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CADET - Centre for Advanced Design in Engineering Training

Guy Littlefair; Alex Stojcevski
School of Engineering, Deakin University, Geelong Australia
guy.littlefair@deakin.edu.au

BACKGROUND

The Centre for Advanced Design in Engineering Training (CADET) is a partnership of Deakin University and the Gordon Institute of TAFE that will improve access and pathways into careers to address Australia's critical engineering skills shortage (Walton, C). Local high schools, Belmont High and Matthew Flinders Girls Secondary College are included as strategic partners. CADET is proposed to be a teaching and learning facility providing a project focused modern engineering approach to students at regional schools and TAFE as well as Deakin's degree programs. CADET will emphasize engineering design and development through virtual and physical modelling, simulation and prototyping – skills at the heart of the 21st century engineering challenges, and will serve as an attractor to engineering and related professions.

PURPOSE

The purpose of this paper is to present an argument toward the development of a Centre for advanced design in engineering training. CADET is proposed to increase the awareness and attractiveness of engineering as an education and career option, particularly for women, in regional schools, provide under one roof state-of-the-art engineering design, modelling and prototyping facilities, facilitate access and articulation pathways between school, VET and Higher Education, increase the physical capacity to serve student demand in western Victoria, and reinvigorate engineering as an essential component of a skilled regional economy.

DESIGN/METHOD

The evidenced based argument towards the proposed centre for advanced design in engineering training is based on a detailed literature review as well as a research study with industry representatives in engineering design. The learning principles of the model are also investigated and aligned to the proposed centre.

RESULTS

CADET is a change to the way engineering has traditionally been taught. The outcomes of CADET will be to provide a broad range of contemporary/relevant teaching programs, improve the social benefits gained from teaching programs, improve retention rates, advance partnerships that link with rural and regional victoria, and collaborate with local communities to encourage governments to support regional capacity building. Through focus group interviews and open discussions with industry and academia over the past 12 months on the integration of design skills in engineering education, results indicate that the following key skills are essential elements required for a successful project oriented design based learning curriculum are creative & innovative skills, successful industry engagement, and awareness of design skills in early years. Feedback also showed that 80% of the industry representatives are looking to recruit graduates who acquired design-equipped skill and 60% indicated that they want graduates who acquired knowledge through projects.

CONCLUSIONS

CADET projected benefits are significant at the strategic and operational levels. They include access for more women in engineering, facilitates articulation pathways between VET and HE, targeted recognised critical current engineering skills shortage in Australia, improvement of regional access, attractiveness and participation in tertiary education, achievement of a significant improvement in the teaching-research nexus.

KEYWORDS

Design based learning; project based learning; engineering education.

Introduction

This paper describes a proposed initiative towards addressing the national engineering skills shortage. It takes place in the form of a Centre for Advanced Design in Engineering Training (CADET) proposed at Deakin University Geelong Waurn Ponds campus in partnership with the Gordon Institute of TAFE. Geelong high schools, Belmont High and Matthew Flinders Girls Secondary College are also involved as strategic partners. CADET is proposed to be a teaching and learning facility providing practical, project oriented design based learning pedagogy to students in programs at regional schools and TAFE as well as Deakin's engineering degree programs.

CADET will emphasise on design based learning oriented around group projects, virtual modelling and prototyping. These skills at the heart of 21st Century engineering challenges and will serve as an attractor to engineering and related professions. This design-focused approach is proven to make engineering more attractive to students, especially young women who must be better served in technical education (Walton C, 2012). The objectives of the CADET are to:

- Increase the awareness and attractiveness of engineering as an education and career option, particularly for women, in regional schools;
- Provide under one roof, state-of-the-art engineering design, modelling and prototyping facilities, and project based studios
- Facilitate access and articulation pathways between school, VET and Higher Ed;
- Increase the physical capacity to serve student demand in western Victoria and
- Reinvigorate engineering as an essential component of a skilled regional economy

The proposed facility involves a total expenditure of over $50 million including $45.3 million for construction of new and refurbishment of existing infrastructure and $6.0 million for advanced teaching and learning facilities and equipment.

