AN EXTENDED CDIO SYLLABUS FRAMEWORK WITH PREPARATORY ENGINEERING PROFICIENCIES

Duncan Campbell
Les Dawes
Hilary Beck
Sam Wallace

Queensland University of Technology, Brisbane, Australia

Carl Reidsema

University of New South Wales, Sydney, Australia

Brenton Dansie

University of South Australia, Adelaide, Australia

ABSTRACT

The CDIO Initiative has been globally recognised as an enabler for engineering education reform. With the CDIO process, the CDIO Standards and the CDIO Syllabus, many scholarly contributions have been made around cultural change, curriculum reform and learning environments. In the Australasian region, reform is gaining significant momentum within the engineering education community, the profession, and higher education institutions. This paper presents the CDIO Syllabus cast into the Australian context by mapping it to the Engineers Australia Graduate Attributes, the Washington Accord Graduate Attributes and the Queensland University of Technology Graduate Capabilities. Furthermore, in recognition that many secondary schools and technical training institutions offer introductory engineering technology subjects, this paper presents an extended self-rating framework suited for recognising developing levels of proficiency at a preparatory level. The framework is consistent with conventional application to undergraduate programs and professional practice, but adapted for the preparatory context. As with the original CDIO framework with proficiency levels, this extended framework is informed by Bloom's Educational Objectives. A proficiency evaluation of Queensland Study Authority's Engineering Technology senior syllabus is demonstrated indicating proficiency levels embedded within this secondary school subject within a preparatory scope. Through this extended CDIO framework, students and faculty have greater awareness and access to tools to promote (i) student engagement in their own graduate capability development, (ii) faculty engagement in course and program design, through greater transparency and utility of the continuum of graduate capability development with associate levels of proficiency, and the context in which they exist in terms of pre-tertiary engineering studies; and (iii) course maintenance and quality audit methodology for the purpose of continuous improvement processes and program accreditation.

KEYWORDS

CDIO Syllabus, Graduate attributes, Learning outcomes, Integrated curriculum, Engineering in Schools

INTRODUCTION

Curriculum and cultural reform in engineering education is very much on the agenda internationally. An immediate driver for this is the global professional engineering skill shortage. Engineering skills contribute directly to the global economy, environment, security and health. In Australia, there is a current reported shortfall of some 20,000 engineers to undertake *known or available* engineering work [1]. Engineering businesses seek engineers with abilities and attributes in two broad areas – technical understanding and generic graduate attributes. The first of these comprises: a sound knowledge of disciplinary fundamentals; a strong grasp of mathematics; creativity and innovation; together with the ability to apply theory in practice. The second is the set of attributes that enable engineers to work effectively in a business environment: communication skills; team working skills; and business awareness of the implications of engineering decisions and investments. [2]

Over the past decade, Australian engineering schools have been innovative and responsive to students' needs, while meeting the requirements of industry and the professional accreditation bodies. The Engineers Australia (EA) accreditation process assesses programs against the delivery of graduate attributes, the educational environment, assessment and the quality systems used to ensure program delivery. The graduate attributes are also elaborated in the accreditation system as *professional competencies* that may be used for program design. The real test of the professional competencies for most graduates will be their fit to employers' requirements, and the rate at which they can progress through work-place experience to gain the required competencies for practice as independent professionals and gain full Chartered status. Despite progress made by institutions worldwide, it remains a challenge to integrate these professional outcomes in engineering programs in a manner that prepares students for the professional complexities of their careers. This is due to traditional thinking about engineering curricula, and in a sense holding onto past messages [3]. Felder and Brent point out that equipping students with necessary skills (graduate attributes) is much harder than determining whether or not they have these skills [4].

The Australian accreditation process is benchmarked formally as producing "substantially equivalent" outcomes as those of the other 12 signatory jurisdictions of the Washington Accord (for professional engineering qualifications) and the six other signatory jurisdictions of the Sydney Accord (for engineering technologist qualifications). Each accord has developed a set of program outcome standards (otherwise called *graduate attribute exemplars*) that are reviewed periodically by the accord signatories to ensure that they are in step with on-going changes to national higher education systems. The accord standards and processes demonstrate a powerful means of international benchmarking of professional qualifications. [1]

Australian engineering schools have maintained good international educational standards by a combination of mechanisms, including international benchmarking, international staff recruitment, student and staff exchanges, and participation in international curriculum networks such as the CDIO model, strong academic participation in international engineering education conferences, and foundation membership by Engineers Australia of the International Engineering Alliance.

