Learning science and technology through cooperative education

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Cooperative education, a form of experiential or work-integrated learning is common in tertiary educational institutions worldwide. However, in New Zealand few institutions provide work-integrated learning programs in science or technology, and the management and process of work-integrated learning programs is not that well understood. How well do such programs work? What infrastructure is needed to ensure learning actually occurs? Are graduates of work-integrated learning programs able to satisfy employer needs? This chapter synthesizes decades of work around such issues, and details research initiatives that provide valuable insights into how students learn science on in the workplace, how their skill development matches that desired by employers, and best practice for management of work-integrated learning in science and engineering (Asia-Pacific Journal of Cooperative Education, 2007, 8(2), 131-147).

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HIGHER EDUCATION IN NEW ZEALAND

Higher education in New Zealand is offered through eight universities, 20 polytechnics and a large variety of vocational and training private training organizations (Institutes of Technologies and Polytechnics, 2007). Entry into higher education is dependent on the particular programs offered by the tertiary education providers (TEPs), but generally requires students to 'pass' year 12 or year 13 national qualifications. These vary with many students intending to follow vocational training (involving completion of diplomas in science and related disciplines) completing National Qualifications Framework Unit Standards (NQF, 2007) administered by the New Zealand Qualifications Authority (NZQA, 2007), which can be done at school, and post-school in publically funded polytechnics, or in private training enterprises (PTEs). Unit standards contain statements, in the form of specific performance criteria, which describe what students are able to know and do for credit. Judgment of student achievement occurs at two levels: achieved and not-achieved. The normal entry requirement for entry into university and degree-level polytechnic programs including the sciences is the *National Certificate of Educational Achievement* (NCEA) completed at years 12 and 13 (MoE, 2007).[1] NCEA, first introduced in 2002 supersedes the older external summative examinations of New Zealand *School Certificate* (SC), *University Entrance* (UE), and *University Bursary* or *University Scholarship*. The assessment regime, like Unit Standards, is performance-based, with a significant amount of internal assessment - albeit moderated externally - and some external assessment. Students are awarded one of 'not-achieved',

[1] Polytechnics also offer nursing programs and teacher training, including science teacher training, is offered by some stand-alone colleges of education, and some colleges subsumed into universities.

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'achieved', 'merit' or 'excellence' in contrast to numerical and letter-grade systems of SC and UE. Student do not get a single certificate as occurred under the old regime, but can accumulate credits from a variety of providers and across a much greater diversity of topics of study making evaluation of their knowledge a rather complicated task. NCEA has proven fairly controversial with some New Zealand schools, employers, and TEPs (Blundell, 2003; Ministry of Education [MoE], 1997; Welch, 2003). However, Hume (2003) notes that this is at least in part due to the fact that it is simply a new assessment regime that will require some time for people to become familiar with. Very recent changes to the NCEA regime may go some way to ameliorate these concerns.[2]

Probably the single most important shift in higher education in New Zealand over the last two decades, particularly in the case of degree and university-level study, is an enormous increase in intake and in the academic diversity of this intake (Buntting, Coll & Campbell, 2007). Whether this is due to changes in the assessment regime is debatable; it probably has contributed at least in part, but also may just be part of an international trend as governments worldwide strive to produce a more skilled workforce (Laws, 1996). In any case the New Zealand government is increasingly concerned with what it sees as a skill shortage in New Zealand, particularly in the case of economically enabling disciplines such as science and engineering at the university level, and for technical trades at the polytechnic level (Worksite, 2007) and via industry training organizations (ITOs, see Tertiary Education Commission, 2007).

A key feature of the graduate profile of many degree and vocational programs is emphasis on practical skills (Coll & Zegwaard, 2006; Wang & Coll, 2005). Traditionally universities as TEPs have not been seen as having the capacity to provide graduates with adequate practical experience to complement their more theoretical, on-campus, academic learning (see, Dressler & Keeling, 2004). However, worldwide there is a collaborative education strategy called *cooperative education*, which seeks to do just that.

COOPERATIVE EDUCATION

Definition and Historical Development

Cooperative education is a collaborative enterprise in which students, employers and TEPs work together to produce work-ready graduates; that is graduates that have (particularly) practical skills that complement theoretical academic learning, and that make them of almost immediate value to employers (Groenewald, 2004). Cooperative education has a variety of names and these often reflect its location. So in the UK it is seen most commonly in 'sandwich' programs, and in the USA, it takes the form of 'co-op' work placements spaced evenly throughout the degree, or in the from of capstone internships – placements added on to the end of a degree (e.g., in medicine). In any system, the students spend predetermined periods of time - such periods of time commonly called work placements - in a relevant workplace. So an engineering student at university might complete two three-month work 'placements' in an engineering firm, a food technology student at a polytechnic might do the placement in the form of one day a week in a food testing laboratory, and so on.

[2] Principally the actual level of achievement, together with details of what was not achieved (i.e., failed) will now appear on student certificates. These were originally omitted so as not to appear negative and to focus on achievement rather than failure; but were criticized as not providing incentives for striving to do well.

