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Project Oriented Design Based Learning (PODBL)
in Engineering Education

by

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

Deakin University

June 2014
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Project Oriented Design Based Learning (PODBL) in Engineering Education
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My work is dedicated to the most important people in my life to date.

My Grandfather R B Gopal Pillai and
My Grandmothers Malarveni Ammal, Kuppulakshmi Ammal

I dedicate my work to my dad Chandrasekaran and my mum Girija Chandrasekaran, whose love, hard work, sacrifice, affection, encouragement and confidence took me to this high in my life.
I am proud to be their son forever.

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List of Abbreviations

ABET  Accreditation Board for Engineering and Technology
ABL   Action Based Learning
AQF   Australian Qualifications Framework
BLM   Blended Learning Model
DBL   Design Based Learning
DCC   Design Centric Curriculum
DCP   Design Centric Program
CADET Centre for Advanced Design in Engineering Training
CBL   Collaborative Based Learning
EA    Engineers Australia – Australia’s Engineering Accreditation Body
ED    Engineering Design
EUR-ACE European Accreditation of Engineering Programs
OBL   Outcome Based Learning
OECD  Organisation for Economic Co-operation and Development
PBL   Problem Based Learning
PjBL  Project Based Learning
PODBL Project Oriented Design Based Learning
RBL   Research Based Learning
SCANS Secretary Commission on Achieving Necessary Skills
SBL   Scenario Based Learning
SDL   Student Driven Learning
TAFE  Technical and Further Education
TBL   Team Based Learning
TEQSA Tertiary Education Quality and Standards Agency
IAB   Industry Advisory Board
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<th>Abbreviation</th>
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<tr>
<td>IBL</td>
<td>Inquiry Based Learning</td>
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<tr>
<td>ILM</td>
<td>Industry Liaison Management</td>
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<tr>
<td>IP</td>
<td>Intellectual Property</td>
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<tr>
<td>VET</td>
<td>Vocational Education and Training</td>
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<td>WBL</td>
<td>Work Based Learning</td>
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Abstract

In engineering education, students are active learners while teachers are perceived as facilitators. All universities have the capability to produce qualified professionals by motivating and developing the skill set of students to become experts in a chosen field. The graduation rate for engineers in Australia is increasingly growing, however students lack practical knowledge. There is no consistency in types of courses, facilities, infrastructures, or frameworks for students. This comes as many universities have mixed opinions surrounding the connotation of 'education'. Some believe education is one becoming a skilful product of human society, while another belief is that education acts on the needs of the stakeholder. Despite this, there are still many students who are overlooked for job opportunities for reasons unknown.

To counter this problem, a number of educators have developed various approaches and concepts such as Project Based Learning and Problem Based Learning. These approaches have highlighted noticeable changes within the performance and knowledge of students, especially when breaking out of traditional cultures and introducing creative ideas. To deal with problems and to find solutions for problems is an essential quality for any professional. Therefore, curriculum needs to educate and prepare students to be problem solvers. Different types of problems exist in engineering, and design problems are the most important for attracting young, imaginative engineers. This research explores a framework for learning and teaching approach to solve design problems through Project Oriented Design Based Learning in engineering education.

Projects can influence an engineering curriculum in various ways. This can be done at a course level and/or program level. Educators, students and industry clients are approaching project work as a key for establishing social, academic and industrial partnerships. In most Australian universities in
the final year, students complete an individual project involving the application of skills and knowledge attained during the earlier years of their degree program. Through these projects students develop new abilities for the application of this knowledge and these skills to real-world problems, learn the art of modeling, simulation, design, development and management of an industry based or research based project. Projects are thought to be the best way for students to interact with their teacher. These projects occur in the first, second, third and final year of all university prospectuses. This research focuses mainly on learning to solve design problems through projects that influence innovation and creativity. The specific intention of this research is to obtain an approach, a method or a framework that balances the learning and teaching relationship by integrating creative, innovative and communicative skills in a Project Oriented Design Based engineering curriculum.