The CDIO concept promotes the notion that "*learning activities are crafted to support explicit pre-professional behaviour*" [5]. Much of the CDIO philosophy is in line with the expressed focus of most Australian engineering schools with the CDIO Standards and self-rating framework providing a methodology for evaluating the effectiveness of engineering program initiatives at the tertiary level.

The Australian Learning and Teaching Council (ALTC) sponsored report by Robin King, *Engineers for the Future: - Addressing the supply and quality of Australian engineering graduates for the 21st century* [1], has made a number of recommendations to stimulate the agenda for engineering education for the next decade, and at a time when the demand for engineers significantly exceeds the supply of graduates. This paper focuses on two of the recommendations.

1. **Raise the public perception of engineering** ("…including within primary and secondary schools …")
2. **Implement best-practice engineering education** ("…define curricula more strongly around engineering problem solving, engineering application and practice, and develop the themes of design...")

These recommendations are intended to be a 'roadmap' for the next decade of development of Australia's engineering education system.

Two nationally funded projects which are addressing, in part, these recommendations are:

(i) **Design Based Curriculum Reform within Engineering Education** (Australian Learning and Teaching Council)

(ii) **Australian Technology Network (ATN) Engineering in Schools** (Collaboration and Structural Reform)

With respect to the CDIO Standards, a significant aspect of these projects in addressing the two recommendations is the development of integrated curriculum (CDIO Standard 3), design-implement experiences (CDIO Standard 4), active learning (CDIO Standard 8), and enhancement of faculty skills competence (CDIO Standard 9), in the context of both senior secondary school and tertiary engineering curricula. [5]

This paper makes two key contributions which casts the CDIO Syllabus and an extended self-rating framework with preparatory proficiency levels into the Australian engineering qualification context.

1. The CDIO Syllabus topics are linked to the Engineers Australia Graduate Attributes, Washington Accord Graduate Attributes and QUT Graduate Capabilities, the former to provide Australian professional association mapping and the latter to demonstrate an institution mapping. This mapping was based on the same principles used to map the CDIO Syllabus to the ABET Student Outcomes by Crawley et al [5].
2. The self-rating framework introduced by Crawley et al [5] is extended to include levels of proficiency within the context of pre-tertiary engineering technology learning at secondary school and technical training institutions. Bloom's Taxonomy was employed to inform the different levels of cognitive ability to produce learning outcomes and preparatory levels of proficiency. A particular example is given of rating the Queensland Studies Authority senior secondary school Engineering Technology syllabus based on the proposed preparatory levels of proficiency.

CDIO SYLLABUS AND ENGINEERING CAPABILITIES

The CDIO Syllabus is expressed in levels which range from a broad set of competency statements to finer grained syllabus topics. Each syllabus topic is expressed in terms of proficiency levels based on Bloom's Educational Objectives in the cognitive domain:- *Knowledge* (Levels 1 and 2), *Comprehension* (Level 3), *Application and Analysis* (Level 4), *Synthesis and Evaluation* (Level 5) [5][6]. Conceptually, this relationship is illustrated in Figure 1 (below). Greater detail of proficiency levels is given in Table 6.