The origins of cooperative education as an educational strategy lie in the USA, in particular in the University of Cincinnati (UoC). Herman Schneider of the UoC is generally regarded as the founder of the system (although it is acknowledged that the idea of combining work and study has earlier exemplifications, see Walters, 1947), probably because he coined the term and championed the notion of work-integrated learning at the institutional level - something highly novel at the time.

Nowadays, the broader term used to describe this learning system is probably *work-integrated learning* (Franks & Blomqvist, 2004), although cooperative education is still more often used. In any case, the identifying feature of cooperative education is a combination of work experience with on-campus academic learning, but also the notion that learning from each 'site' is *integrated*. So, for example, a student studying analytical chemistry at a university might take knowledge learnt from his or her studies and use this to engage in meaningful work with an employer who runs an analytical service laboratory.[3] But at the same time the student might take perhaps current research ideas based on leading edge research in a particular analytical technique (e.g., modern chromatographic techniques like GC-MS, or HPLC) learned from university study into to the work force. Even if student do not take such knowledge into industry, they take a different culture or way of thinking, and this can form part of the integration in work-integrated learning (Coll, 2004). Remarkably, the extent to which any integration actually occurs has never been studied! It is, however, currently under investigation in New Zealand.

Commitment to cooperative education by employers, TEP and governments waxes and wanes somewhat; although it is currently very much in vogue. After a slowish start, co-op underwent massive expansion in the USA as a result of substantial commitment from federal authorities (Ryder & Wilson, 1987), but this abated dramatically when the rapid growth resulted in program quality issues as many TEPs strived to gain their share of this largesse (Sovilla & Varty, 2004). Outside the USA, growth has been less spectacular, but probably more measured in nature, and in recent times cooperative education has expanded into Asia in particular (see, e.g., Coll, Pinyonatthargarn & Pramoolsook, 2003, 2004). The benefits of cooperative education across all three sectors are now well recognized, so that many governments see cooperative education as a means of preparation of work-ready graduates - as exemplified by Lord Dearing's recommendation that all UK degrees should incorporate some work experience (Dearing, 1997).

Reported Benefits of Cooperative Education

Cooperative education in one form or another is now a major 'industry' worldwide and is practiced widely in the USA, UK, Australia, the Asia-Pacific region, South Africa, and Europe (Franks & Blomqvist, 2004). It is interesting to consider why cooperative education has been so successful, and yet maintains a relatively low public profile. Cooperative education is something of an intuitive concept; one that appeals to almost anyone engaged in hiring employees or training graduates (Eames, 2003). The principal argument is that all three parties involved in cooperative education (i.e., students, employers, and TEPs) stand to benefit (Franks & Blomqvist, 2004). It also now has a fairly substantial research base that

[3] This need not necessarily be *paid* work, but it needs to be of value to the employer see Coll, Eames, Zegwaard & Hodges (2002)

supports anecdotally claimed operational outcomes (Bartkus & Stull, 2004).[4] Dressler and Keeling (2004) provide a substantial list of research studies that report students' accruing a variety of benefits as a consequence of cooperative education over conventional programs. These consist of: *academic benefits* (e.g., increased motivation to learn, increased ability to finance tuition, improved perception of benefits of study, etc.), along with *personal benefits* (e.g., increased autonomy, increased communication skills, improved time management, etc.), and *career benefits* (e.g., increased employment opportunities, career clarification, international opportunities, etc.). Employer benefits, as might be expected, are fairly pragmatic in nature and mostly concern the work-readiness of graduates (Braunstein & Loken, 2004). Overall employer benefits are financial in nature (lower recruitment costs, increased productivity, etc.) but also issues to do with image (e.g., addressing equity in employment, enhanced public image of major multi-national corporates, etc.). Reported benefits for TEPs again are fairly pragmatic, and include things such as enhanced student recruitment, stakeholder input into program development, and enhanced links to 'industry' the latter which often results in on-going, commercially-beneficial, relationships (Weisz & Chapman, 2004).

COOPERATIVE EDUCATION AS AN *EDUCATIONAL* STRATEGY

The literature thus suggests cooperative education is beneficial, in mainly operational terms, for all three parties. However, the practice of what comes under the umbrella term 'cooperative education' varies substantially and this has consequences for it as an educational strategy. A key issue here is the purpose of the particular cooperative education program. This, not surprisingly, is related to perceived benefits mentioned above. So the purpose of co-op from an employer's view point is largely vocational (Dressler & Keeling, 2004). Hence the educational purpose here is *vocational training*. A similar view is held by many TEPs, who see a similar purpose and the fact that co-op graduates gain work more easily fits in nicely with TEP recruitment strategies. However, recently Coll and Eames (2004) have argued that co-op needs to be more broadly educational in nature. That is to say, "cooperative education is about learning" (p. 273), even if the *outcomes* are pragmatic and vocationally-oriented. This, it is argued, allows co-op to function as a much broader, more holistic educational strategy:

> Only by employing strong curricula and pedagogy underpinned by theory, and objectives that are *relevant and appropriate to all parties* involved can a successful co-op program be sustained. We are not here advocating total focus on the student (although the role of co-op placement coordinators might well drive them to such a position); we feel that a balance is necessary, and have some concern that a program that is too vocationally-focused might well lose sight of the student. Students *do* need to be equipped with skills that will help them find meaningful employment (something which will likely satisfy employers), but surely education is broader than this … Our point is that in our view we do need to maintain clear *educational* goals in co-op. The objectives set for the co-op program and the work component should allow the student to engage in critical thinking and transformative learning. We recognize the tension that exists between the primary goals of academia (education) and industry (productivity), but we feel education must remain paramount. (Coll & Eames, 2004, pp. 274-275, original emphasis).

