

PROFESSIONAL PRACTICE AND DESIGN: KEY COMPONENTS IN CURRICULUM DESIGN

Jane Goodyer, Allan Anderson

Massey University, School of Engineering & Advanced Technology,
Palmerston North, New Zealand

ABSTRACT

This paper describes the development of a new engineering curriculum at Massey University. The new curriculum is an innovative approach to engineering education in New Zealand and will be a point of difference from other providers of engineering qualifications. A comprehensive curriculum architecture has been developed around a project based spine allowing appropriate technical disciplinary linkages to be made through design and build activities and where professional skills are emphasised. Active learning experiences are developed throughout the integrated curricula. The CDIO Standards are used as a benchmark for this new curriculum and provides an opportunity for reflection and improvement. Through an effective redesign it is envisioned that the new degree will be attractive to prospective students, will enable more engagement and retention during their education and will produce graduates that are highly sought after by industry.

KEYWORDS

Engineering curriculum design, project based learning, benchmarking, graduate profile.

INTRODUCTION

Engineering and technology programmes have been offered at Massey University for over 40 years. For the past few years, student numbers have been static. This, combined with a lower recognition of Massey Engineering in the student market, prompted the School of Engineering & Advanced Technology (SEAT) executive to review its strategic direction. Pivotal to this, was the definition of a compelling value proposition and clearly defined point of difference from other providers of engineering qualifications in New Zealand.

Coincidentally, at the same time as SEAT was embarking on its strategic review, the International Engineering Alliance's (IEA) Graduate Attributes and Professional Competencies [1] adopted by the Washington, Sydney and Dublin Accords required signatories to review their current standards. Within New Zealand, this prompted the Institution of Professional Engineers New Zealand (IPENZ) to formulate the National Engineering Education Plan [2] defining the gap between IEA's graduate exemplar and the current IPENZ accreditation criteria and graduate profile. The key outcomes were:

- There is a need for professional engineering graduates who are "rounded" and not just technical boffins – many of the existing graduates do not have strong "soft" skills.

- Professional engineering graduates should aspire to leadership roles, and their education should equip them to commence their preparation towards such roles.
- Graduates entering industry have technical knowledge that is largely theoretical, and industry needs to invest considerably to close off the knowledge gap between principles as taught and codified knowledge as used in industry.
- Graduates entering industrial research roles are educated in insufficient depth towards the frontiers of knowledge.

New Zealand's nearest neighbour, Australia, through Engineers Australia, has also recently undertaken a revision of their Stage 1 competency standards, which has also taken into account the Threshold Learning Outcomes developed by the Discipline Scholars in Engineering and ICT; under the Australian Teaching and Learning Council's Standards and Assessment project [3]. What is pertinent about this project's resulting learning standards is the emphasis on the professional skills. There are five standards which are built on a strong knowledge base:

1. needs, context and systems
2. problem solving and design
3. abstraction and modeling
4. coordination and communication
5. self management [4]

It is quite clear that the professional associations within NZ and Australia are changing their expectations of graduate engineers. This change, combined with SEAT's student enrolment and market recognition challenges, provided the context and focus for its strategic review. Central to this review has been the re-design of its undergraduate degree programme (BE re-design).

In general, whilst the technical ability of graduates was not in question, it was apparent that the current programme lacks emphasis on professional practice attributes, and the wider contextual aspects of engineering practice. Interestingly, these aspects were at the very core of engineering at Massey University during the 1980's and 1990's, where there was great alignment to industry through such practice. During the last decade this 'industry connectivity' has been eroded due to the strong driver for faculty to focus on research.

In mid 2010 a Working Group, led by the director of teaching and learning, involving faculty representing all majors (i.e. disciplines) within the BE(Hons), has been setup. The programme is a four year honours degree which consists of four majors: chemical and bioprocess engineering (CBE), electronics and computer engineering (ECE), mechatronics (MEX) and product design engineering (PDE). The redesigned BE(Hons) is targeted for launch in February 2012.

In the early stages of the BE re-design, the CDIO syllabus was identified as a model against which to benchmark SEAT's new curriculum developments. Rather than apply the CDIO templates directly, it was decided to focus on the issues facing the engineering students and graduates in New Zealand, and specifically engineering at Massey University, and to compare the resulting findings with the CDIO syllabus.

This paper presents the method used to design the BE curriculum that is intended for launch next year. It outlines the decisions made during the curriculum design and the consequent benchmarking against the CDIO Standards.