This thesis identifies the need to enhance important skills such as innovation and creativity through a whole learning process that incorporates design based learning features. From an in-depth analysis of all learning approaches and methods, design can be learned and taught through a design based learning approach in a convalescent way. As a consequence, this research focuses on Project-Oriented Design Based Learning in engineering education. The aim of this thesis is to develop a framework for learning and teaching to solve design problems through Project Oriented Design Based Learning (PODBL) in engineering education.

**Keywords:** Project based learning, Problem based learning, Accreditation, Engineering design, Design based learning, Project Oriented Design Based Learning, Students perspectives, Staff perspectives, industry perspectives, curriculum development.
Chapter 1

Introduction

1.1 Foreword

An important role for an engineer is to create innovative design models from learning and operational experiences that are used in various ways, whether it is for industry, commercial, domestic or personal infrastructure. The role of engineers can be seen in the production of food for agriculture, power generation for electricity, building dams for water resources, transport systems that save time, equipment for industrial productivity, communication, computer systems for telecommunication and networking, and medical instruments for health and consumer treatment.

When students enter engineering at university from secondary school, they have learned physics, chemistry, mathematics, science and computer systems. However, this broad knowledge will not assist them to become an expert in any engineering field if they lack creativity, innovation and communication skills. It is basic requirement that a professional deals with problems and finds a solution. Therefore curriculums need to educate and prepare students to become problem solvers. In the engineering field, there are different types of problems but for young and imaginative engineers, problems related to design are the most attractive.

In undergraduate university courses, projects are believed to be the best way for students to interact with their teacher. Project work takes place in the first, second, third and final year of all university curriculums because during this four year program there has always been a strong commitment to engineering design [1]. This thesis identifies the need to enhance important skills such as innovation and creativity through a whole learning process that incorporates design based learning features. From an in-depth analysis of all learning approaches and methods, design can be learned and taught through a design based learning approach in a convalescent way. This research focuses mainly on learning to solve design problems through projects that influence innovation and creativity. As a consequence, this research focuses on developing a new learning and teaching model in engineering
education. The aim of this thesis is to develop a framework for a new learning and teaching model to solve design problems through design based learning in engineering education.

1.2 Motivation for the Thesis

Modern engineering expects students to be a professional graduate, problem solver, good communicator, critical design analyser and an innovative creator. Education practitioners are aware of these modern engineering skills expected by the industry. Every university has the responsibility to educate students with knowledge in their engineering disciplines. The level of students’ learning outcomes should be assessed at every stage of the curriculum that makes teachers to accelerate their curriculum content. By assessing students’ perceptions on teaching content and approaches, it is always a good way of monitoring one’s own teaching approach in a classroom environment. Self-assessment helps lecturers to understand the perceptions of students about their learning and teaching environment.

To deal with problems and to find solutions is an essential quality for any professional. Therefore, university curriculum needs to educate and prepare students to be a problem solver. Different types of problems exist in engineering and to address this reality educators have developed a number of approaches and concepts such as Project Based Learning (PjBL) and Problem Based Learning (PBL) etc. These approaches have exposed noticeable changes within the performance and knowledge of students, especially when breaking out of traditional cultures and introducing creative ideas.

Design is not restricted to engineers even though they are professional designers. Everyone is a designer who devises courses of action aimed at changing existing situations. This research insists the design process and design artefact are both important criteria to solving engineering design problems. When students learn to solve design problems, they need to use the design process as a methodology to approach the problem and they have to understand the user requirements for the end product. It is a vital role for an engineer to satisfy the user’s needs in every aspect of designing an end product.

This research explores a framework for new learning and teaching model to solve design problems through design based learning in engineering education. The specific intention of the research is to obtain an approach, a method or a framework that balances the learning and teaching relationship
by integrating creativity, innovation and communication skills in a design based engineering curriculum.