[4] Operational outcomes are practical things like, do employers find that students who graduate from cooperative education come up to speed more quickly? Do graduates earn more, or advance more rapidly in their careers?, etc.

Eames elsewhere argues that co-op has not had a strong focus on learning, and little co-op research is reported of *what* and *how* students learn (see Eames, 2003; Eames & Bell, 2005). This is crucial if we are to run sustainable mutually beneficial co-op programs, as Coll and Eames (2004) argue: "…we need to know a lot more about what happens in terms of the 'what' and 'how' of co-op *learning* that occurs before we can begin to design curricula and decide appropriate pedagogies" (p. 277). Eames (2003) argues that for co-op to be sustainable, it needs to be seen and *respected* as a key 'value-added' educational strategy, at the institutional, and governmental levels, and not just as a useful way of producing work-ready graduates. This has proven problematic, with co-op often scattered throughout a given institution, and with few institutions having a coordinated, coherent, institution-wide approach to co-op. It is worthwhile, however, to note that there are several North American-based TEP that have fully embraced co-op as an educational strategy, namely Northeastern University (Northeastern University, 2007), and Waterloo University in Canada (McLaughlin, 1997), both of who offer co-op at the institutional level.[5]

There have been a number of recent New Zealand-based studies that strive to understand the learning component of co-op, and these are described below. First, we outline the status of co-op in New Zealand presently.

COOPERATIVE EDUCATION IN NEW ZEALAND

Cooperative education is alive and well in New Zealand and is championed by a national professional body, the New Zealand Association for Cooperative Education (NZACE, 2007). Two national surveys point to over 300 cooperative education programs available in the New Zealand tertiary education sector (NZACE, 2003). In many ways this is an extraordinary figure,[6] for a small country, and a modest number of TEPs.[7] But it perhaps mostly reflects the variety of co-op practice. These programs vary enormously in terms of descriptive program parameters: namely, the amount of time spent off-campus; whether or not the work component is credit bearing; whether or not the work placement is paid; at which phase of the program the work component occurs; the duration of the placement; whether the work component is done in one or more 'placements'; and so on. Remarkably, despite the large number of reported programs, there are few in engineering, a few in the IT-sector (Fielden & Williamson, 2002; Skelton & Wilkie, 2005), and only one sustained program in science and technology (Coll, 1996).[8]

Teasing out some of these parameters, allows us to gather a picture of co-op practice in New Zealand. First, the amount of time spent in the workplace varies from a few hours a week throughout a two or three year program (common in the polytechnic sector) to 12 months work out of a four-year program (the largest proportion of the program, and placement of longest duration). Also common is for co-op to consist of an industry-based project (see, e.g., Fielden & Williamson, 2002), which involves students working on industry-initiated issues or problems (typically unpaid). Very common is a three-month block spent

[5] Interestingly, at the time of writing the University of Waikato had just introduced a generic program structure for undergraduate degrees, with one feature being a co-op option for all disciplines of study.
[6] This is in fact likely to be an underestimate, given the voluntary nature of the survey.
[7] Co-op in New Zealand is practiced almost exclusively at the tertiary level, with few programs reported for pre-higher education (for an exception see Draper & Wilson, 2005).
[8] Victoria University of Wellington introduced a co-op program in applied science program, but this was eventually discontinued due to lack of industry support and enrolments.

over summer vacation, and this is the most common model for engineering (Todd & Siddons, 2004). Many placements are unpaid; these typically being shorter in duration, or part-time placements. Many placements count credit to the program, especially project and longer duration placements. Assessment varies with longer, more complex placements often employing full grading (C, B, A, A+ etc.) but pass-fail regimes also are common, especially for shorter work-experience type placements. Likewise, assessment regimes vary from evaluation of reports and limited employer feedback (Coll, 1996) to more complex arrangements where student learning objectives and outcomes are negotiated at tripartite meetings (Ayling & Hodges, 2007).

The management of co-op programs also varies. There are three basic systems. One in which students find their own placements, with TEP staff perhaps posting work offers or providing list of past employers. Second, is a centralized model in which a central group more actively manages placements, sometimes securing the placements for the student. Third, is a comprehensive management system where placements are found for the student, student learning is closely monitored, and the placement staff (who may be centralized or distributed across academic units/departments) strive to strengthen links with 'industry' (Coll & Eames, 2000). In the latter case, this can often only occur when students enroll in formal recognized 'industry papers', pay tuition fees comparable to other papers, and such papers receive central government tuition subsidies (Langdon & Judd, 1994).