This paper describes the educational requirement and alignment to the proposed Centre of Advanced Design in Engineering Training as well as the infrastructure of the CADET. Importantly, it also describes the learning principles of such an educational philosophy.

Project-Oriented Design Based Learning (PODBL)

A facility like the CADET will require an alignment of the physical infrastructure with the learning and teaching mode of delivery. The educational framework around supporting CADET is a project-oriented design based learning philosophy, which is described in this section.

Constrctive Alignment in PODBL

The construction of educational programs and courses is usually a challenging task due to many factors, which must be considered. What are the questions, which must be asked while designing these courses? Below are some questions, which should be considered when, undertaking this task:

- What are the aims and learning outcomes?
- What outcomes will the learners achieve?
- What should be assessed?
- How to assess?
- What is the correct content for the learners?
- What teaching and learning strategies should be employed?
- What is the delivery method of the course?

A well-designed course will stimulate the students' learning by integrating and answering all of the above questions. The integration of these elements is critical to the success of the course, and therefore, the student's learning cycle. If a course for some reason does not act to integrate and incorporate these elements into the curriculum development, then it will be very difficult for learners to achieve the set learning outcomes of the course. The integration of these elements is what educators refer to as "constructive alignment" (Biggs J, 1999; Vygotsky L, 1978). Biggs describes this model as the underpinning concept behind the current requirements for program specification, declarations of Intended Learning Outcomes (ILOs) and assessment criteria, and the use of criterion based assessment. There are two parts to constructive alignment:

- Students construct meaning from what they do to learn.
- The teacher aligns the planned learning activities with the learning outcomes

The principle of the model is that the curriculum is developed so that the learning activities and assessment tasks are aligned with the learning outcomes that are intended in the course. This way, total consistency can be achieved. This is illustrated in figure 1.

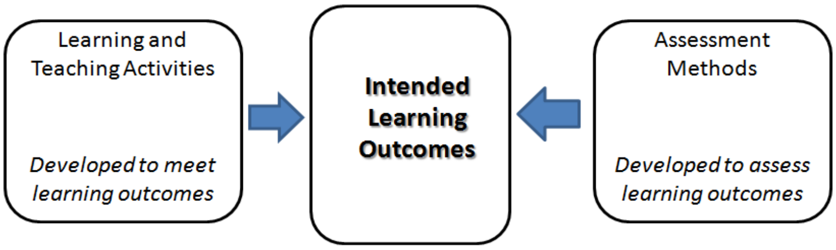

Figure 1: Aligning learning outcomes, learning and teaching activities and assessment [4]

The model could also be described as a linear relationship of these elements. A linear constructive alignment model can be seen in figure 2 below.

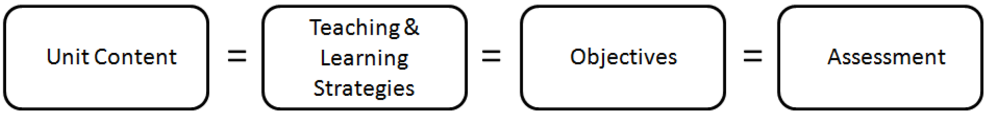

Figure 2: A linear illustration of the Constructive Alignment Model

A more realistic view of constructive alignment and one, which could be more suitable to a project oriented design based learning curriculum, is illustrated below in figure 3.

Figure 3: Suitable Constructive Alignment for a PODBL curriculum

Figure 3 still illustrates the four elements essential to constructive alignment, however they are shown to be overlapping each other, and not linearly equal to each other. This is a key observation and could be very positive to PBL due to the overlapping integration.

