

Addressing Challenges for Internationalisation and Mobility in Engineering Through CDIO Standards

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***Abstract:** There is a growing need for international transparency of engineering qualifications, and mechanisms to support and facilitate student mobility. In response, there are a number of global initiatives attempting to address these needs, particularly in Europe, North America and Australia. The Conceive-Design-Implement-Operate (CDIO) Initiative has a set of standards, competencies, and proficiency levels developed through a global community of practice. It is a well-structured framework in which best-practice internationalisation and student mobility can be embedded. However, the current 12 CDIO Standards do not address international qualifications or student mobility. Based on an environmental scan of global activities, the underpinning principles of best practice are identified and form the basis of the proposed 13th CDIO Standard – “Internationalization and Mobility”.*

Introduction

Graduate engineers of the future will increasingly need to be international in their outlook and experience, and be prepared to operate globally. Businesses have to compete and collaborate on a global scale, and operate across national and international borders with organisational environments being increasingly complex, dynamic and with more interdependencies. Our challenge as educational institutions is to aid our students to prepare for this global environment.

CDIO is a global initiative beginning with collaboration between a consortium of Swedish Universities, Massachusetts Institute of Technology (MIT), and the US Naval Academy, funded originally by the Knut and Alice Wallenberg Foundation. Based on the broad engineering principles of product and system design, CDIO gets its name from the product and system design principles of Conceive, Design, Implement and Operate. It has grown into a global community of practice with more than 40 engineering schools in the U.S., Europe, Canada, U.K., Africa, Asia, Australia and New Zealand.

CDIO has adopted 12 Standards as guiding principles for program reform and evaluation. The 12 CDIO Standards address program philosophy, curriculum development, design-build experiences and workspaces, new methods of teaching and learning, faculty/academic development, and assessment and evaluation (Crawley et al, 2009). However, at present, the Standards do not explicitly address international qualifications or student mobility. In response, the first author of this paper (Duncan Campbell) has drafted the 13th CDIO Standard, Internationalization and Mobility. This paper presents the underpinning case for the formulation of the draft Standard and process for its potential adoption.

Background

A shortage of students willing to study abroad is causing international embarrassment for Australian universities, which stand accused of being more interested in export dollars than educational exchanges (Rout, 2007).

The benefits of and growing need for international transparency in engineering qualifications, simple cross-credit processes, international dual awards and mechanisms to encourage student mobility are

receiving much attention around the world at present. In response, there are a number of global initiatives now examining how these issues may be addressed, particularly in Europe, North America and Australia. A number of these are discussed later in this paper.

The challenge for educational institutions is to assist students to prepare for this interdependent global environment. The Stratégé Study (Buisson and Jensen, 2009) found that worldwide, there is a requirement to increase the internationalisation of engineering programs, content and context, as well as support the mobility of engineering students and scholars. Indeed, employers have expressed the need for undergraduates to have global competence to enable them to function in the corporate environment (Dolby, 2008, Grandin and Hirleman, 2009). Not only will engineers need technical competence, but will also need to have an understanding of global conditions, and be aware of and sensitive to differences in cultural environment and work ethic (Abanteriba, 2006). Mobility and international experience give students the opportunity to be immersed in other cultures, with exposure to different and unfamiliar situations and different approaches to problem solving (Department of Education, Employment and Workplace Relations (DEEWR), n.d.). Other benefits include “the promise of returning with an enhanced understanding of the world and its intricate web of political, economic, social and cultural relationships” (Dolby, 2008). The Queensland Education and Training International (QETI) & International Education Association of Australia (IEAA) study of the attitudes and perceptions of Australian employers (2006, in DEEWR n.d.) claims that 61 percent of employers view international study experiences as unique and a competitive addition to a resume, while 81 percent of employers believe that graduates who undertake an overseas experience return to Australia with enhanced skills that are applicable to the workplace.

Global experience for students, as part of their degree, is supported by (but not limited to) governments of Australia, the EU, the USA, the engineering profession and employers. While the trend for student mobility increases annually, study abroad demands the mutual understanding and recognition of others’ educational systems (Buisson and Jensen, 2009).