A key, defining aspect of good co-op program management, whatever the operational management model, is sound understanding of the student to be placed (Sundar, 2005). This Coll and Eames (2004) have argued, is necessary if placement coordinators are to match a student to an employer. So it is not very useful to send just any chemistry or biology student to an employer in the 'science' sector. We should strive to place a student who is studying microbiology into a microbiology laboratory, an analytical chemistry major into an analytical services laboratory, and an electronics major into a manufacturer of electronic goods, and so on. To do this, of course, requires placement coordinators who actually know their science, and specific science areas for which they are responsible in placing students. The match of student and employer naturally requires an in-depth understanding of employer skill needs (Clark & Wempe, 2005; McLay & Corich, 2005; Skelton & Wilkie, 2005); again the argument is for specialist scientists - perhaps in joint appointments with a co-op placements service unit - as placement coordinators involved in the facilitation of student-employer matching and subsequent placement (Coll & Eames, 2000).

More recently some authors have argued that an often forgotten party is academics within the co-op program provided by the TEP. This latter view is supported by Coll and Zegwaard (2006) who argue that deciding learning outcomes (in terms of graduate competencies) must involve all three parties, including academics (see also, Burchell et al., 2000). The argument here is that for co-op generally; that is, it is a genuinely *cooperative* effort. Some examples may illustrate the reason why we need to consider teaching faculty's' views. What is the destination of a co-op graduate? Traditionally it has been 'industry'. But many co-op graduates, like their non-co-op counterparts, go on to further study. Coll (1996) says this may occur as a result of career clarification; so a co-op student interested in say forensic science might do a co-op placement in forensic science, find it is not as glamorous as he or she thought and change careers. Or the forensic science co-op student might see that to become what he or she conceptualizes as a forensic scientist requires a PhD (Eames & Bell, 2005). So do academics know about co-op (i.e., 'ordinary' science academics, who are not much involved in co-op), and if so, what do they think of it? MuCurdy (2005) says they do care,

they sometimes think it takes good students away from postgraduate study,[9] and they are somewhat ambivalent as to whether or not co-op graduates are better prepared for science postgraduate study.

RESEARCH INTO OPERATIONAL ASPECTS OF NEW ZEALAND COOPERATIVE EDUCATION PROGRAMS

Cooperative education in substantive form represents a reasonably recent development in New Zealand (with the exception of the teaching practicum and medical internships). Hence, as occurred elsewhere, historically research was concerned with how to make programs run better and how to provide good evidence to employers that co-op 'worked' in New Zealand (i.e., provided them with direct, often financial, benefits). This is not unreasonable and reflects early development of the co-op movement; we do after all have to justify our existence! This is easier if we can convince our key partners, that is, our employers - that they stand to gain from helping us in operating our programs (see Pauling, 1994; Wise, Priestly, Owen, Gregory & Gilchrist, 1994). Coll and Gardner (2001) argue this often occurs because co-op practitioners or program mangers in TEPs come into co-op from other fields, 'discover' co-op and feel the need to justify its existence within their TEP, or to employers. This sentiment is reflected by the continuation of research into program management or operational aspects of co-op programs in New Zealand; that is, research *not* concerned with learning or education. This battle has been largely won, with most TEP in New Zealand holding substantial databases of satisfied employers, and many conducting regular evaluation studies (Coll, 1996; Skelton & Wilkie, 2005; Sundar, 2005), which generally show evidence of stakeholder satisfaction. But research in this area continues, and so Burchell et al. (2000) report on employer evaluation of perceived desirable graduate competencies in the business sector, and Coll and Zegwaard (2006) report similar research for the science and technology sector.

As well as evaluation studies (i.e., do our stakeholders like the way we run co-op?, see Chapman, Coll & Meech, 1999), there have been some recent studies that focused on perhaps more interesting, under-researched, aspects of co-op, and that have a stronger theoretical base. For example, Coll, Lay and Zegwaard (2002) looked at how trial interviews can enhance access to experiential learning, and Coll and Lay (2001) looked at how to develop self-efficacy in students; other research has concerted how the placement process can be managed remotely using modern IT (McQueen, 2005).

RESEARCH INTO EDUCATIONAL ASPECTS OF NEW ZEALAND COOPERATIVE EDUCATION PROGRAMS

Towards a Theoretical Framework for Inquiry into Educational Aspects of Cooperative Education

Research in co-op in New Zealand took a step forward with the publication of the first major New Zealand co-op study of learning by Eames. As noted above, co-op research has been criticized for a lack of theoretical base (see Bartkus & Stull, 2004; Eames & Cates, 2004); here we the mean theoretical basis to *learning*. Eames's work helped shift the research agenda in New Zealand to a new, more rigorous, level for several reasons. First, it provided the 'missing link'; namely, a solid theoretical base to co-op research - drawing on sociocultural

[9] At the University of Waikato at least statistics show this is not the case.

theories of learning (Eames & Bell, 2005). Here Eames argues that to understand co-op learning, and co-op as an educational strategy, we need to be cognizant of the importance of contextual factors, especially sociological factors. So he talks of the student learning to become a scientist via *legitimate peripheral participation* (Lave & Wenger, 1991), as he or she works alongside scientific experts. This opportunity to appropriate the knowledge, skills and culture of that scientific workplace leads to a deeper understanding of what it means to work in science (Rogoff, 1995). He then speaks of the notion of *mediated action*, in which learning in the workplace is a feature of the particular social circumstances. For example, language, such as the use of acronyms, features as a Vygotskyian tool (Vygostsky, 1986), meaning that there is a way of using language (e.g., writing or speaking 'scientifically'), that is specific to the sociocultural context in which learning occurs. So acronyms like LCMS, GLC, NMR are normal language in a chemistry laboratory, whereas terms like ATP and ADP are common in a biology laboratory. He also notes the concept of *distributed cognition* (Perkins, 1997) where knowledge is not resident solely in an individual (e.g., the workplace supervisor) but is distributed across the workplace (e.g., scientists in the organization might hold knowledge about how to conduct scientific research, but technicians hold knowledge of specific instrument operation and maintenance; and administrators about management and workplace OSH policies, etc.). A work placement then allows a science student to develop an identity and become enculturated within a science community of practice (Wenger, 1998).