Engineering education should be a combination or integration of solid knowledge on the basis of natural sciences and a good knowledge in some aspect of technology. Students should be able to develop the ability and willingness to take ownership of their learning that prepares them to be good engineers in society. There are many perspectives from which one might view design-focused projects within the first, second, third or final year of any engineering degree. Engineering education in the U.S, Australia, UK, India, Singapore, Malaysia, China and in some European countries fulfills the demand from clients, governments, environmental groups and the general public. Observing various formats of engineering curriculums, there are many more approaches adopted at several institutions that will be examined in this review. Design based learning in engineering education is an overarching learning principle proposed in this research project and is set to satisfy many requirements of the revised accreditation criteria in Australia and around the world, as well as satisfying industrial needs for the next generation of engineering graduates.

1.3 Objectives of this Research

The objectives of this research are:

- To review different learning and teaching approaches in engineering education.
- To collect and analyse the students’ perspectives on learning engineering design from different engineering disciplines at Deakin University.
- To collect and analyse the staff members’ perspectives on teaching and conduct research about engineering design from different universities in Australasia and Asia region.
  - To collect and analyse the staff members’ perspectives in the School of Engineering at Deakin University, Australia.
  - To collect and analyse the staff members’ perspectives in the Australasian University A.
  - To collect and analyse the staff members’ perspectives in the Australasian University B.
  - To collect and analyse the staff members’ perspectives in the Asian University A and Asian University B.
- To collect and analyse the Industry perspectives in a design discussion forum.
To develop a framework for a new learning and teaching model.
To develop framework guidelines for students, staff members, industry, academic leadership and accreditation organisations.

1.4 Design Methodologies

The School of Engineering at Deakin University has always tried to improve its unit delivery method to enrich the student experience and to produce capable job ready engineering graduates. To this end, it has explored new teaching methods to aid in this process. One such method is Design Based Learning (DBL). Unlike Problem Based Learning (PBL) and Project Based Learning (PjBL), DBL is a self-directed learning approach and opens up learning activity so design skills must be learnt and applied [2]. Students must locate the resources required, and analyse any needs in order to create a design [3]. This method gives students the freedom to apply their design skills as they think best. DBL not only looks at the end product but also at the underlying process in creating that product [4]. Whilst this seems to be a valid unit delivery method, one key piece of information is missing: what do students, staff and industry representatives think about DBL? The perspective of students, staff and industry is required to help validate, improve or reject this method as a useful teaching tool in engineering education.

1.4.1 Paper Based Survey for Students

The purpose of a survey to explore students’ perspectives about a design based learning approach is to discover their teaching expectations and learning outcomes. The DBL survey was conducted using a qualitative and quantitative analysis method. Qualitative methods are useful for evaluating, developing program goals and for involving participants in the evaluation process to gain their insight and perspective. In this method, results from the survey are manually analysed by the researcher. The questions in this paper-based survey were developed to obtain the students’ views on design based learning in engineering education. The survey results provided various views and expectations from students that could assist a school to implement a design centred education. In addition, the questionnaires were prepared to identify the difficulties in teaching and learning and to discover student perspectives for practicing design based learning. Qualitative methods are useful for evaluating, developing program goals and for involving participants in the evaluation process to gain their insight and perspective [5]. This is important because it is about students’ perceived value.
of DBL and not about the value of DBL itself. The implication is that if students value the teaching method then this gives more value to that teaching method itself.

1.4.2 Face-to-Face Interviews for Staff

Face-to-face interviews are used to investigate staff perspectives on design based learning in engineering education. Face-to-face interviews are based on qualitative questions that are analysed and presented in quantitative form. The questions covered here are designed to determine staff perspectives on design based learning through their level of experience from first to final year. An interview question set was asked of each staff member that teaches and conducts research in engineering design. The research assistant involved in the project conducted the interviews and data collected is anonymous and non-identifiable.

The data collected are the various perceptions of staff, which includes their knowledge and expectations. In turn this can inform the school to implement a design centred education. This research was carried out in adherence to Deakin University’s ethics approval process and procedures. The questions were prepared to identify the challenges in teaching and learning and in particular to investigate the perspectives of staff on the practice of design based learning. From these results, this research will lead to new teaching and learning approaches, which will enhance student-learning outcomes.