In all of the three figures above, it is very clear and obvious that assessment is a critical element in the aligning process. For this reason, this paper looks into the assessment methods in a PBL course undertaken by first year students in electrical and electronics engineering. The observation and data collection is performed by qualitative and quantitative research where participants are asked to rank the effectiveness of a portfolio as an assessment tool in the course.

Project Based Learning

Project based learning (PBL) as an educational teaching and learning methodology has been actively used for some time now. One of the first applications of PBL is recorded in the study of medicine in the 1960s. Since then PBL has spread in other higher education disciplines such as engineering, mathematics, business, and architecture. Project based learning is generally regarded as an innovative method for engineering education. The success of this method is very much dependant on the theoretical learning principles which the method possesses. When compared to traditional lecture-based or teacher-entered engineering curriculum, the PBL model appears to inspire a higher degree of involvement in study activity (Stojcevski A, 2007; Graaff E, 2003). The definition of PBL is still somewhat open and designing a PBL curriculum is dependent on the objectives of an institution.

In project-based learning, learning begins by dealing with project, which occur from professional training. Traditionally, education within the School of Engineering at Deakin University has been structured according to the logic of separate units. However, because professional training and individual learning practices do not pursue such dissection, this can lead to an amplified gap between professional engineering training and education.

Design Based Learning

Design based learning (DBL) is a self-directed approach in which students learn to design and solve creative solutions which fulfil academic, community, and industry expectations. Design Based Learning is an effective vehicle for learning, which is centred on a design problem solving structure adopted around a project-oriented approach. Design projects have been used to motivate and teach science in elementary, middle, and high school classrooms and can serve to open doors to possible science or engineering careers. It has been discussed and implemented for a number of years now but it is a concept that still needs further development. Therefore it is very important to characterise DBL as an educational concept in higher engineering education, particularly oriented around projects. With different learning styles students are able to express their skills and talents through working on projects or simply designing experiments in authentic learning environments. In addition, integrating design and technology tools into engineering education provides students with dynamic learning opportunities to actively investigate and construct innovative design solutions. A design based learning environment helps a curriculum to practice 21st Century Skills for students such as problem solving, collaborative teamwork, innovation and creativity, active learning, and real-world learning.

The design based learning process is illustrated in figure 4.

Figure 4: Design based learning process

Accrediting bodies such as the Accreditation Board for Engineering and Technology (ABET, 2012-2013), Engineers Australia (EA, 2012), as well as the European Accreditation of Engineering Programs (EUR-ACE, 2008), all specify that Design is an essential element of graduate outcomes for an engineering program. When students' require the opportunity to apply their knowledge to solve the design problems, Design based learning is approached as an innovative method for engineering education.

Australian firms recognize that they need to become even more efficient and productive, innovative and attuned to their customers' needs. The Australian firms are looking for their employees with demanding higher-level soft skills (willingness to learn, good communication and teamwork skills, problem solving skills), solid basic skills (numeracy and literacy) and right attitude. The exchange of knowledge and experiences between universities and industry, willingness of industry to engage with academics, with students and with the engineering curriculum is a possible way to overcome this situation (K S, 2006).

Infrastructure Arrangement - CADET

Apart from human resource implications, a major implication to successfully initiate and sustain a PODBL program in engineering within the School is to have the appropriate infrastructure. This is one of the major reasons for the proposed Centre for Advanced Design in Engineering Training.

CADET is a new teaching and learning facility for Engineering and Design to stimulate, attract and retain local and regional engineering students (particularly young women). The proposed infrastructure will provide for increased load capacity and a 'step change' approach to the T&L of DU's engineering undergraduate courses at the Waurn Ponds Campus. CADET will also be a broader resource for TAFE and High School partners in the Greater Geelong and Victorian southwest corridor regions.