A particular feature of Eames's study is its longitudinal nature (the work spanned some 4-5 years, tracing a cohort of students all the way through their undergraduate co-op degree).[10] The study also provides a fascinating insight into what and how learning occurs in a variety of New Zealand scientific enterprises. A few insights were that students gain an in-depth understanding of the research process (e.g., learning that research agenda shift depending on circumstances; and the role of financing in NZ research communities) enabling them to learn the behavior of a researcher, and to develop a way of working and thinking in accordance with a New Zealand research culture. Eames's students also were reported to have developed a deep sense of how they learned, and from whom they learned (i.e., a developing sense of metacognition). They expected to learn from scientists, but were surprised to learn many useful things from others in the learning community in which they were situated (e.g., the technicians and office staff mentioned above). Arguably the most important understanding to come from this work was how different the sociocultural environment was in the workplace compared with academic learning environment. Two examples illustrate some important differences. First, in the workplace one-on-one interactions were routine; in the TEP this was rare, except in the advanced stages of the degree program. Second, in the workplace, particularly in the case of students placed into research institutes, students encounter learning experiences in terms of practical science that were totally different. At university the laboratory classes were highly organized, the way to conduct an experiment was highly detailed in the course laboratory manual, and there was an expected (often numerical) outcome, known in advance. This is in almost dialectic contrast with genuine research in a research institute; where the answer was most certainly not known - or even necessarily attainable, and the way to get 'the answer' needed to be developed from scratch!

[10] This is unusual in New Zealand educational research especially for sole researchers; in New Zealand co-op research it is unknown!

Evidence that Eames's work has indeed helped shift the research agenda in New Zealand co-op research comes from a number of recent studies that have drawn upon his work.[11] This is quite varied and shows the utilitarian nature of the theoretical framework developed for co-op inquiry. The research mostly tries to understand science learning from a student viewpoint. Arguably then, it is not about learning *per se*, but about how people think they learn, what they see as barriers and enabling factors in their science learning, and about how science learning is linked to assessment, and so on. A few examples show how this agenda research has developed.

Practical Science Learning Experiences

The capacity of TEPs to provide real, in-depth learning experiences in practical science is debated extensively in the literature. In a recent substantial review, Nakhleh, Olles and Malina (2002) come to the conclusion that there are very mixed results when it comes to justification for, and convincing evidence that, practical science experiences in school or higher education laboratories actually provide measurable learning outcomes. Other research suggests that this might be due to students' apprehension about engaging in practical science. Fletcher (1990, 1991) suggests co-op can enhance self-efficacy and encourage learning by a process of enactive mastery (i.e., as students with sound mentoring are scaffolded though their learning in the workplace they gain in confidence as they 'master' tasks). Coll, Lay and Zegwaard (2001) subsequently looked at the influence of co-op on student perceptions of their ability in practical science. This it is argued enhances student self-efficacy, and thereby practical science skills by a number of ways. Students learn some practical skills at their TEP. They are typically very nervous about using expensive scientific instrumentation when they first start in industry placements. However, as the practice under good supervision they gain in skill and in efficacy. This is mediated by good mentoring enabled by *verbal persuasion* (i.e., positive encouragement from their mentors) and *personal valuation* of their own capabilities (Figure 1). If one accepts that enhancing self-efficacy is an enabling feature of learning, then this provides an example of the educational value co-op work experience can provide in science learning, and in achieving competency in practical science in particular. It is interesting how complex this process appears in the *dual-situated* learning environment that makes up the co-op experience as presented in the proposed theoretical framework.

Co-op as a Vehicle for Enhancing Equity in Science and Technology Learning and Careers

Second, there has been much research about underrepresentation of certain groups such as women and indigenous peoples in science and technology study in higher education, and in science and technology careers (see, e.g., Cobern, 1998; Hanson, 1996). Paku, Zegwaard and Coll (2003) looked at the role co-op might play in enhancing access to science and technology careers, again drawing on sociocultural notions of learning proposed by Eames. Previous research into this area has been concerned with issues such as 'border crossing' (Aikenhead, 1996) in which students are thought to cross 'cultural' borders from their life world subculture to the subculture of science and science learning.

[11] Eames's work also has contributed to a more theoretically-rigorous research agenda in co-op research internationally (see, e.g., Eames, 2000), and in particular in the from of an invited paper as a lead paper in the 2006 issue of the *Journal of Cooperative Education & Internships* – see Eames and Coll (2006).