1.5 Originality of the Thesis

Design projects have been used to motivate and teach elementary, middle, and high school students. For over a decade, students have been taught different methodologies in the hope of pursuing science and engineering careers. With different learning styles, students are able to express their skills and talents through team based projects or simple design experiments in authentic learning environments[6]. Engineering schools must develop best practice in engineering education to promote student learning and deliver intended graduate outcomes [7].

Project-based learning is perceived to be a student centred approach to learning. Students need to produce a solution to solve the problem and they are required to produce an outcome as a report supervised by the teacher. Teaching is considered as an input directing the learning process [8]. Problem-based learning is focused around problem scenarios rather than discrete subjects and the
selection of the problem is essential here. The teacher is to facilitate the learning process rather than to provide knowledge. Solving the problem may be part of the process [9].

Accrediting bodies such as the Accreditation Board for Engineering and Technology (ABET), Engineers Australia (EA), as well as the European Accreditation of Engineering Programs (EUR-ACE), all specify that design is an essential element of graduate outcomes for an engineering program. When students are required to apply their knowledge to solve design problems, design based learning is used as an innovative method for engineering education [10-12].

Design based learning (DBL) is a self-directed approach in which students initiate creative learning using hands on solutions to meet the academic and industrial expectations of society. It is an effective process centred on problem solving structures which flow from problem-oriented project based education. By engaging students in design, DBL provides an opportunity to apply original and inventive ideas that aid in students’ development and growth. The intention of engineering science education is to produce a curriculum that improves learning for all students. This can be achieved by using design based learning through the preparation and training of project based activities that support the learning of cooperative methods.

Students are encouraged to study subjects where they learn by building, creating and implementing products and prototypes. The objective is for students to integrate their knowledge in processes where problem solving is essential. Therefore, design based learning is used to enrich student involvement by integrating experience. DBL is a type of problem-based learning where problems are solved in teams. It is important to have a pedagogy style or approach, such as design based learning, which is similar to project based or problem based learning. The objective of this research is to develop a framework for new learning and teaching model. In the process of developing a framework, this research focused on collecting and analyzing the perspectives of students, staff members and industry about a design based learning approach to explore teaching expectations and learning outcomes they experienced.

1.6 Thesis Organisation

The thesis is organised into seven chapters. Following the thesis introduction, Chapter 2 is divided into two parts. The first part reviews the different types of problems (engineering), the problem solving process, the design process and different learning approaches. The second part of this
Chapter 1

Chapter 1 reviews the design based learning approach in various disciplines. Chapter 3 presents details about the proposed aim of the research, the research questions and the design methodology. Chapter 4 describes an overview of learning through projects, different project types, design projects in engineering education and accreditation requirements for engineering design. Chapter 5 looks at various national and international case studies in Asia pacific universities, students and staff perspectives on design based learning, different design practices at various universities in Asia pacific universities. In Chapter 6, a developed framework of new learning and teaching model is presented and described in detail with framework guidelines for students, staff, industry, academic leadership and for accreditation requirements. The thesis conclusion with future work is presented in Chapter 7.
Chapter 2

*Literature Review*

**PART I: Student Centred Learning**

**2.1 Introduction**

In engineering courses, many educators use different teaching and learning approaches to teach students about engineering design, design processes, engineering and technology, and discipline related engineering practice. When it comes to solving a design problem, students gain important experience from their course that assists them in their future engineering career. Students need to learn how to solve design problems, how to use the design process as a methodology to approach a problem and to understand the user requirements for an end product. It is important for an engineer to satisfy the needs of a user in every facet of designing an end product.

Many educators believe education is about becoming a skilful product of human society, while others believe it is about acting on the needs of stakeholders. Despite this, many students are still overlooked for jobs for unknown reasons. To counter this problem, a number of educators have developed a number of approaches and concepts such as Project Based Learning, Problem Based Learning, and Design Based Learning. These approaches have exposed noticeable changes with the performance and knowledge of students, especially when breaking out of traditional cultures and introducing creative ideas. To deal with problems and find a solution is an essential quality for any professional. Therefore, a curriculum needs to educate and prepare students to be problem solvers. This thesis firstly looks at different types of problems encountered in engineering, how users approach these problems through the problem solving and design process. It also explores different types of learning styles that encompass different learning modes. This chapter is split into two parts. The first part reviews the different types of problems (engineering), the problem solving process,
the design process and different learning approaches. The second part of this chapter reviews the design based learning approach used in various disciplines.