THE BE RE-DESIGN PROCESS

The key focus of the Working Group was on addressing those issues that were contributing to recognition and reputation of the degree programme, and its attractiveness to key stakeholders – current students, potential students and employers. Industry feedback from individual companies and SEAT advisory board, together with information from student focus groups identified the following core issues:

A clear point of difference and strong value proposition. There are a number of providers of tertiary engineering education in New Zealand. Although, in earlier years, Massey University held a strong and well defined position in this market, over recent time this strength has been largely eroded. The visibility and recognition of Massey Engineering has declined and with it the reputation of its undergraduate degree programme.

Professionally relevant curriculum. Feedback from a 2009 Institution of Professional Engineers of New Zealand (IPENZ) accreditation highlighted the need for greater alignment with IEA graduate attributes and professional competencies. Significant deficiencies were identified in the current curriculum. Additionally, student feedback pointed to a real lack of attractiveness and student engagement. In particular, the lack of integration of fundamental knowledge into active learning situations was highlighted.

Engaging delivery. The current programme is centred on traditional lectures with large numbers of students. Modes of knowledge delivery and application are outdated, resulting in an environment and culture lacking real energy, vitality and enthusiasm.

To bring all this together and communicate it to the key stakeholders a comprehensive marketing campaign is required. In parallel with the BE re-design a complementary marketing campaign has been developed to communicate the core value proposition and point of difference. The strap line OBSERVE INVENT REALISE forms the basis of the campaign with associated visual images used as reinforcement. Biomimicry images were chosen to underpin the principles of observe, invent, realise. The observe invent realise message and associated images are being applied to a range of marketing collateral – booklet covers, billboards, busbacks, business cards etc. Besides the obvious external marketing benefits, this campaign is already having an internal effect on staff and students through providing a sense of pride, focus and unity.

Defining the Point of Difference and Value Proposition

Through industry consultation SEAT identified the need to focus on producing graduates who were “industry ready”, had strong problem solving skills and who could work effectively in a multifunctional or multidisciplinary environment. These characteristics not only met current industry needs but they are also well aligned with the new professional engineering requirements.

The term OBSERVE, INVENT, REALISE was coined to represent the fundamental ethos of SEAT and of its graduates. It also defined the key point of difference and value proposition for the School and its graduates:

Observe – taking an active interest in all that surrounds us and linking this to engineering principles.

Invent – creatively apply our engineering & contextual knowledge to the solution of problems; today and in the future.

Realise – ensure that our inventions are focused on social or commercial wealth creation.

Whilst the Observe, Invent, Realise mission statement portrays an ethos for the School’s operation, not just in undergraduate teaching but through its research and day-to-day

activities, it is necessary to emulate this through to the graduate profile of the BE(Hons) programme. There are three defining attributes of the graduate:

Embedded Knowledge

- Our graduates can effectively apply the knowledge that is at the FOREFRONT of their discipline, built on UNDERPINNING science and in-depth TECHNICAL capability to solve complex engineering problems that industry faces today and in the future.

Design and Achieve

- Our graduates are able to creatively and systematically solve complex problems that are both challenging and contemporary to industry and ensure that the solutions are focused on social and/or commercial wealth creation.

Professional Practice

- Our graduates have honed skills that allow them to continually develop professional skills, knowledge and intuition through self-reflection and an urge for lifelong learning.

The outward demonstration of this profile is the inherent ability of graduates to observe, invent and realise. These are not simply words, they are at the very heart of the graduates thinking processes and mode of operation.

To ensure that faculty, students and industry can easily connect with what the programme is trying to achieve the Working Group decided to present the graduate profile as an illustration. Figure 1 shows the profile, which has been adapted from Taiichi Ohno's Toyota Production System house [5].