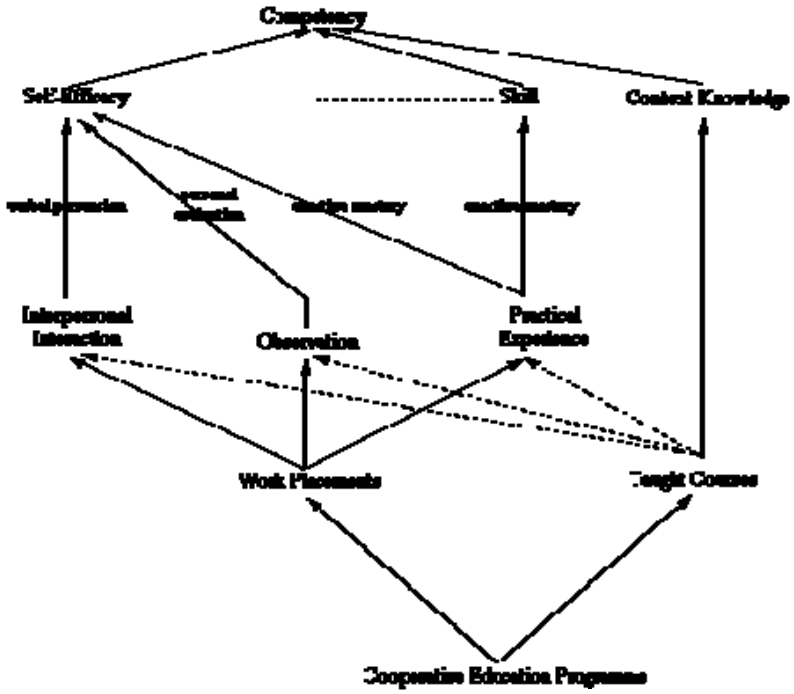

FIGURE 1
Relationship between self-efficacy, learning and cooperative education (after Coll et al. 2001)

Traditional research of 'enculturation' (where a student's life-world subcultures harmonize with the subculture of science) and 'assimilation' (whose life-world cultures differ from the sub-culture of science) also have been addressed in the literature (Aikenhead, 1996). At the institution in which Paku et al. (2003) worked, the approach to improve representation centered on the development of culturally-appropriate support structures for Māori (i.e., individuals who self-identify as indigenous New Zealanders). Here the support structure comprises of *kaitiaki* (mentors). These *kaitiaki* are graduate students and are allocated undergraduate students with similar degree interests. The support given is focused on guidance, providing students with direction and helping them to become 'university-wise'. Contact is maintained by encouraging *kanohi ki te kanohi* approach (face-to-face approach) throughout laboratory sessions and regular *hui* (meetings) throughout the year. Students are also encouraged to take advantage of a resource room that is available to them; which is also an opportunity to meet with other Māori, and utilize the facilities available to them there. All of these initiatives are driven by a consideration of Māori culture, values, ways of thinking - their impact on a sense of belonging, and the impact this has on learning. So how can co-op fit into, or enhance, such support structures? Paku et al. (2002) report that it is clear that Māori students that completed a co-op placement had gained considerable understanding during this period, strongly influenced by the type of knowledge, background of study and type of placement. They freely used terms common to their scientific discipline and those gained from the co-op placement to describe broader terms such as science and technology,

and this influenced how they viewed the roles of technologist and scientist.[12] Students who had completed co-op placements found the experience particularly useful, viewing that their understanding and enthusiasm for their study of discipline had been improved, and further helped the understanding of the relevance of aspects of their studies and complemented the practical component of their discipline. Most importantly, these Māori students felt there was a place for them in science and in science careers, the net result being an enhanced sense of belonging.

Developing a Model for the Assessment of Workplace Learning in Co-op Programs

Finally, the assessment of co-op learning remains a perennial problem (Coll, Eames, Zegwaard & Hodges, 2002; Hodges, Smith & Jones, 2004), and can be equally problematic in practical science. In part at least, the sheer diversity of co-op experiences on placement complicate what is already recognized as a problematic concept - the assessment of what science learning has occurred in a given educational context (Bell & Cowie, 2001). Some authors (e.g., Coll & Zegwaard, 2006) argue that if we know stakeholder expectations of science graduate competencies (i.e., what we would conceptualize as science learning outcomes) then we can devise assessment activities or regimes appropriate to the learning outcomes. So, for example, we might well require students to be able to 'write scientifically', so an appropriate assessment activity would be the marking of a scientific report on what work they did on their placement. But if all three parties felt learning interpersonal communication skills and showing 'ability and willingness to learn'[13] are important, then how can we assess such things? Such issues are of course similar to issues associated with the assessment of practical science classes; viz. there are some skills which are inherently difficult to assess (Nakhleh et al., 2002). Hence research that sheds light on the assessment of co-op work experience may be useful in informing assessment of related activities like practical science classes. Hodges et al. (2004) note this is not exactly obvious. Hodges (2006) and Hodges and Ayling (2007) say we must consider the sociological aspects of the learning situation. So, in addition to negotiating the learning objectives, what constitutes adequate, fair, reliable and valid evidence for achievement of learning outcomes, necessitates more than completing some tick-box sheet sent to employers, marking of a rather conventional written report and somehow combining these into a final 'grade'. Who makes decisions about what evidence is adequate and so on, he argues, is a feature of the social environment. Its is perhaps because of such complexity than many use a dualistic pass-fail assessment regime, but Coll, Taylor and Grainger (2002) comment that this typically leads to all students passing, and provides little incentive for striving to do well.