Internationalisation and Mobility Agenda

International study experience has been on the educational agenda for at least a decade (Pasfield, Taylor and Harris, 2009), with employers, governments and educational institutions driving student mobility changes that will ensure graduates are equipped to face a globalised workplace. Most agree on the individual, social, educational, cultural and national benefits derived from broad exposure to international experience, and the intellectual benefits from global collaboration. Specifically, companies need culturally-sensitive workers, prepared to accept the challenges and benefits of working in a different environment, and who can be mobilised to suit their strategic needs.

The Newport Declaration (2008) calls on engineering educators, engineering administrators, and engineering policy leaders to “take deliberate and immediate steps to integrate global education into the engineering curriculum to impact all students, recognizing global competency as one of the highest priorities for their graduates”.

Student mobility, both inbound and outbound, has well-documented benefits for students and employers that are broadly acknowledged across the globe. However, the impediments to student mobility including costs, language difficulties, timing (of the mobility window), but especially academic recognition, have significantly limited the potential for students to study abroad.

The *International Student Mobility Study* undertaken by the Universities of Sussex and Dundee (UK), states that around 1.8 million students were studying outside their country of origin in 2000, a figure that is expected to rise to 7.2 million by 2025 (DEEWR, n.d.). An estimated 200,000 American students studied abroad in 2006 (Rexeisen, Anderson, Lawton and Hubbard, 2008); or 8.5% pa in 2007, and 2.2% of Canadian college and university students also studied abroad (DEEWR, n.d.).

Inbound mobility

In a speech on 26 May 2009, The Hon Julia Gillard MP stated: “International education has made a significant contribution to Australia. It has grown to now be our third-largest source of overseas earnings, generating \$15.5 billion in 2008 and supporting more than 125,000 jobs. In 2008, nearly half

a million students came to Australia. It is the lead sector in terms of export earnings in Victoria and the second largest in New South Wales". Indeed, inbound mobility students studying in Australia in 2008 numbered more than 543,000, injecting \$14.2 billion into the Australian economy (DEEWR, n.d.).

Outbound mobility

There is no real tradition of studying abroad for Australian students as there has been for European students. However, the trend for overseas study in the past five years indicates a ten percent growth in this area (DEEWR, n.d.). The Australian Universities International Directors' Forum (AUIDF) Report (2008) reveals that in 2007, 8354 undergraduate students, or 5.8% of completing students, from 37 Australian universities undertook international study. Of this number, 5.6% were engineering students. The corresponding proportion of mobile engineering students for the UK is 1.2% and 0.3% for the USA (Australian Education International (AEI), 2009). UNESCO data indicates that the top host countries for Australian students in 2006 were the USA, New Zealand, the UK, Canada, Germany and Japan (AEI, 2009).

The majority of international study experiences of all types were funded by the university or by government; 60% were supported by university funds, 4% from Australian Government programs such as University Mobility in Asia and the Pacific (UMAP), 5% by a combination of university funds and Government programs, 13% by OS HELP (\$14 million in student loans in 2009. [AEI 2009]), and 5% supported privately or by other Australian foundations (AUIDF, 2008).

Impediments to student mobility

The process of cross-credit is problematic, where knowledge of the worth of study programs is questionable or unknown. Recognition, curricula rigidity and credit are identified by several studies as obstacles to student mobility, along with the potential of prolonged study and the lack of recognition by the home university (Buisson and Jensen, 2008; Grandin and Hirleman, 2009). Resolving these issues contributes to realizing the potential of trans-national cross-accreditation and the prospect of students owning their own eportfolio of transferable attributes and credentials.