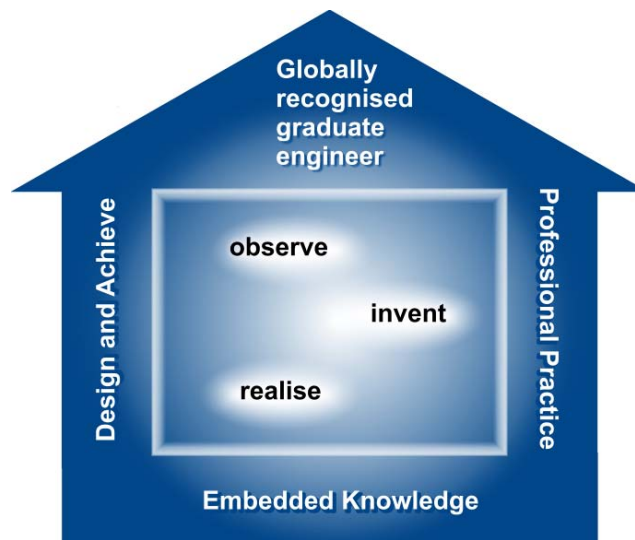


Figure 1. Graduate profile for a Massey University Engineer

The foundation of the house must be sound thus the core knowledge that supports each major is imperative. However, technical knowledge alone cannot produce an engineer without the 'walls' of design and achieve and professional practice. Take out one of these attributes (i.e. the walls and the foundation) and the roof collapses. At the heart of the house is our ethos, observe, invent, realise.

Professionally Relevant Curriculum

The tangible product – what the students experience everyday is the curriculum. When the current BE(Hons) was originally designed it had a cohesive set of courses with a clear

pathway of how each course contributed to the whole programme. It is now quite apparent that the curriculum's cohesion has been gradually eroded. It can be described as a collection of silo'd courses, which is augmented by the fact that the first year courses are not taught by faculty within SEAT. Courses such as Physics 1A, Physics 1B, Calculus 1, Programming Fundamentals, Computer Science Fundamentals, Chemistry and Living Systems, Biology of Cells and Principles of Statistics are owned and taught by faculty within the College of Sciences and these courses serve many programmes such as the Bachelor of Science and Bachelor of Veterinary Science. In addition the majority of courses focus on the developing the disciplinary skills where very little emphasis is given on incorporating wider professional practice skills.

A key focus of the BE re-design was to engage and enthuse students right from the beginning of the degree and maintain this engagement and enthusiasm throughout the 4 years of the degree. Active learning which provided application focussed embedding of knowledge was seen as central to achieving this aim.

The curriculum architecture has been developed with consultation of faculty, industry, students and alumni, using focus groups. Figure 2 pictorially represents the curriculum's structure and where the graduate attributes are emphasised. Note that letters correspond to the three defining attributes of the graduate. K represents embedded knowledge (i.e. technical knowledge and reasoning). P represents professional practice (i.e. personal and professional skills and attributes and interpersonal skills). D represents design and achieve. The progression through the curriculum is shown by year 1 (at the bottom) moving through to year 4 (at the top of the diagram).

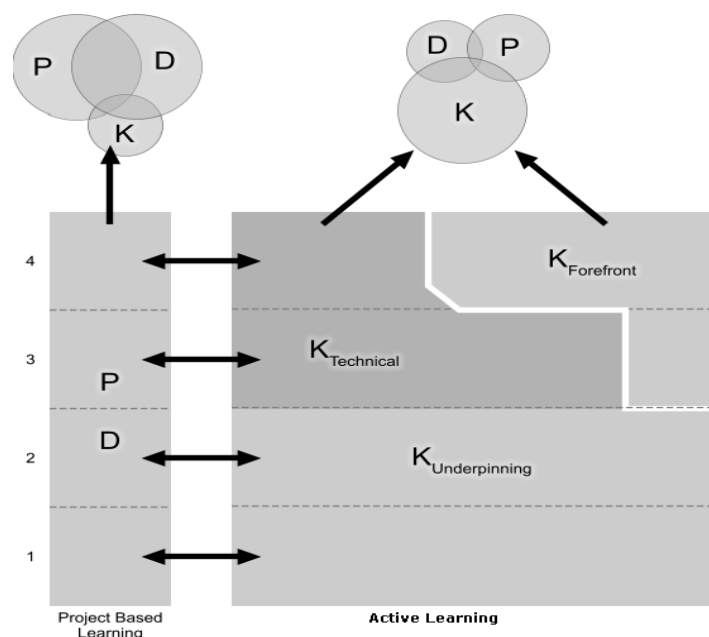


Figure 2. Curriculum Architecture and Relationship to Graduate Attributes

The application of contextual knowledge through professional practice, which enables students to develop and apply their skills in engineering reasoning, experimentation, systems thinking, personal and professional skills, communication, teamwork, and the ability to design and achieve within a societal and business context is an important facet of the new curriculum. To reinforce its importance the curriculum will have 25% (i.e. two 15 credit courses from a total of eight courses per year) aligned to achieve these attributes. Here there will be a considerable change to the instructional system to achieve this. Project-based learning (PjBL) [6] will be a core component, where it is expected that students will work in

teams to solve engineering problems by having design-build experiences that are aligned with industry and the wider society. It is important that this experience begins from day one of the programme so that students begin to appreciate what it means to be an engineer and stimulates their enthusiasm for the profession. This experience will be built on in each of the remaining 3 years where the projects will become more complex and open-ended. The details of how this is to be achieved will be outlined in a later section.