Hodges (2006) has been brave enough to develop a sophisticated model for the assessment of the work placement in co-op programs. Assessment of such diverse experiences, Hodges argues, necessitates the development of a negotiated, sociocultural portfolio that incorporates tripartite negotiated achievement outcomes, and a component of student self- and peer-assessment (Ayling & Hodges, 2007, see Figure 2). This represents significant advancement

[12] Interestingly, this fist in closely with Eames's (2003) findings for non-Maori students, pointing to the utilitarian nature of his theoretical framework, and consequent methodology.

[13] Interestingly, this was the most important graduate competency identified by all of employers, students, new graduates and higher education teaching faculty in science and engineering (Coll & Zegwaard, 2005) and in business sectors (Burchell et al., 2000).

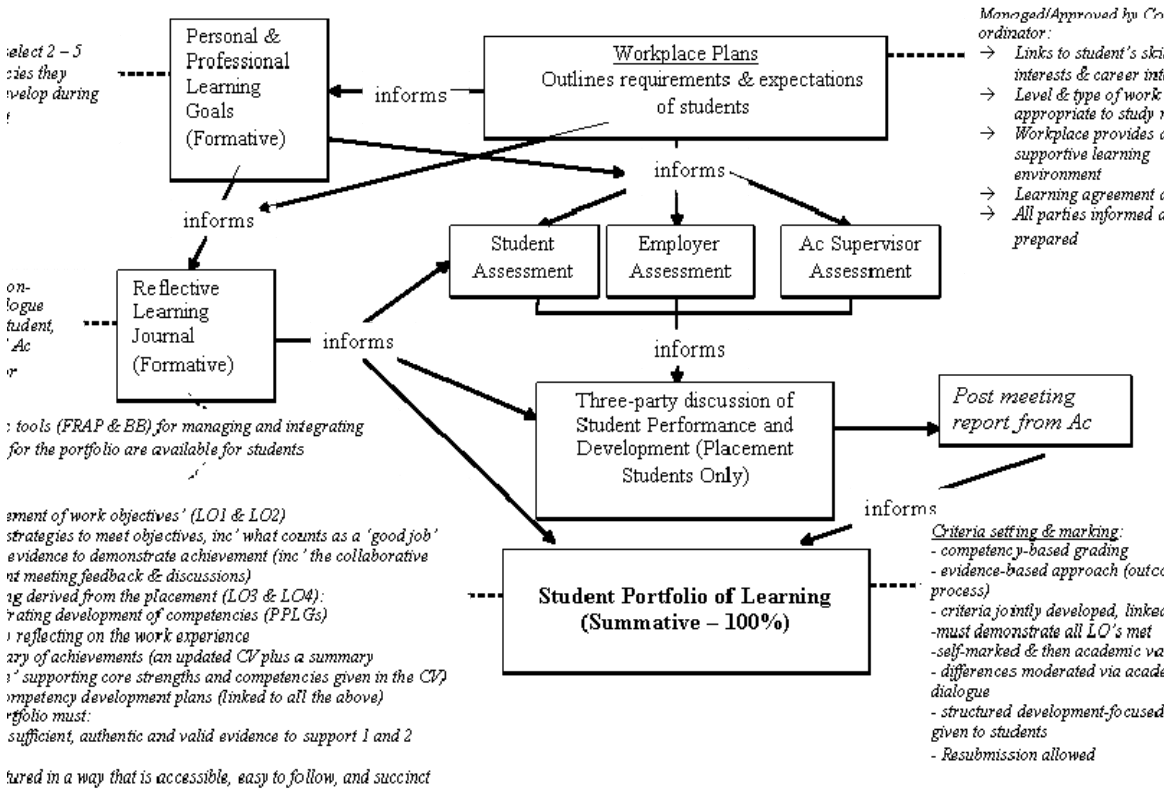

FIGURE 2
A sociocultural portfolio approach to assessment of student learning on placement (Ayling & Hodges, 2007)

on traditional, rather simplistic ways of assessing student learning in co-op (Hodges et al., 2004). As Hodges et al. (2004) point out, the challenge is how to allow for diversity of workplace situations, together with associated differences in learning aims and expectations. At the time of writing this model is under evaluation in a series of pilot studies.

ISSUES AND FUTURE TRENDS IN NEW ZEALAND COOPERATIVE EDUCATION PROGRAMS

Cooperative education seems to be prospering in New Zealand, if the number of programs being offered and research interest in co-op is used as a yardstick.[14] Furthermore, sustained research in cooperative education in New Zealand, mirroring overseas research, suggests many programs are meeting the operational needs of the three stakeholder groups, and that practitioners have a sound understanding of stakeholder needs - particularly employers, and more recently faculty. Programs seem to have appropriate management structures in place, with suitable support for students on placements, and that these structures can help traditionally underrepresented groups, such as indigenous peoples, come to a better understanding of science, and their potential place in the scientific community. Recent research for science and technology programs in New Zealand also suggests co-op has the capacity to be a genuine educational strategy, and as such should be considered a curriculum option for New Zealand TEP of science programs. Co-op learning, including science learning, it seems, can be understood through a sociocultural lens; is facilitated by understanding of program and stakeholder operational needs and desired outcomes (such as desired graduate competencies); is facilitated by an understanding of the *what* and *how* of learning; and is driven by the nature of assessment regimes.