In a report to the National Summit Meeting on the Globalisation of Engineering Education, The IFEES (International Federation of Engineering Education Societies) Secretariat identified obstacles and hurdles to international academic opportunities, with which Australia might also identify, summarised as follows (Grandin and Hirleman, 2009):

- **Curricular rigidity**
- **Lack of tradition**
- **Lack of support** from study abroad professionals; for cross-disciplinary activities; by departments, colleges of engineering or faculty
- **American mono-lingualism**
- **Academic rewards system**
- **University financial restrictions**
- **Student financial restrictions**
- **Difficulty in transferring credit**
- **Negative perception of study abroad**
- **Disconnect** in the corporate world between CEO and HR
- **Private vs. university-based programs**
- **Lack of emphasis on total immersion for a significant length of time**
- **Difficulty in recruiting**
- **Lack of cultural preparation**

Transportability of qualifications

The transportability of qualifications has long been an issue perceived by students. However, means of improving the mobility of students between the EU and Australia have been identified by Buisson and Jensen (2008), who claim that transportability of qualifications will be critical in the future not only for academic credit but potentially for accreditation under the Washington Accord or under the EUR-ACE (EUROpean Accredited Engineer), accreditation being developed in Europe.

European students are well catered for through programs such as the following, but many of these may not be applicable for Australian students studying abroad:

- **IFEES** - Through the collaboration of its member societies, IFEES works to establish effective engineering education processes of high quality around the world to assure a global supply of well-

prepared engineering graduates. IFEEES also enhances the ability of engineering faculty, students and practitioners to understand the varied cultures of the world and work effectively in them.

- **International Cotutelle** - The international Cotutelle program, involving a number of Australian Universities, is a French national initiative that offers jointly supervised PhD qualifications leading to a doctoral degree that is recognized by the two participating countries.
- **Erasmus Mundus (2009-2013)** is a cooperation and mobility program that supports joint postgraduate programs, researchers and university staff as well as joint projects to enhance European higher education worldwide. Recognised courses are hosted from a consortium of higher education institutions from across Europe, and other Northern hemisphere regions.
- **EUR-ACE** - The European engineering accrediting agency, has proposed a European system of accreditation of engineering educational programs (ENAAE, 2009). This system raises the potential for mutual recognition of accreditation in collaboration with Engineers Australia (Buisson and Jensen, 2009).

Other frameworks for the recognition of qualifications do exist, but are limited for, or totally preclude, Australian outbound students. These include:

- **European Credit Transfer and Accumulation System (ECTS)** - ECTS guarantees academic recognition of studies abroad. “With ECTS, higher education institutions preserve their autonomy and responsibility for all decisions concerning students' achievements, without amending existing course structures and assessment methods: all courses and assessments are those which are normally taken by regular students at the host institution” (AEIE, 2009). The ECTS standard allows comparison of study attainment and performance of EU higher education students and other collaborating European countries. (ECTS, 2009)
- **SEFI - Société Européenne pour la Formation des Ingénieurs** - Europe's largest network of higher engineering institutions, was founded in 1973 for the purpose of contributing to the development and the improvement of engineering education in Europe (SEFI, 2009).
- **The European Qualifications Framework (EQF)** - The European Qualifications Framework for Life Long Learning (EQF, 2009) is a common reference framework which enables European countries to link their qualifications systems to one another. Its key aim is to contribute to creating a truly mobile and flexible European workforce.
- **National Coordination Point (NCP)** - The National Coordination Point, established by the European Commission, is intended as a means of relating each Member State's qualifications systems to the European Qualifications Framework (EQF). It is tasked with referencing levels of national qualifications systems to the EQF, promoting quality assurance principles while maintaining transparency of the methodology (QCA, 2009).
- **World Federation of Engineering Organisations (WFEO)** –A working group of the WFEO Committee on Education and Training has been tasked to prepare a policy on the mobility of professional engineers, “WFEO Policy on Accreditation of Courses and Mobility of Engineering Professionals” (Greenwood, 2008). The policy is currently draft with the intention of having it adopted later in 2009.

Draft CDIO Standard (13) – Internationalization and Mobility

The CDIO Initiative has a number of syllabus topics around internationalisation expressed through:- 3.3 *Communications in Foreign Languages*; 2.5.2 *Professional Behavior*; 2.5.4 *Staying Current on World of Engineer*; and 4.1.6 *Developing a Global Perspective* (Crawley et al, 2009). There is a current revision taking place of the CDIO Syllabus and is likely that greater emphasis on internationalisation will be made. Oosthuizen (2009) also writes about the need for greater internationally based experiences within the curriculum.