The projected benefits are significant at the strategic and operational levels and are:

- Key enabler of the strategic intent to grow student load across the Geelong campuses
- Promotes access for more women in engineering
- Contribute to addressing a wide range of Federal, State and Local Government aspirations
- Facilitates articulation pathways between VET and DU

- Targets a recognised critical current skills shortage area in Australia, Victoria and Geelong (This shortage will be exacerbated with the potential future economic imperative to stimulate and support manufacturing)
- Improves regional access, attractiveness and participation in tertiary education
- Achieves a significant improvement in the teaching-research nexus (while Deakin University (DU) is ranked world class in aspects of engineering it currently has a low market share of undergraduate student load in Victoria due, particularly, to the loss of commencing undergraduates to the metro universities)
- Addresses serious deficiencies in scope, functionality and amenity of current infrastructure in supporting the current engineering student load level (as well as capacity for significant growth)

Drawing on new and emerging pedagogies internationally (e.g. Singapore University of Technology and Design, MIT, Aalto University) and locally (E.g. Swinburne University of Technology), CADET will achieve the above through a new approach to teaching engineering that emphasizes project oriented design based learning aspects. Working directly with TAFE and High School partners on course development, implementation and marketing, CADET will provide hands on, under one roof access to state-of-the-art engineering design, modelling and prototyping facilities and the introduction of a PODBL approach enabling new DU and Gordon TAFE courses in Product Design Engineering, Medical Technology, Sports Engineering, Design Technology and Engineering Design.

Figure 5 illustrates the CADET infrastructure.

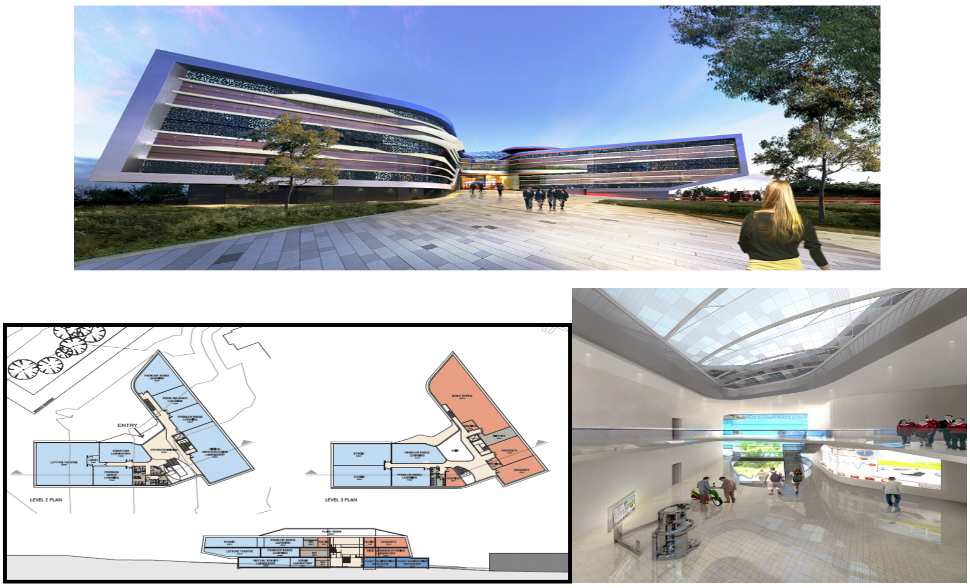

Figure 5: The Centre for Advanced Design in Engineering Training

The infrastructure includes approximately 7000m^2 facilities at Waurn Ponds including high end to support industry and research and lower end for demonstrations and engagement with high schools and student projects. It also includes open plan multi purpose project based education space for both engineering students and industry.

Learning Principles of the Model

On the basis of previous recommendations by industry and academic as well as national and international research, it is very important and critical that we identify a framework that is unique to Engineering at Deakin based on a project oriented design based learning model.

Based on Engineers Australia Stage 1 competencies as well as industry input it is proposed here that fundamental knowledge base, engineering ability, and professional attributes are they key elements of competency and part of the integrative learning principle for all Deakin graduates under this framework. The other key learning principles forming part of our model are practice based learning which includes action based learning, analytical thinking and problem solving, and industry based learning which is based on project learning and interdisciplinary learning. These three learning principles are all constructively aligned and are underpinned by constant engagement between students, staff, community, industry, and the government. Taking all this into consideration, the Deakin PODBL learning framework is illustrated in figure 6.