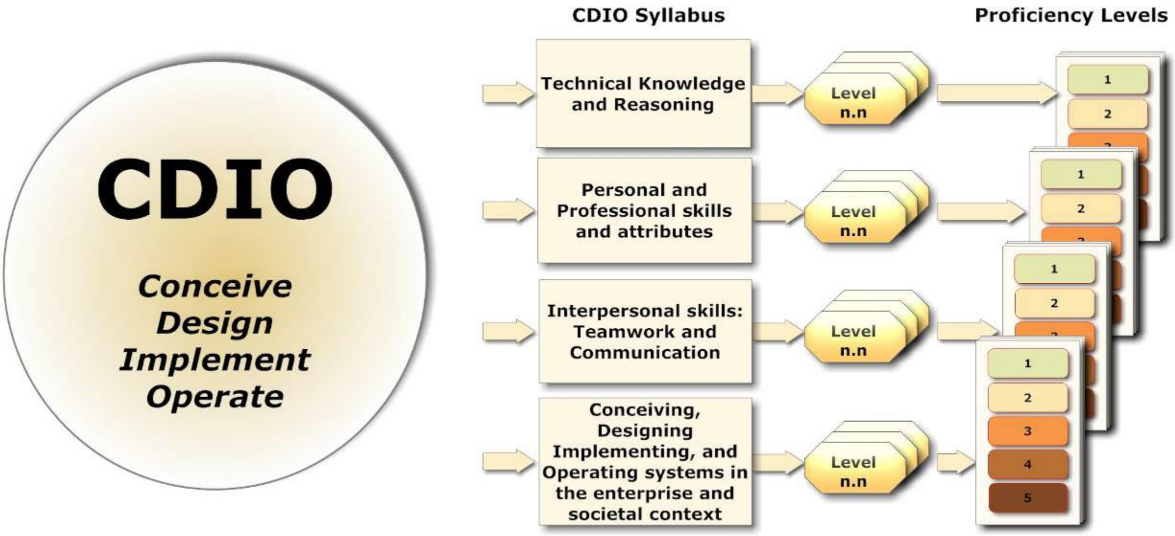

Figure 1. Conceptual overview of the CDIO Syllabus and topic linkage with proficiency levels [5].

The three levels of the CDIO Syllabus can be represented in terms of *n*, *n.n* and *n.n.n*. The top level (*n*) comprises the four broad ranging statements as shown in Figure 1. The top two CDIO Syllabus levels (*n* and *n.n*) have the greatest alignment with commonly stated graduate attributes, graduate capabilities and (key) learning outcomes from accrediting bodies and syllabus stakeholders. The mapping to ABET Student Outcomes [7] has been performed previously by Crawley et al [5].

CDIO Syllabus Mapping in the Australian Context

With a growing community of practice throughout the CDIO Australia and New Zealand Regional Group, and the Australasian Association for Engineering Education (AAEE) via the CDIO Special Interest Group, there is a need to map the CDIO Syllabus within the Australian context. In this exercise, the mapping exercise was applied to the graduate attributes/capabilities published by Engineers Australia (the professional accrediting body in Australia) [2], the Washington Accord (an international alliance of accrediting bodies to which Engineers Australia is a signatory) [8], and the Queensland University of Technology (QUT) (to give an institutional example of graduate capability mapping) [9].

These mappings are tabulated along with the previously published mapping against the ABET Graduate Outcomes in Table 1 (below). This mapping is an initial proposition based on the same principles stated for the ABET mapping. Linkages are indicated where attributes have a “strong correlation” and those with a “reasonable correlation” (bracketed). Alignments are subjective, however, this initial proposed mapping is intended for use and refinement by the growing CDIO community.

The mappings relate the CDIO syllabus topic to the relevant graduate attribute or outcomes as listed in Table 2 to Table 5.

Table 1
CDIO Syllabus topics mapped against ABET Student Outcomes (Table 2) [5], Engineers Australia Graduate Attributes (Table 3), Washington Accord Graduate Attributes [8]) and QUT Graduate Capabilities (Table 5).