A key issue for co-op research in New Zealand is achieving a critical mass for what is a relatively modest-sized co-op research community. There are now a number of co-op practitioners involved in, or who have recently completed masters and PhD theses, on co-op educational and operational issues, meaning the level of expertise in educational research has significantly increased recently. The New Zealand co-op professional body, NZACE, is working to develop a supportive collaborative research environment. For the first time, in 2007 a cohort of researchers from NZACE ranks has developed a substantial cross-institutional, cross-sector, research agenda (that includes science, business & sport studies) that seeks to better understand the integration of workplace and on-campus learning. This ambitious project will draw upon the landmark co-op research by Eames (2003) that provides a rigorous basis for research design and methodology.

Coll and Eames (2004) argue that co-op needs such a shared agenda; an agenda *that focuses on education rather than training*:

> Co-op practitioners, researchers, and professional bodies, perhaps aligned with employers, at the national and international level must strive to advance co-op as *education*. Researchers need to provide these bodies with the lobbying tools, high-quality research that co-op is operationally successful (we have plenty of evidence for that now), and research that shows how and what students learn during co-op. Co-op educators must be true to educating the student first and foremost in quality programs that adhere to well-founded organization, curricula, and pedagogy. (pp. 280-281)

[14] Research interest and output in co-op in New Zealand has undoubtedly increased, but this may be due, in part at least, to the introduction of Performance-Based-Research Funding (PBRF), a form of Research Assessment Exercise (RAE) practised in the UK.

We have argued in this article that in New Zealand, this agenda has at least begun, and that a continued, shared purpose is an essential feature of a sustained research effort. The outcomes of research on a variety of fronts will in time show if this aim is in fact realized.

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ABOUT THE JOURNAL

The Asia-Pacific Journal of Cooperative education (APJCE) arose from a desire to produce an international forum for discussion of cooperative education issues for practitioners in the Asia-Pacific region and is intended to provide a mechanism for the dissemination of research, best practice and innovation in work-integrated learning. The journal maintains close links to the biennial Asia-Pacific regional conferences conducted by the World Association for Cooperative Education. In recognition of international trends in information technology, APJCE is produced solely in electronic form. Published papers are available as PDF files from the website, and manuscript submission, reviewing and publication is electronically based.

Cooperative education in the journal is taken to be work-based learning in which the time spent in the workplace forms an integrated part of an academic program of study. Essentially, cooperative education is a partnership between education and work, in which enhancement of student learning is a key outcome. More specifically, cooperative education can be described as a strategy of applied learning which is a structured program, developed and supervised either by an educational institution in collaboration with an employer or industry grouping, or by an employer or industry grouping in collaboration with an educational institution. An essential feature is that relevant, productive work is conducted as an integral part of a student's regular program, and the final assessment contains a work-based component. Cooperative education programs are commonly highly structured and possess formal (academic and employer) supervision and assessment. The work is productive, in that the student undertakes meaningful work that has economic value or definable benefit to the employer. The work should have clear linkages with, or add to, the knowledge and skill base of the academic program.

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The editorial board welcomes contributions from authors with an interest in cooperative education. Manuscripts should comprise reports of relevant research, or essays that discuss innovative programs, reviews of literature, or other matters of interest to researchers or practitioners. Manuscripts should be written in a formal, scholarly manner and avoid the use of sexist or other terminology that reinforces stereotypes. The excessive use of abbreviations and acronyms should be avoided. All manuscripts are reviewed by two members of the editorial board. APJCE is produced in web-only form and published articles are available as PDF files accessible from the website http://www.apjce.org.

Research reports should contain; an introduction that describes relevant literature and sets the context of the inquiry, a description and justification for the methodology employed, a description of the research findings-tabulated as appropriate, a discussion of the importance of the findings including their significance for practitioners, and a conclusion preferably incorporating suggestions for further research. Essays should contain a clear statement of the topic or issue under discussion, reference to, and discussion of, relevant literature, and a discussion of the importance of the topic for other researchers and practitioners. The final manuscript for both research reports and essay articles should include an abstract (word limit 300 words), and a list of keywords, one of which should be the national context for the study.

Manuscripts and cover sheets (available from the website) should be forwarded electronically to the Editor-in-Chief directly from the website. In order to ensure integrity of the review process authors' names should not appear on manuscripts. Manuscripts should include pagination, be double-spaced with ample margins in times new-roman 12-point font and follow the style of the Publication Manual of the American Psychological Association in citations, referencing, tables and figures (see also, http://www.apa.org/journals/faq.html). The intended location of figures and diagrams, provided separately as high-quality files (e.g., JPG, TIFF or PICT), should be indicated in the manuscript. Figure and table captions, listed on a separate page at the end of the document, should be clear and concise and be understood without reference to the text.