The CDIO Standards however, do not make explicit mention of internationalisation or mobility. There is little guidance or environmental consideration around internationalisation, and enablers of mobility for CDIO programs. It is therefore proposed that the CDIO Initiative responds through: (i) more explicit recognition of international issues and multi-cultural curriculum through the CDIO Syllabus, (ii) that collaboration and resource sharing be facilitated in this domain, and (iii) that a new CDIO Standard be adopted on “Internationalization and Mobility”. The draft Standard, authored by the first

author of this paper (Duncan Campbell) is intended to provide guidance and key attributes based on current best practice and recommendations summarised in this paper. It was tabled at the 2009 CDIO Conference in Singapore for initial debate. The proposed Standard was subsequently circulated around the global CDIO community for comment over a three month period. Final debate and decision by the CDIO Council is scheduled for the October CDIO Collaborators' meeting in Turku (Finland) (following the final submission of this paper). An extract of the proposed Standard 13 is shown below.

Standard 13 (July Draft) - CDIO Internationalization and Mobility

Programs and organizational commitment which exposes students to foreign cultures, and promotes and enables transportability of curriculum, portability of qualifications, joint awards, transparent recognition and international mobility.

Description: CDIO Program Internationalization and Mobility encourages and recognizes organizational commitment which prepares engineers for a global environment and exposes them to a rich set of international experiences and contexts during their studies. It represents the exposure, promotion, facilitation, opportunity and scholarship of an internationalized curriculum, qualifications and international mobility of students.

Rationale: Graduate engineers of the future will increasingly need to be international in their outlook and experience, and be prepared to operate globally. Businesses have to compete and collaborate on a global scale, and operate across national and international borders with organizational environments being increasingly complex, dynamic and with more interdependencies. Our challenge as educational institutions is to aid our students to prepare for this global environment.

Evidence may include, non-exclusively, one or more of the following:

- The embedding of authentic cultural awareness and experiences within the curriculum, or social activities
- Opportunities for students to learn second languages
- Programs which encourage and recognize study abroad, and other international experiences (including internships, exchanges) for credit
- Establishment of a mobility window within programs and curriculum
- An ePortfolio facility which links student learning outcomes with artifacts, and graduate attributes and competencies which are recognized through international accords
- A demonstrable and tangible institutional commitment to internationalization and student mobility
- Complimentary partnerships between international universities
- Transparent expectations of student learning outcomes from an international experience
- International benchmarking of programs
- Active involvement in international engineering education scholarly activities
- Program accreditation with international cross-accreditations (eg. Washington accord, ...)
- Transparency in intuitional cross-credit for study aboard
- Partnerships with international corporations/industry with offices co-located with partnering institutions
- Professional development programs (including sabbatical leave) on internationalization and mobility for faculty
- Dual award programs involving two or more countries
- Participation in international global mobility networks

Conclusion

The benefits and growing need for international transparency in engineering qualifications, simple cross-credit processes, international dual awards and mechanisms to encourage student mobility are recognised. A number of impediments to mobility, and trans-national curriculum and qualification compatibility are identified, however there are now several global initiatives examining how these issues may be addressed, particularly in Europe, North America and Australia.

The CDIO Initiative has a well established global community of practice, organisational affiliations, and institutional collaborations. It brings a network of relationships beyond regional bounds and jurisdictions. In many ways, CDIO already embraces and practices the key characteristics which positively contribute to internationalisation and mobility. This paper encapsulates the underpinning argument to adopt a new CDIO Standard:- Standard 13 (Draft) – “CDIO Internationalization and Mobility” with the view of bringing an extra and unique dimension to establishing a global culture and practice of internationalisation and mobility.

