (1991) *Learning contexts of university and work.* Department of Employment, Education and Training. Canberra: Australian Government Publishing Service.

Harvey, L., Geall, V. and Moon, S. (1998) *Work experience: expanding opportunities for undergraduates.* [Online] Available: http://www.uce.ac.uk/crq/publications/we/zwecon.html [2002, March 15].

Katula, R. A. and Threnhauser, E. (1999) Experiential education in the undergraduate curriculum. *Communication* Education, **48**, 238-255.

Kolb, D. A. (1984) *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: PTR Prentice Hall.

Martin, E. (1997) *The effectiveness of different models of work-based university education.* Evaluations and Investigations Project. No. 96/19.

Martin, E. (1998) Conceptions of workplace university education. *Higher Education Research and Development*, **17**(2), 191-205.

National Board of Employment, Education and Training (NBEET) (1992) *Skills sought by employer of graduates.* Commissioned Report No. 20. Canberra: Australian Government Publishing Service.

National Commission for Cooperative Education (NCCE) (2002) *Benefits of cooperative education.* [Online] Available: http://www.co-op.edu/benefits.html [2002, March 15].

Prosser, M., Trigwell, K. and Taylor, P. (1994) A phenomenographic study of academics' conceptions of science learning and teaching. *Learning and Instruction,* **4**, 217-231.

Saltmarsh, J. (1992) John Dewey and the future of cooperative education. *The Journal of Cooperative Education*, **28**(1), 6-16.

Senate Employment, Workplace Relations, Small Business and Education References Committee Report (2001) *Universities in crisis.* Canberra: Commonwealth of Australia.

Tomas, J. C. (1997) Graduates strangers to work practices. *Australian Financial Review*, 30 January, 5.

Tough, A. (1971) *The Adults Learning Projects.* Toronto: Ontario Institute for Studies in Education.