It is also expected that the problems will utilise the disciplinary technical knowledge that is obtained from other courses and is continually used and built on from year to year. It is intended that the PjBL approach contextualizes the underlying sciences and engineering technical knowledge, and equips graduates with a broader set of professional skills and attitudes. The curriculum is designed so that there will be greater emphasis on developing the professional practice (P) and design and achieve attributes (D).

The remaining 75% of the curriculum is focused on embedding the underlying sciences and engineering technical knowledge so that sufficient depth can be achieved and an opportunity to explore the forefront of the discipline through rigorous research capability. The focus here is on developing the technical knowledge and reasoning (K) although there is an expectation that P and D will also be developed concurrently, albeit to a lesser degree.

The main instructional system used here will be active learning [7] (although it could be seen that PjBL is also part of the active learning instructional system). It is apparent that the current student body is changing and teachers need to challenge their approach about traditional knowledge transmission teaching. The new curriculum expects a greater degree of active learning to take place in each course.

To ensure that this happens guidelines have been prepared that support staff in the challenging task of designing courses that ensures the learning outcomes and assessment strategies meet the required graduate attributes. Within these guidelines there are guiding principles that must be followed:

- Contextual learning should be integral to every course. Teaching should circulate between deductive and inductive processes, normally starting with a particular case, working through to a general principle.
- Active learning modes that promote knowledge acquisition, understanding, use and analysis that allows synthesis and evaluation/assessment to be accomplished (i.e. a requirement to move up the learning pyramid [8]).
- That there are clear linkages between courses and that there is a clear recognition of how courses contribute to the graduate profile i.e. specify how the learning outcomes contribute to achieving K, P and D.
- All courses must have an allowance of independent learning activity to allow for reflection and the generation of an e-portfolio.

The guidelines also encourage the use of a variety of assessment methods (e.g. observation, peer assessment, posters) as well as the more common approaches, i.e. examination, laboratory or reports. Faculty are expected to use the appropriate method to achieve the learning outcomes.

Engaging Delivery

All products need a delivery system that complements that product attributes and benefits. In the case of an undergraduate degree programme the delivery includes a range of features:

the environment and workspaces; the climate and culture of the organisation; the teaching styles and modes

The Environment and Workspaces

The redesign of the curriculum coincides with the refurbishment of SEAT's buildings and facilities. The refurbishment programme began in 2006 and initially focussed on remodelling and expanding its laboratories to allow for more space and updated equipment to facilitate hands-on learning. It is currently in its final phase with a completion date of December 2011. This final phase is focused on hub of the School, joining together different parts of SEAT to create a focal space.

The BE Working Group believes this is an opportunity to ensure that this space is used to support social learning, which will be an important part of the design-build experiences. Currently a student space user group has been set-up, which involves faculty and students to develop a plan for the effective use of this space. Its aim is:

'Create an environment within the public/student spaces that fosters pride and understanding of Massey's School of Engineering and Advanced Technology, and promotes innovation, teamwork and a sense of belonging for students and staff and can communicate the special nature of Engineering at Massey to visitors, industry and potential students.'

Initial ideas suggested are:

- Build large viewing windows in laboratories, workshops and meeting rooms that allow student activity to be clearly seen. This has actually been implemented in the earlier build phases of the refurbishment and will continue to be implemented during the final phase.
- Create a video wall capable of displaying single and multiple digital images. This would be visible from all parts of the central hub of SEAT and be the point of focus from walkways that connect all majors to the hub. For example it could display completed student projects, emerging technologies, world events and business headlines and presentations from industry.
- Create stand up (scrum) meeting venues to be used for short sharp team meetings. It is envisioned that these venues would contribute to an atmosphere of innovation and energy through the buildings. The venues could be used by both staff and students. The design-build courses would use these for break-out sessions.
- Provide low, café-style tables and chairs that can be easily rearranged to encourage more informal social interaction.