	CDIO SYLLABUS TOPIC	ABET GRAD. OUT.	EA GRAD. ATT.	WA GRAD. ATT.	QUT GRAD. CAP.
TECHNICAL KNOWLEDGE AND REASONING	1.1 KNOWLEDGE OF UNDERLYING SCIENCES	A	A	B	A
	1.2 CORE ENGINEERING FUNDAMENTAL KNOWLEDGE	A	A	B	A
	1.3 ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE	K(A)	C	B	A
PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	2.1 ENGINEERING REASONING AND PROBLEM SOLVING	'E'(K)	D	C	B
	2.2 EXPERIMENTATION AND KNOWLEDGE DISCOVERY	B	-	E	-
	2.3 SYSTEM THINKING	C,'H'	E,G	D	-
	2.4 PERSONAL SKILLS AND ATTITUDES	I	F,(J)	G,(N)	E,G,(D)
	2.5 PROFESSIONAL SKILLS AND ATTITUDES	F,(K)	I,(J)	J(N)	F,(D)
INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	3.1 TEAMWORK	D	F	G	E,G
	3.2 COMMUNICATIONS	G	B	H	C
	3.3 COMMUNICATIONS IN FOREIGN LANGUAGES	-	-	-	-
CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT	4.1 EXTERNAL AND SOCIETAL CONTEXT	H,(J)	G	I	F
	4.2 ENTERPRISE AND BUSINESS CONTEXT	-	-	L	-
	4.3 CONCEIVING AND ENGINEERING SYSTEMS	C	E,H	F,K	B,F
	4.4 DESIGNING	C	E,H	F,K	(A),(B)
	4.5 IMPLEMENTING	C	E,H	F,K	(A),(B)
	4.6 OPERATING	C	E,H	F,K	(A),(B)

Mappings indicated as "strong correlation". *(X)* indicates reasonable correlation. *'X'* is the contention of these authors for mapping against ABET and not mentioned in the original reference.

For example, **CDIO Syllabus topic, *Advanced Engineering Fundamental Knowledge***, maps to:-

- **ABET Graduate Outcome K**, *An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice* (strong correlation)

- **ABET Graduate Outcome A**, *An ability to apply knowledge of mathematics, science, and engineering* (reasonable correlation)
- **Engineers Australia Graduate Attribute C**, *In-depth technical competence in at least one engineering discipline* (strong correlation)
- **Washington Accord Graduate Attribute B**, *Knowledge of Engineering Sciences*, (strong correlation)
- **QUT Graduate Capability A**, *Knowledge and skills pertinent to a particular discipline or professional area*, (strong correlation)

Institutional, Professional and Syndicated Graduate Capabilities

Table 2
Accreditation Board for Engineering and Technology (ABET) Student Outcomes [7].

A	An ability to apply knowledge of mathematics, science, and engineering
B	An ability to design and conduct experiments, as well as to analyze and interpret data
C	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
D	An ability to function on multidisciplinary teams
E	An ability to identify, formulate, and solve engineering problems
F	An understanding of professional and ethical responsibility
G	An ability to communicate effectively
H	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
I	A recognition of the need for, and an ability to engage in life-long learning
J	A knowledge of contemporary issues
K	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 3
Engineers Australia (EA) Graduate Attributes [2].

A	Ability to apply knowledge of basic science and engineering fundamentals;
B	Ability to communicate effectively, not only with engineers but also with the community at large;
C	In-depth technical competence in at least one engineering discipline;
D	Ability to undertake problem identification, formulation and solution;
E	Ability to utilise a systems approach to design and operational performance;
F	Ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member;
G	Understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development;
H	Understanding of the principles of sustainable design and development;
I	Understanding of professional and ethical responsibilities and commitment to them; and
J	Expectation of the need to undertake lifelong learning, and capacity to do so.

Table 4
Washington Accord Graduate Attributes [8].

A	Academic Education	Completion of an accredited program of study typified by four years or more of post-secondary study.
B	Knowledge of Engineering Sciences	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.
C	Problem Analysis	Identify, formulate, research literature and solve complex engineering problems reaching substantiated conclusions using first principles of mathematics and engineering sciences.
D	Design/ development of solutions	Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
E	Investigation	Conduct investigations of complex problems including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
F	Modern Tool Usage	Create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.

G	Individual and Team work	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
H	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
I	The Engineer and Society	Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
J	Ethics	Understand and commit to professional ethics and responsibilities and norms of engineering practice.
K	Environment and Sustainability	Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.
L	Project Management and Finance	Demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations.
M	Life long learning	Recognize the need for, and have the ability to engage in independent and life-long learning.

Table 5
Queensland University of Technology (QUT) Graduate Capabilities [9].