2.2 Different Types of Problems

In engineering, a ‘problem’ is to design or build something. This is a challenge for many engineering students as they need an incentive to start their learning process. Pale Quist in [13] states that ‘a problem is a wondering which takes the concrete form of a question’. David Jonassen [14] defines ‘a problem as an unknown entity in some context, finding or solving for the unknown must have some social, cultural or intellectual value’. The students are encouraged to view a problem from different perspectives [14]. The kind of problems most often encountered are:

- Logical problems (learn to solve puzzles)
- Algorithms (using formula or procedure)
- Story problems (e.g. in mathematics and science)
- Rule using problems (e.g. calculating material needed in addition)
- Decision making (e.g. how I am going to pay this bill),
- Troubleshooting (e.g. troubleshoot an inoperative modem)
- Diagnosis solution (e.g. develop an individual plan of instruction for special education students)
- Strategic performance (e.g. teaching in a live class)
- Case-policy problems (e.g. evaluate performance of a stock portfolio)
- Dilemmas (e.g. should abortions be banned?)
- Design problems (e.g. developing curriculum for school)

To select their own learning goals, students should analyse problems and frame questions with respect to the information they lack to solve the problems. Gardner and Hatch [15] state that ‘intelligence is the capacity to solve problems’. Therefore, students should learn to integrate knowledge from different disciplines and learn to select methods, theories and tools to come up with a solution that is based on the chosen problem [16].

2.3 Problem Solving Process

The Secretary Commission on Achieving Necessary Skills (SCANS) reports on what problem solving skills are required for schools. The Commission states that problem solving is an essential
skill for students [17]. The Accreditation Board of Engineering Technology (ABET) in the United States specifies the ability to identify, formulate, and solve engineering problems is an essential skill for an engineering program. Problem solving is the foundation of all engineering activities. Figure 2.1 shows the problem solving process, which is similar to the design process.

![Figure 2.1: Problem solving process [17]](image)

George Polya [18] describes how to solve problems and identifies four basic principles of problem solving. The first principle is to understand the problem. This is due to the fact that students have difficulties understanding the problem. The second principle is how to develop a plan. There are many ways to solve a problem but choosing a good strategy is best learned by solving many problems. The third principle is to carry out the developed plan. The idea behind this principle is for students to follow the developed plan and identify if the plan is suitable to achieve their required goal. The fourth principle is to reflect on the process so far and identify what, if anything has been missed. This process allows students to gain knowledge for further problem solving activities [19].

### 2.4 Design Process and Artefact

Design is one of the fundamental processes and activities in engineering and all other engineering activities relate to it. Studying engineering not only involves learning scientific knowledge and technological skills, it also involves learning the language, established practices, beliefs, and professional values of an engineering culture that makes a student an engineer [20]. RM Felder [21] identifies ‘Engineering Design’ as a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints.
Design problems are classified as open-ended problems that generally have multiple solutions. A formal systematic problem-solving methodology is useful for these types of problems. Design is a continuous process of problem solving that may involve multiple iterations. The design process starts by identifying the problem. This allows students to search for possible opportunities to assist them in understanding the problem and therefore develop a design brief. Through research, students can then gather information on different methods, approaches and ideas to allow them to seek new solutions [22, 23]. When a new solution is implemented, a model or prototype is developed. The prototype is then tested and evaluated against the specifications developed in the design brief for functionality. Figure 2.2 illustrates the design process described above.