Climate and Culture

The SEAT's executive team have developed a strategy that focuses on developing faculty that are well connected with industry, have collaborative relationships, have a sound appreciation of industry needs, and undertake research to support the knowledge of future industry needs. To enable this to happen SEAT have changed the recruitment policy to put greater emphasis on an applicant's affinity with industry. The recognition and reward policy has been reviewed to have more balance between research and teaching excellence. There is more financial and academic recognition for faculty to do consultancy work. There is greater willingness and encouragement for faculty to take secondments in industry.

Teaching Styles and Modes

SEAT has also built into the budget a significant amount for faculty development in teaching and learning practices to support the change in teaching strategies. This has enabled the BE Working Group to bring in the expertise of one of the Australian Teaching and Learning

Council's Discipline Scholars in Engineering and ICT (Prof. Ian Cameron from the University of Queensland). Prof. Cameron acts as a mentor and has visited SEAT several times over the last 12 months and is crucial in providing influence and authority to support the vision.

Recently there has been a 2 day curriculum development workshop involving 40 faculty members from SEAT and from the College of Sciences (i.e. chemists, computer scientists, mathematicians and physicists). This provided the direction and approach faculty must take in designing the curriculum. Subsequently learning teams have been formed with responsibility for developing particular parts of the curriculum. All teams have been supported by training about the design process, which is using Threshold Concept Theory [9] to provide focus on content and appropriate teaching and learning strategies to tackle concepts students have difficulty with. This approach has helped faculty concentrate on the 'jewels in the curriculum' rather than trying to squeeze in as much content into the curriculum.

There is also a plan of 1 day workshops which will have a focus around a specific teaching and learning issue, e.g. assessment in PjBL, active learning in laboratories, reflective portfolio development, etc. Each workshop will have a guest speaker who has experience of the issues with an engineering and science focus and will be facilitated by teaching consultants from Massey University's National Centre for Teaching and Learning.

The development of the personal, professional, interpersonal and CDIO skills are a core component of the new curriculum by allowing students to work in teams to solve engineering problems by having design-build experiences. In the current syllabus there are two courses that specifically focus on developing these skills. One is in semester 2 of the second year and there is a capstone project in semester 1 and 2 of the fourth year. The new programme will have a double semester (30 credits) opportunity in each year to develop these skills. This block of learning is locally referred to as the "project based spine" of the curriculum.

There is a team of 5 faculty members taken from across the disciplines to develop the curriculum for this project based spine, although as it's an integrative part of the curriculum there will be iterative consultation with the wider faculty. The detailed development of this spine is currently underway and is following a specific process based on the suggestions provided by the CDIO Syllabus.

The first step in this process is to define the proficiency or competence level expected of a graduating engineer for each topic stated in parts 2, 3 and 4 of the CDIO Syllabus. The team has used the CDIO survey to identify viewpoints from industry, alumni and faculty. This is currently underway and it is envisaged that there will be 30 respondents from industry and alumni and 20 respondents from faculty.

The intention is to use the results to provide a specification of student proficiency in these skills that informs the team to develop appropriate learning outcomes using the Bloom verb patterns used in the CDIO Syllabus [10]. Although this specification of proficiency will focus on the project based spine it is intended that this proficiency statement will inform the other courses, i.e. the remaining 75% of the curriculum, of their contribution to meeting this proficiency.

The intention is to map the development of each skill throughout each of the four years of projects. For each project there will various CDIO syllabus topics that will be explicitly taught and assessed in line with the specific learning outcomes for the project. There will be defined learning outcome levels (referring to the 5 activity based proficiency levels [10]) and whether a topic is introduced (I), specifically taught (T) or utilised (U) [11]. Table 1 shows an example of what could result of this mapping exercise.

Table 1
An Example of a Proficiency Map for the Project Based Spine

| Yr. | Course | CDIO Syllabus Topic | | | | | | | | | | | | | |
|-----|------------|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 3.1 | 3.2 | 3.3 | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 |
| 1 | Project101 | T2 | | I | T2 | I | T2 | T2 | T1 | T2 | T1 | T2 | T1 | I | I |
| 2 | Project201 | U | | T2 | U | U | | T4 | | T3 | T2 | T3 | T2 | T1 | |
| 3 | Project301 | | T2 | U | U | U | T4 | U | | U | U | U | T3 | T2 | T |
| 4 | Project401 | T4 | U | T3 | U | T2 | U | U | | U | T3 | U | T4 | T3 | T |

The next step in this process is to define the type of project which will allow these proficiencies to be developed in each year's project(s). Note it hasn't yet been decided whether there will be one project over the 2 semesters or a separate project in each semester. Table 2 highlights the initial brainstorming ideas of the types of projects that could be developed.