A	Knowledge and skills pertinent to a particular discipline or professional area	encompassing: coherent theoretical and practical knowledge in at least one discipline area at the level of entry to a profession; technological skills appropriate to the discipline
B	Critical, creative and analytical thinking, and effective problem-solving	including: the ability to critique current paradigms and contribute to intellectual inquiry; the capacity to exhibit creative as well as analytical ways of thinking about questions in at least one discipline; the ability to identify, define and solve problems in at least one discipline area
C	Effective communication in a variety of contexts and modes	including: effective written and oral communication with discipline specialists and non-specialists and in cross-cultural contexts
D	The capacity for life-long learning	including: searching and critically evaluating information from a variety of sources using effective strategies and appropriate technologies
E	The ability to work independently and collaboratively	including: managing time and prioritising activities to achieve goals; demonstrating: the capacity for self-assessment of learning needs and achievements; being a cooperative and productive team member or leader
F	Social and ethical responsibility and an understanding of indigenous and international perspectives	encompassing: active contribution to intellectual, social and cultural activities; understanding and appreciation of indigenous perspectives; recognition and appreciation of gender, culture and customs in personal and community relations; valuing and promoting truth, accuracy, honesty, accountability and the code of practice relevant to the discipline or professional area
G	Characteristics of self-reliance and leadership	including: the ability to take the initiative, to embrace innovation, and to manage change productive

SENIOR SCHOOL ENGINEERING CURRICULUM AND LEARNING OUTCOMES

There is evidence that many graduate attributes can develop, at least to a limited extent, through studies prior to tertiary engineering degree programs [10]. Feedback from industry representatives on the Queensland Studies Authority (QSA) senior secondary school Engineering Technology curriculum has been positive in terms of the rigour in the curriculum and identifies the major strength as developing problem solving skills and producing tangible outcomes.

> "*It was only after studying Engineering Technology that I understood the importance and relevance of mathematics and science to everyday life. The problem solving skills I learnt in this subject has helped me in getting through first year engineering at university and better understand how engineers work together.*" Student, Kelvin Grove State High School, now studying Engineering at QUT.

An examination is made of an engineering technology syllabus within secondary school senior years (years 11 and 12). The QSA senior Engineering Technology Curriculum [11] states a number of key learning objectives, such as:-

- *apply knowledge to unfamiliar and/or complex engineering problems*
- *use mathematical concepts and techniques in preparing and interpreting engineering data*
- *investigate and analyse engineering problems, and identify and prioritise their critical elements*
- *propose and validate possible solutions to engineering problems*
- *select suitable engineering solutions by drawing conclusions based on the evidence gathered*
- *evaluate proposed solutions in terms of their capacity to solve engineering problems, meet environmental and societal needs, and comply with appropriate benchmarks and standards.*

To read these learning objectives, it is not immediately clear that they are cast within the context of a senior secondary school syllabus. Indeed, one could have difficulty discerning these from professional graduate capabilities. This context may be defined, relative to the tertiary level proficiencies, as one:-

1. That is highly controlled in a highly supervised environment
2. That has limited scope and context of topics, and learning activities
3. That has outcomes which are generally aligned with graduate attributes, however the levels of proficiency are somewhat limited in comparison

With the contention that engineering proficiencies can indeed start for those who take pre-tertiary engineering related subjects, it is beneficial to recognise and identify these preparatory proficiencies cast within the CDIO framework. This process will inform application to other preparatory pathways to undergraduate engineering programs.

EXTENDED CDIO FRAMEWORK FOR PREPARATORY CAPABILITIES

The CDIO framework bases the levels of proficiencies on Bloom's Educational Objectives (in the cognitive domain). It is proposed here to extend this framework to include sub-levels, or preparatory levels of proficiencies. This is done with the same sets of verbs, however within the preparatory context characterised in the previous section. The established CDIO proficiency levels, linked to Bloom's Educational Objectives is tabulated below (Table 6) and extended to include the proposed preparatory sub-levels.

Table 6
CDIO levels of proficiencies link to Bloom's Educational Objectives and expanded to include preparatory proficiencies.