![Design Process](image)

**Figure 2.2: Design Process [14]**

There is always a difference between the design process and the designed end products created by designers in various domains. Design in architecture, interior design, product and industrial design, or urban and landscape design, all require the designer to produce beautiful yet practically useful and well-functioning end products. Students are future consumers, manufacturers, engineers or designers and they need to have creativity towards designing products and be aware of the way in which the products/systems affect individuals, society and the environment. They must become considered users rather than passive consumers of technology [24, 25]. Figure 2.3 illustrates four different segments of a design artifact.
Learning is an active process of investigation and creation based on a learner’s interest, experience and curiosity and it should result in expanded knowledge and skills. Learning can be conducted in many ways such as discovery learning, which is student driven with activities based on interest. When students are taught how to solve a problem or design a model, they generally remember 10\% of what they read, 20\% of what they hear, 30\% of what they see, 50\% of what they hear and see, 70\% of what they say and write, 90\% of they do (practical) [26]. Table 2.1 shows three learning modes, different types of learning approaches and how it helps students remember what they learn. The best way to achieve learning is to become involved in all three learning modes [26].

<table>
<thead>
<tr>
<th>Learning Mode</th>
<th>How Do we Learn?</th>
<th>How Much Do We Remember</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Learning</td>
<td>Participate in activity</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Simulate the activity</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Teach the activity</td>
<td>70%</td>
</tr>
<tr>
<td>Visual Learning</td>
<td>Watch Demonstration</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Watch moving pictures</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>View pictures</td>
<td>30%</td>
</tr>
<tr>
<td>Verbal Learning</td>
<td>Hear words</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>10%</td>
</tr>
</tbody>
</table>

There are different learning styles that encompass the three learning modes described above. They form part of a learning philosophy that, if practiced well, could achieve similar outcomes. These learning styles are described as follows.

### 2.5.1 Project Based Learning

Project Based Learning is perceived to be a student centred approach to learning. It is predominantly task oriented and facilitators often set the projects. In this scenario, students need to
produce a solution to solve the project and are required to produce an outcome in the form of a report guided by the facilitators. Teaching is considered as input directing the learning process. The project is open ended and the focus is on the application and assimilation of previously acquired knowledge.

Engineering students require the opportunity to apply their knowledge to solve problems through project-based learning rather than problem solving activities as those do not provide a real outcome for evaluation [26-28]. One of the greatest criticisms of traditional engineering pedagogy is that it is a theory based science model that does not prepare students for the ‘practice of engineering’. Self-directed study is a large part of a student’s responsibility in project based learning modules [27, 29-31]. Figure 2.4 illustrates project based learning.

The learning principles of a project-based model are:

a. Pupils work together in groups and collaborate on project activities.
b. A real world problem that affects the life of the pupil is presented for investigation.
c. Pupils discuss findings and consult the teacher for guidance, input and feedback.
d. The maturity of pupil skills determines the degree of guidance provided by the teacher.

![Figure 2.4: Project based learning [29]](image)

2.5.2 Problem Based Learning

In this type of learning and teaching, students are usually presented with a situation, a case or problem as a starting point. The role of the teacher is to be a supervisor of the learning process. The subject knowledge gained by students is considered to be about the same for problem-based learning as it is for traditional teaching methods, however it does aid in developing creative thinking skills for problem solving. In this approach, students learn how to learn. Using problems or cases from real life in teaching is effective for motivating students and enhancing their learning and development of skills. Students need to learn how to find information when needed as this is an essential skill for professional performance.
Problem solving is a component of the problem-based approach. Problem based learning (PBL) focuses on problem scenarios rather than discrete subjects and the selection of the problem is essential in PBL [32-34]. The teacher acts to facilitate the learning process rather than to provide knowledge and solving the problem may be part of the process. Here, problem scenarios encourage students to engage in the learning process. The learning process is the central principle, which enhances students’ motivation, and is a common element in problem and project-based learning. PBL is an approach to learning that is characterised by flexibility and diversity, which can be implemented in a variety of ways in different subjects and disciplines. Students work on their own learning requirements and teachers support this learning [35-38]. Figure 2.5 illustrates problem based learning, where the green circles are students and the red circles are the facilitators in PBL.