Table 2
Examples of Project Types

| Yr. | Project Focus | Project Examples |
|-----|---|--|
| 1 | <ul style="list-style-type: none"> Provide students with an interesting, challenging and practical project at the outset of their programme. Focus on developing self, creativity with a global context. | <ul style="list-style-type: none"> All Majors. Engineers Without Borders Challenge. Foresighting 2050 - set the scene with changed demographics (i.e. aged) and socio-economic profiles. The smart home with implications of telecommunications, etc. |
| 2 | <ul style="list-style-type: none"> Company & industry environment focus, how companies would work. Focus on design and development, and manufacture. Constrained by cost and equipment/component availability. | <ul style="list-style-type: none"> ECE, MEX, PDE Majors - digital and electronics circuit design. E.g. to develop a controller to sort cartons on a production line. CBE Major – develop a particular product and design the pilot plant to make it. E.g. create plant to cool down sugar solution at a particular rate. Appreciate implications of scaling up to full production |
| 3 | <ul style="list-style-type: none"> Reverse engineering. Tear down product, analyse design specification to improve functionality. Tests to prove that meet specification. Complex technical problems built on student's strength in technical disciplinary knowledge. | <ul style="list-style-type: none"> ECE Major - design product to fit specific purpose. Eg. on-line Scotland Yard board game; an add-on to Google maps; remote controller for TV. MEX, PDE Major – Teardown of a manual system that requires automation. CBE Major – select a real life manufacturing plant, collect data and assess. E.g. boiler house – do energy balances, handle unknown data. |
| 4 | <ul style="list-style-type: none"> Near to real world/industrially based project. Using company based problems requiring multidisciplinary solutions. Emphasis is on students taking total ownership of its aim, and deliverables. | <ul style="list-style-type: none"> The project integrates the majors. E.g. working with a brewery on plant optimisation; involving chemical, mechanical and electronic contributions to a solution of a complex industrial problem. |

BENCHMARKING AGAINST CDIO STANDARDS

In order to ensure that the new curriculum is designed in a systematic and holistic manner the BE Working Group used the 12 CDIO standards [12] to benchmark the decisions made. Table 3 relates the BE re-design to the CDIO standards.

Table 3
Benchmarking Against CDIO Standards

| CDIO Standard | Application to SEAT BE Re-Design | Progress Evaluation |
|---|--|--|
| 1. Adoption of the principle that product and system lifecycle development and deployment, i.e. CDIO, are the context for engineering education. | <ul style="list-style-type: none"> • Adherence to IEA graduate attributes and professional competencies. • Inherent in the SEAT value proposition of OBSERVE INVENT REALISE. • The basis of the project based spine – 25 percent of the curriculum. | <ul style="list-style-type: none"> • Principle well recognised and adopted in curriculum design process. Explicit within SEAT strategy and understood by most faculty. Continuing reinforcement still required through to implementation. |
| 2. Specific, detailed learning outcomes for personal, professional, interpersonal, and product and system building skills, consistent with program goals and validated by program stakeholders. | <ul style="list-style-type: none"> • Professional practice and product and systems building skills are key elements of the graduate profile. • Program validation has been carried out directly with companies and through SEAT's industry advisory board. | <ul style="list-style-type: none"> • Having specific learning outcomes is recognised as a key weakness in the current programme. • Preliminary development has begun but significant development and validation must be completed before launch. |
| 3. A curriculum designed with mutually supporting disciplinary subjects, with an explicit plan to integrate personal, interpersonal and product system building skills. | <ul style="list-style-type: none"> • A comprehensive curriculum architecture has been developed based on embedded knowledge, design and achieve, and professional practice. • Multidisciplinary and contextual focus is emphasised in the project based spine allowing appropriate technical disciplinary linkages to be made. • Formation of learning teams that ensures faculty recognise the delivery of specific technical disciplinary content in context and the integration of this content through the project based spine. | <ul style="list-style-type: none"> • Although significant work has been done there are still a number of challenges in achieving cross faculty and cross university collaboration. |