Bloom's Educational Objectives	CDIO Proficiency	Preparatory Proficiency
Knowledge	**1** To have experience or been expose to … **2** To be able to participate in and contribute to …	**Prep1** To have elementary knowledge and basic awareness of … **Prep2** To be able to participate in and contribute in controlled situations
Comprehension	**3** To be able to understand and explain …	**Prep3** To be able to understand and explain elementary principles.
Application **Analysis**	**4** To be skilled in the practice or implementation of …	**Prep4** To have preparatory skills in the practice and implementation of …
Synthesis **Evaluation**	**5** To be able to lead or innovate.	**Prep5** Beyond the scope of preparatory proficiency.

Using Bloom's verbs and associated proposed preparatory proficiencies to determine the level of skill, this extended framework was then applied to the QSA senior secondary Engineering Technology Syllabus as follows.

The stated general objectives of the Engineering Technology Syllabus are expressed in terms of *Knowledge and understanding*; *Reasoning*; and *Communication* as listed below [11]. An assessment is made in terms of proficiency level (Prep1 through to Prep4) within the extended framework. The linked broad CDIO Syllabus topic is indicated in square brackets.

QSA Engineering Technology - Knowledge and understanding

By the conclusion of the course students should have acquired knowledge and understanding of:

Prep1	• *interdependence that occurs among technology, industry and society [4.1]*
Prep1	• *nature and diversity of engineering materials, their properties and applications [1.1]*
Prep2	• *methods for testing and modifying the properties of engineering materials [1.2]*
Prep2	• *principles of engineering mechanics and their applications [1.2]*
Prep2	• *statics and dynamics involved in machines, structures and components [1.2]*
Prep2	• *control systems in industry and society [4.1]*
Prep2	• *mathematical concepts and techniques [1.1]*
Prep1	• *conventions used to communicate engineering information [3.2]*

QSA Engineering Technology – Reasoning

By the conclusion of the course students should be able to:

Prep4	• *apply knowledge to unfamiliar and/or complex engineering problems [2.1]*
Prep2	• *use mathematical concepts and techniques in preparing and interpreting engineering data [2.1]*
Prep4	• *investigate and analyse engineering problems, and identify and prioritise their critical elements [2.1]*
Prep3	• *propose and validate possible solutions to engineering problems [2.1]*
Prep3	• *select suitable engineering solutions by drawing conclusions based on the evidence gathered [2.1]*
Prep4	• *evaluate proposed solutions in terms of their capacity to solve engineering problems, meet environmental and societal needs, and comply with appropriate benchmarks and standards [4.3]*

QSA Engineering Technology - Communication

By the conclusion of the course, students should be able to:

Prep2	• *select suitable modes and genres for the communication and presentation of engineering information, whether oral, written, graphical, multimedia or using models [3.2]*
Prep1	• *organise and present information in the selected mode and genre [3.2]*
Prep2	• *demonstrate technical literacy through the use of appropriate symbolic, graphical, engineering, language and referencing conventions [3.2]*

DISCUSSION AND CONCLUSION

The CDIO Syllabus mapping and extended proficiency framework presented in this paper provides a transparent connection between engineering education communities within Australia and the CDIO global community of practice. It is the intention that a more fluid pathway now exists for sharing of ideas, processes, resources and initiatives in global efforts of engineering curriculum reform. Through these contributions, a further mechanism now exists for globalisation of the curriculum, and to foster student mobility.

Through this extended CDIO framework, students and faculty have greater awareness and access to tools to promote (i) student engagement in their own graduate capability development, (ii) faculty engagement in course and program design, through greater transparency and utility of the continuum of graduate capability development with associate levels of proficiency, and the context in which they exist in terms of pre-tertiary engineering studies; and (iii) course maintenance and quality audit methodology for the purpose of continuous improvement processes and program accreditation.

In summary of the relationship between the CDIO Syllabus and the extended proficiency levels (with Bloom’s verbs) a chart has been produced Figure 2. This is chart is best printed in at least A3 portrait style.