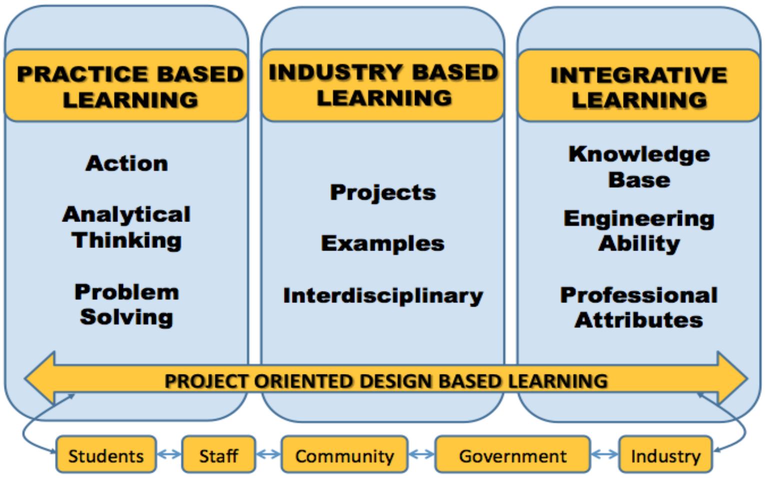

Figure 6: CADET learning principles framework

Justification for PODBL and CADET

In an industry forum conducted in Melbourne Australia in 2012, a research study was performed to investigate the industry and academia requirements from students' focusing on achieving design skills. Majority of the participants' who took place were design engineers, designers, architects, industrial design practitioners, real world project team leaders, teachers, lecturers, entrepreneurs from different disciplines and participants' from Engineers Australia (Australia's Engineering Accreditation Body).

Qualitative analysis of the feedback provided shows a requirement of the following skills actions:

- Creative & innovative skills
- Industries engagement
- Global perspective skills and awareness
- Internationalisation skills
- A connection between design and innovation
- Design awareness
- Communication skills
- Project management skills

Feedback also showed that 80% of the industry representatives are looking to recruit graduates who acquired design-equipped skill and 60% indicated that they want graduates who acquired knowledge through projects. The research is summarised around a sustainable design model and is illustrated in figure 7.

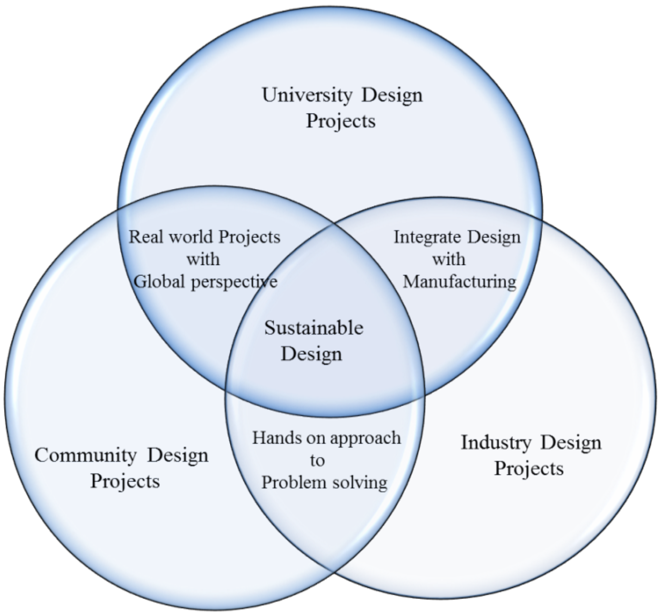

Figure 7: Sustainable Design model from industry and academic feedback

The findings from the research performed with the industry indicate that learning is a combined source of students' own initiation to social, global responsibility and the expected skills from the industry. Industry is looking for graduates who are ready to practice and perform the essential competences such as practical knowledge, problem solving, teamwork, and innovative and creative designing of real-world projects. In addition, both educators and industry representatives stated that students lack motivation in most cases due to the learning and teaching style they are exposed to. Thus academes must focus on teaching engineering science rather than engineering and should undergo practice rather than theory in the classroom. In learning and teaching institutions, practicing design is one of the fundamental processes and activities in engineering and all other engineering activities related to it.