| | | |
|--|---|--|
| <p>4. An introductory course that provides the framework for engineering practice in product and systems building, and introduces essential personal and interpersonal skills.</p> | <ul style="list-style-type: none"> • Significant emphasis on re-focusing the first year of the curriculum away from pure fundamental sciences to scientific principles that underpin engineering. • Active learning of engineering principles with an experience of the practice of engineering is developed from day 1 through the project based spine. | <ul style="list-style-type: none"> • It is envisaged that the adoption of an interesting and challenging project in the first year as an introduction to engineering practice is seen as essential to the successful launch of the new BE(Hons). The Engineering Without Borders Challenge has been selected as a best practice framework for this to happen. |
| <p>5. A curriculum that includes two or more design-build experiences, including one at a basic level and one at an advanced level.</p> | <ul style="list-style-type: none"> • The project based spine will include up to 8 individual or integrated projects. These will be developed from basic to advanced levels through the level of proficiency expected and the complexity of engineering problem solving. | <ul style="list-style-type: none"> • The basic templates for the first two years of design-build experiences have been well defined with a focus on the 1st year on social, cultural context and the 2nd year around industry/company context. • Emphasis over the next few months will be placed on the projects that will allow design-build experiences in the 3rd and 4th years. |
| <p>6. Workspaces and laboratories that support and encourage hands-on learning of product and system building, disciplinary knowledge, and social learning.</p> | <ul style="list-style-type: none"> • As part of the current building re-design and development, considerable emphasis is being placed on creating work spaces and an environment that promotes and encourages practical learning in a team environment. • Most projects are expected to have an industrially based context where students will be encouraged to work in a company's own facilities. | <ul style="list-style-type: none"> • Social learning spaces will be completed by the end of 2011. • Challenge is about creating a culture around faculty and students to effectively use these spaces. |
| <p>7. Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal, interpersonal, and product and system building skills.</p> | <ul style="list-style-type: none"> • Project based learning is a core spine through the curriculum which provides the focal point for the integration of technical disciplinary and wider contextual knowledge within a framework of professional practice. • The project based spine all 4 majors will have common contextual and professional practice elements. Specific technical disciplinary focus will be major dependent. | <ul style="list-style-type: none"> • Current focus is on developing the framework for these projects by a multidisciplinary team who are developing the development of the core contextual and professional practice content. • Further development required on the technical disciplinary content to provide specific focus each major. Industry advisory boards will contribute. |
| <p>8. Teaching and learning based on active experiential learning methods.</p> | <ul style="list-style-type: none"> • All courses will have active learning components. • The project-based spine will provide continual reinforcement of active and experiential learning. • Industry based projects and in-company placements during vacations will provide real-life context of professional practice. | <ul style="list-style-type: none"> • Significant work to be done on embedding the use of active learning methods across the faculty. • Need to build a wider network of industry relationships to support active learning. |

| | | |
|--|--|---|
| <p>9. Actions that enhance faculty competence in personal, interpersonal, and product and systems building skills.</p> | <ul style="list-style-type: none"> • The development of a SEAT strategy that emphasises the requirement for faculty connectivity with industry. • Revisions to recruitment guidelines to place greater emphasis on context-based engineering problem and on multidisciplinary experience and ability. | <ul style="list-style-type: none"> • Recognised as a significant challenge given current faculty competencies. Above everything else this is recognised as the critical element for ultimate success. |
| <p>10. Actions that enhance faculty competence in providing integrated learning.</p> | <ul style="list-style-type: none"> • A significant budget has been allocated to faculty development in teaching and learning practices. • External authorities have been employed to run workshops with faculty. • Cross disciplinary teams have been established to foster greater collaboration across individual courses from different faculties. | <ul style="list-style-type: none"> • Formulate a training programme that addresses active learning approaches, assessment, evaluation of student's and themselves. • SEAT will be a pilot for the University's Peer review scheme to be instigated during 2012. |
| <p>11. Assessment of student learning in personal, interpersonal, and product and systems building skills, as well as in discipline knowledge.</p> | <ul style="list-style-type: none"> • A working group has been established to research areas of individual and team assessment with clearly defined linkages to specified learning outcomes – both within individual courses and across years. | <ul style="list-style-type: none"> • Recognised as an area of current weakness and will be addressed in relation to developing standard 10. |
| <p>12 A system that evaluate programs against these 12 standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement.</p> | <ul style="list-style-type: none"> • Some internal systems area available for individual course evaluation but these are relatively superficial. • Some feedback systems area available for external stakeholders – mainly informal or through advisory boards. These need greater focus and formality. | <ul style="list-style-type: none"> • Recognised as an area of current weakness and one to be addressed over the coming year. • Develop robust systems for both internal and external feedback. |

By benchmarking against the CDIO standards it is clear that there has been significant progress made in identifying what needs to be done with respect to the design of the new curriculum. However, the critical challenges that lie ahead centre on the development of the desired faculty competencies to deliver this new curriculum.