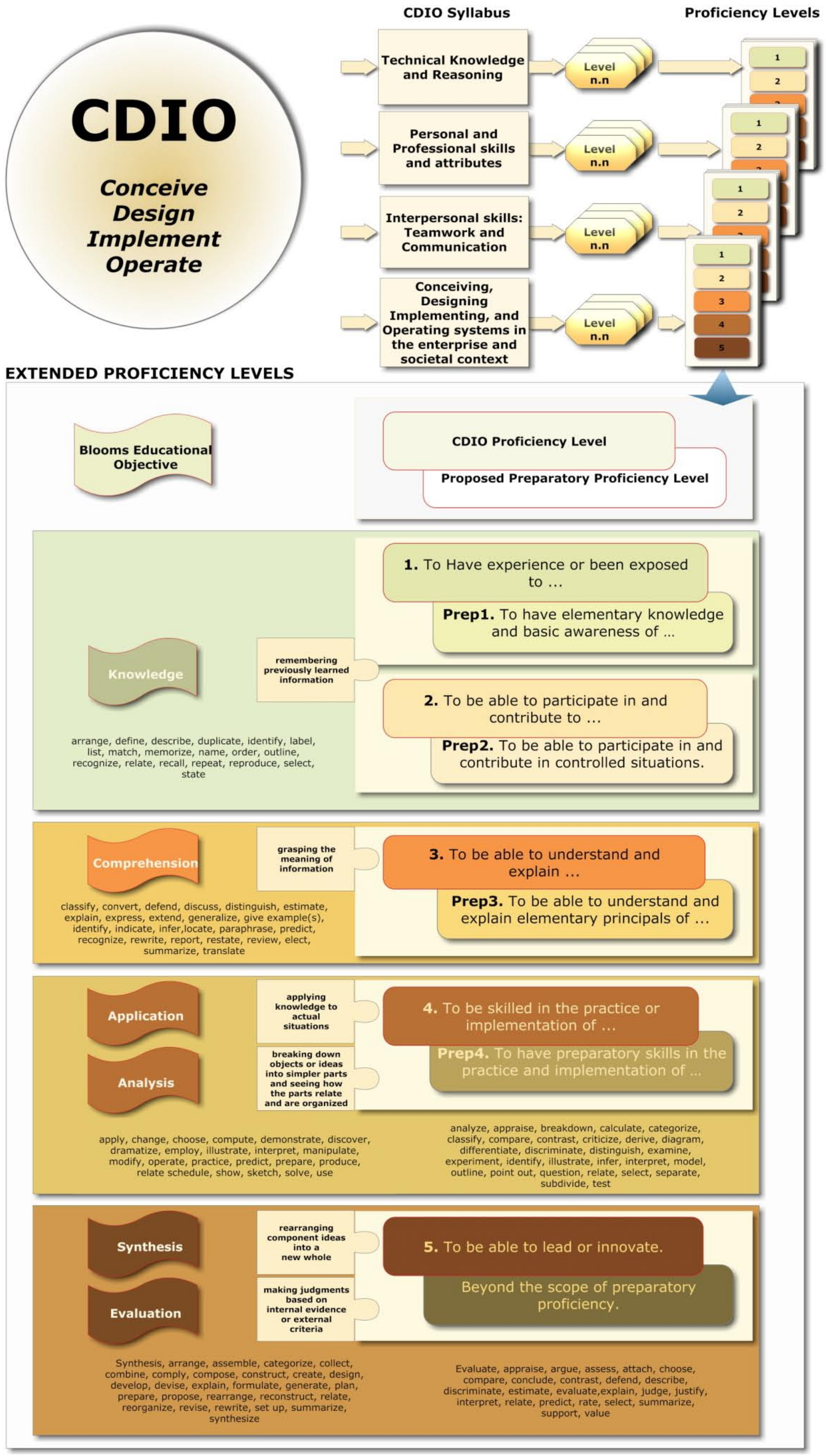

Figure 2. Conceptual representation of the CDIO Syllabus with extended proficiency levels.

REFERENCES

[1] King, R., *Addressing the Supply and Quality of Engineering Graduates for the New Century*, March 2008. *Support for the original work was provided by The Carrick Institute for Learning and Teaching in Higher Education Ltd, an initiative of the Australian Department of Education, Employment and Workplace Relations.*

[2] *Engineers Australia Policy on Accreditation of Professional Engineering Programs*, Engineers Australia, 2006

[3] Rover, D., 2008. Attention Engineering Educators, Journal of Engineering Education, 97(4): 531-534.