References

- Abanteriba, Sylvester. (2005). Development of strategic international industry links to promote undergraduate vocational training and postgraduate research programmes. *European Journal of Engineering Education*, 31(3). June 2006, pp. 283-301. Accessed at www.pdfserve.informaworld.com/887448_751316001_747659790.pdf on 22 May 2009.
- AEI – Australian Education International, July 2009. Research Snapshot. Accessed at <http://aei.gov.au/AEI/PublicationsAndResearch/Snapshots/2009070310.pdf> on 7 August 2009.
- AUIDF Report (2008). Outgoing International Mobility of Australian University Students 2007. Australian Universities International Directors' Forum, August 2008.
- Australian Technology Network of Universities. (2009). Media statement: International Education Critical to our Nation's Learning Environment. Email from Executive Director dated 2 June 2009.
- Rout, Milanda. (2007). No Place Like Home. *The Australian*, (8 August 2007). Accessed at <http://www.theaustralian.news.com.au/story/0,25197,22206743-12332,00.html> on 8 August 2009.
- Buisson, David and Jensen, Robert. (2008). STRATÉGÉ – Study of mobility of Australian and European Union engineering students and tools to assist mobility. *Proc. 2008 AaeE Conference*, Yeppoon, Australia.
- Buisson, David and Jensen, Robert. (2009). STRATÉGÉ – Study of Transparent recognition, Accreditation Tools and Experience in a Global Environment. Project Report to ATN Universities, Australia.
- Crawley, E., Malmqvist, J., Ostlund, S., Brodeur, D., 2007. Rethinking Engineering Education – The CDIO Approach, Springer, 2007.
- Department of Education, Employment and Workplace Relations (n.d.). Australian outbound mobility: Current trends. Australia.
- Dolby, Nadine. (2008). Global Citizenship and Study Abroad: A comparative Study of American and Australian Undergraduates. *Frontiers: The Interdisciplinary Journal of Study Abroad*. V. XVII, Fall 2008. P. 51-67.
- ECTS - European Credit Transfer and Accumulation System. European Commission. Accessed at http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm on 25 May 2009.
- ENAAEE - European Network for Accreditation of Engineering Education (2009). Accessed at <http://www.enaee.eu/enaee/presentation.htm> on 24 May 2009.
- European Qualifications Framework (2009). Accessed at http://www.qca.org.uk/qca_19302.aspx on 12 May 2009.
- Grandin, J.M. and Hirableman, E.D. (2009). Educating Engineers as Global Citizens: A Call for Action/ Report of the National Summit Meeting on the Globalization of Engineering Education. *Online Journal for Global Engineering Education*, V.4, Is. 1. Accessed at <http://digitalcommons.uri.edu/ojgee/vol14/iss1> or <http://globalhub.org/resources/799> on 15 May 2009.
- Greenwood, P. (2008). Mobility of Engineering Professionals. Standing Committee on Education and Training Report (CET). Accessed at <http://www.wfeo.org> on 25 August 2009
- Newport Declaration, The (2008). Accessed at <http://globalhub.org/newportdeclaration> On 22 June 2009.
- Oosthuizen, Patrick (2009). International Requirements in CDIO Programs” *Proc. 5th International CDIO Conference*, 7-10 June 2009, Singapore Polytechnic, Singapore.
- Pasfield, A., Taylor, K., and Harris, T. (2009). Encouraging outbound student mobility: An update from Australian Education International. *Proceedings of the 19th ISANA International Education Association Conference*.
- QETI & IEAA study (2006). The Attitudes and Perceptions of Australian Employers Towards an Overseas Study Experience. *Queensland Education and Training International 2006*.
- Qualifications and Curriculum Authority, (2009). European Qualifications Framework. Accessed at http://www.qca.org.uk/qca_19302.aspx on 14 June 2009.
- Rexeisen, Richard J, Anderson, Philip H., Lawton, Leigh and Hubbard, Ann C. (2008) *Frontiers: The Interdisciplinary Journal of Study Abroad*, Vol. XVII, Fall 2008, p.1-20.
- Rout, Milanda. (2007). No Place Like Home. *The Australian*, (8 August 2007). Accessed at <http://www.theaustralian.news.com.au/story/0,25197,22206743-12332,00.html> on 8 August 2009.
- SEFI - European Society for Engineering Education Accessed at http://www.sefi.be/?page_id=2 on 14 May 2009.

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