CONCLUSION

This paper has provided a summary of an approach to design an engineering curriculum that enables the integration of technical disciplinary and wider contextual knowledge within a framework of professional practice. By defining a point of difference for engineering education within New Zealand (through the new curriculum) it is anticipated that the degree will be attractive to prospective students, will enable more engagement and retention during their education and will produce graduates that are highly sought after by industry.

Benchmarking the planned curriculum against the CDIO standards had been an extremely useful exercise; highlighting areas that have been done well but also highlighting those that have fallen short. Benchmarking against an internationally recognised standard has provided confidence in the approach that Massey University has taken. It has also provided focus and a method to prioritise future activities. One particular issue that must be addressed urgently is ensuring that the current faculty capability is developed further to support a curriculum that fully engages with the integration of technical knowledge, personal, interpersonal and professional skills and CDIO.

REFERENCES

- [1] IEA., "Graduate Attributes and Professional Competencies (version 2)", International Engineering Alliance, 2009, Accessed 29 March 2011 at <http://www.washingtonaccord.org/IEA-Grad-Attr-Prof-Competencies-v2.pdf>
- [2] IPENZ Engineers New Zealand., "National Engineering Education Plan" October 2010, Accessed 5 April 2011 at http://www.ipenz.org.nz/ipenz/education_career/NEEP_Project_Report.pdf
- [3] ALTC., "Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access", Australian Learning & Teaching Council, 2011, Accessed 29 March 2011 at <http://www.altc.edu.au/resource-engineering-qualification-curriculum-uts-2011>
- [4] ALTC., "Learning and teaching academic standards project", Australian Learning & Teaching Council, December 2010, Accessed 29 March 2011 at http://www.altc.edu.au/system/files/altc_standards.finalreport.pdf
- [5] Ohno T., Toyota Production System: Beyond Large-Scale Production, Productivity Press, New York, 1988.
- [6] Prince M. J. and Felder R. M., "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases", Journal of Engineering Education, Vol. 95, 2, 2006, pp 123-138.
- [7] Grabinger R.S. and Dunlap J., "Rich Environments for Active Learning: A Definition", Association for Learning Technology Journal, Vol. 3, 2, 1995, pp 5-34.
- [8] Dale E., Audio-visual methods in teaching, The Dryden Press, New York, 1946.

- [9] Meyer J.H.F. and Land R., "Threshold Concepts and Troublesome Knowledge 1: linkages to ways of thinking and practicing within the disciplines", In Improving Student Learning – Ten Years On. C.Rust (Ed), Oxford Centre for Staff and Learning Development, Oxford, 2003.
- [10] CDIO Initiative, "The CDIO syllabus: A Statement of Goals for Undergraduate Engineering Education", CDIO Initiative, Jan 2001, accessed 2 April 2011 at http://www.cdio.org/files/CDIO_Syllabus_Report.pdf
- [11] Bankel J., Berggren K.-F., Engström M., Wiklund I., Crawley E.F., Soderholm D., El Gaidi K. And Östlund S., "Benchmarking Engineering Curricula with the CDIO Syllabus", International Journal of Engineering Education, Vol. 21, 1, 2005, pp121-133
- [12] CDIO Initiative, "12 CDIO standards", CDIO Initiative, 12 April 2004, accessed 2 April 2011 at <http://www.cdio.org/implementing-cdio/standards/12-cdio-standards>

Biographical Information

Jane Goodyer is an Associate Professor and the Director of Undergraduate Teaching and Learning responsible for the engineering and technology programmes within SEAT. She is a manufacturing engineer who teaches and researches in Lean thinking.

Allan Anderson is a Professor in Product Development and SEAT's Marketing Director. His current research focuses on product development management and practices. He's President of PDMA-NZ and a member of PDMA's globalisation committee.

Corresponding author

Assoc. Prof. Jane Goodyer
Massey University
School of Engineering & Advanced Technology
Private Bag 11 222
Palmerston North 4442
New Zealand
DDI +64 6 350 5294
j.goodyer@massey.ac.nz