[4] Felder, R. and Brent, R., 2003. Designing and Teaching courses to satisfy the ABET Engineering criteria, Journal of Engineering Education, 92(1): 7-25.

[5] Crawley, E., Malmqvist, J., Ostlund, S., Brodeur, D., "Rethinking Engineering Education – The CDIO Approach", Springer, 2007.

[6] Bloom, B., Englehatt, M., Furst, E., Hill, W., and Krathwohl, D., *Taxonomy of Educational Objectives: Handbook 1 – Cognitive Domain*, McKay, New York, 1956.

[7] *Criteria for Accrediting Engineering Programs*, ABET, Baltimore, USA, 2008.

[8] *Graduate Attributes and Professional Competencies*, International Engineering Alliance, 2005.

[9] *Graduate Capabilities*, Manual of Policies and Procedures, Queensland University of Technology, 2005.

[10] Dawes, L., Campbell, D., Dansie, B., Beck., H., and Wallace, S., "Inspiring secondary and tertiary students through applied electronics", *Proc. 19th Annual Conference of the Australasian Association for Engineering Education*, Yeppoon, Australia, 2008. (CD-ROM – 7 pages)

[11] *Engineering Technology Senior Syllabus*, The State of Queensland (Queensland Studies Authority), 2004.

Biographical Information

Duncan Campbell is an Associate Professor of Engineering Education with the School of Engineering Systems at the Queensland University of Technology, Brisbane, Australia. He leads a number of engineering education initiatives related to engineering curriculum reform. Duncan is Co-Chair of the CDIO Integrated Curriculum Committee, Chair of the Australasian Association for Engineering Education (AAEE) CDIO Special Interest Group, and is Deputy-Chair of the CDIO Australia and New Zealand Regional group. He has received a number of engineering education awards, the most recent being the AAEE *Citation for Outstanding Contribution to Student Learning and Engineering* (2008).

Les Dawes is a senior lecturer in Civil and Environmental Engineering at Queensland University of Technology and Director of Domestic Relations for the Faculty of Built Environment and Engineering. He has been involved in developing design based activities and learning environments incorporating experiential learning and community outreach for over 10 years. He is also the editor for the Australasian Journal of Engineering Education.

Hilary Beck is a Project Officer within the School of Engineering Systems at the Queensland University of Technology, Brisbane, Australia. She holds a Masters in Adult and Workplace learning, and has been a key member of several projects including the CDIO Project, Work Integrated Learning and ALTC Teaching and Learning projects and has contributed to several conference papers on these topics. Her interests are in curriculum development in engineering education, including high school outreach and mentoring programs.

Sam Wallace is a Senior Electronics Engineer and Manager of Electronics R&D for Auslog – Weatherford Wire-Line Manufacturing in Australia. He has a Master's Rating from Microchip (PIC) in embedded processors and has more than 25 years experience in microprocessor and electronics design across a broad range of areas. Sam is passionate about engineering education and is currently doing a Master of Engineering designing an embedded processor platform to inspire life-long learning in our undergraduate electrical engineering students. He spends one day a week at QUT mentoring students and contributing to scholarship in engineering education.

Carl Reidsema is a mechanical design engineer with over 12 years industry experience. He is the founder of the newly proposed Centre for Design Research and Learning at the University of New South Wales. Dr. Reidsema has led the Faculty development of the University of New South Wale's first year common course in engineering design "ENGG1000 - Engineering Design and Innovation" which was largely based on his educational research and development. He was an invited speaker at several Australian Universities showcasing this innovative approach towards engaging first year engineering students and received the Faculty Teaching Award in 2006 and the Vice Chancellor's Teaching Excellence Award in 2009.

Brenton Dansie is Dean, Teaching and Learning for the Division of IT, Engineering and the Environment at the University of South Australia. He has a long standing interest in promoting engineering within secondary schools. He recently ran the Australian Technology Network Engineering in Schools project and has coordinated a robotics program in schools for the past five years.

Corresponding author
Associate Professor Duncan Campbell
Queensland University of Technology
2 George St
Brisbane, Australia, 4000
+61-7-31382179
da.campbell@qut.edu.au