From the industry's point of view, results indicate that the following key skills are essential elements required for a successful project-oriented design based learning curriculum. They include creative & innovative skills, successful industry engagement, and awareness of design skills in early years of engineering. A summary of findings is illustrated in figure 8.

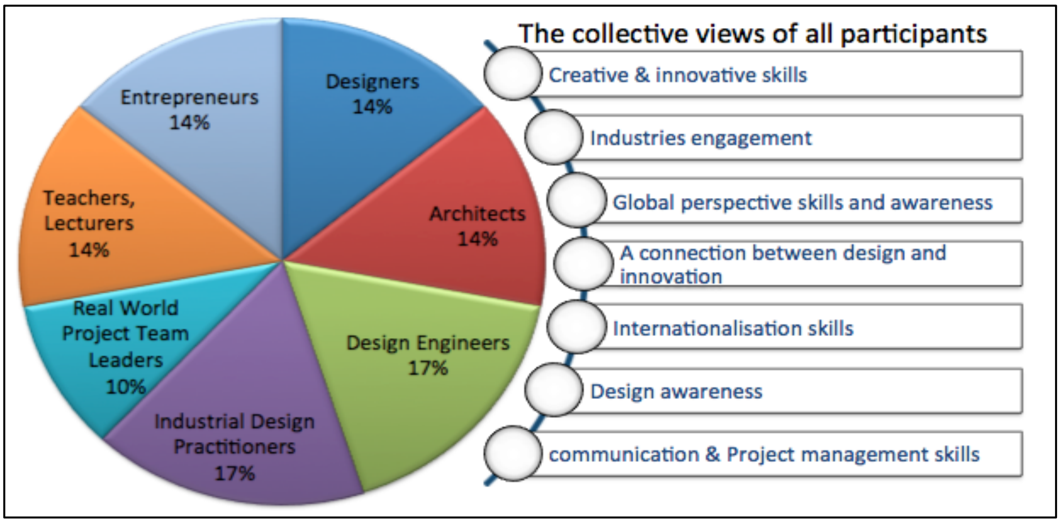

Figure 8: Industry and academia views on design discussion

By engaging the industry with the academe, students will acquire global perspective knowledge about the core attributes expected in future engineering jobs. In today's large-scale industry market, companies tend to prefer graduates with design skills attained through project approach. Thus universities should open their doors and accept the challenges of interacting students with industrial experiences and expectations.

Conclusion

Project Oriented Design Based Learning is set to have a positive effect on student content knowledge and the development of skills such as collaboration, critical thinking, creativity, innovation, and problem solving which increases their motivation and engagement. It is a challenging task for academic staff to implement a PODBL approach and integrate technology into projects in meaningful ways. The Centre for Advanced Design in Engineering Training (CADET) is proposed to resolve these challenges. Underpinning CADET is the recognition that Australian engineering must reinvigorate in response to major economic and social shifts with attention to a global market and greener economy. In other OECD countries, notably Finland and Singapore, tertiary education is playing an important role in adopting teaching and learning approaches directly aligned with engineering innovation in new materials, design, modelling and efficiency. CADET will provide progressive pathways into jobs that will serve a new knowledge economy in areas that have not traditionally had access to such opportunities, largely through limitations in access and education. A core CADET objective is to increase the percentage of females enrolling and completing engineering by partnering with VET and High Schools.

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