![Problem Based Learning](image)

Figure 2.5: Problem based learning [39]

### 2.5.3 Scenario Based Learning

In Scenario Based Learning (SBL), students are provided with real-life scenarios. SBL is a student centred approach where students are considered active participants. The role of the teacher is to guide and support students in their learning process. The word scenario is used to denote several distinctive aspects of the SBL mechanism [40]. Through this type of learning, students get the opportunity to expose and apply their acquired experiences, knowledge and skills to a realistic situation [41]. Here the problem is fairly open and as such, the outcomes are undetermined. Figure 2.6 illustrates the generalised scenario process model.

![Generalised Scenario Process Model](image)

Figure 2.6: Generalised scenario process model [40]
2.5.4 Inquiry Based Learning

Inquiry based learning begins with students being presented with questions to be answered, problems to be solved, or a set of observations to be explained. It is usually used in laboratories based on scientific methods. The learning process is student centred while the teacher acts as a facilitator. Students observe a selected task or phenomenon, develop a proposal and experimental procedure for the observed task, perform their experiments, evaluate their results, and reflect on their learning. This provides excellent training in the design of experiments and scientific methods [42].

Traditional teaching is often considered to be subject-based learning, where students learn specific information and then given a problem to apply to what they have learned. Inquiry-based learning is similar to problem-based learning in the sense that students are first given the problem and secondly they must determine the information needed to fully address the problem before learning specific information and solving the problem query [43, 44]. This type of learning is meant to encourage high-level thinking and collaboration. Figure 2.7 illustrates inquiry-based learning.

![Inquiry Based Learning (facilitator)](image)

Figure 2.7: Inquiry based learning [42]

2.5.5 Work Based Learning

This type of learning derives from utilising opportunities, resources and experiences in the workplace. Work based learning gives students the opportunity to learn a variety of skills by expanding the walls of classroom learning to include the community [42]. By narrowing the gap between theory and practice, work based learning creates meaning for students. It provides opportunities for students to learn a variety of skills through in-depth academic preparation with hands-on project focused experiences. Under the guidance of facilitators, students learn to work in teams, solve problems, and meet employers’ expectations. Through work based learning
experiences students see how classroom instruction connects to the world of work and future career opportunities. Experiences include, but not limited to, apprenticeships, career fairs, field studies, guest speakers, job shadows, and student internships [42, 45, 46]. Figure 2.8 illustrates work-based learning.

![Image of Work Based Learning](image)

Figure 2.8: Work based learning [42]

### 2.5.6 Action Based Learning

Action based learning is a structured method that enables small groups to work regularly and collectively on complicated problems, take action, and learn as individuals or as a team while doing it [42]. The inter-relationship of learning and action occurs through a continuing process of reflecting and acting by the individual on their problem. Action based learning is typically characterised by certain key components such as problem as content, learning through teamwork, and time for personal and group reflection on lessons learned. Action based learning emphasises self-reflection and real-time lessons make it a particularly powerful vehicle for students to achieve understanding about social and environmental issues while students undergo any project [42].

Action based learning is an educational process by which students learn through their actions and experiences to improve performance. It helps students work on a problem through supportive but challenging questions. It also encourages a deeper understanding of the issues involved, a reflective reassessment of the problem and an exploration of ways forward. By following this process, action based learning allows for a structured way of working that provides the discipline students often need to learn and improve practice [42]. Figure 2.9 illustrates the action based learning process.
PART II: Design Based Learning

2.6 Introduction

Design based learning (DBL) is a self-directed approach in which students initiate learning by designing creative and innovative practical solutions which fulfil academic and industry expectations. Design based learning is an effective vehicle for learning that is centred on a design problem solving structure adopted from a combination of problem and project based learning. Design projects have been used to motivate and teach science in elementary, middle, and high school classrooms and can help to open doors to possible engineering careers. Design based learning was implemented more than ten years ago, however it is a concept that still needs further development. With this in mind, it is very important to characterise DBL as an educational concept in higher engineering education [47] [48-50].

With different learning styles students are able to express their skills and talents through working on projects or by simply designing experiments in authentic learning environments. Integrating design and technology tools into science education provides students with dynamic learning opportunities to actively investigate and construct innovative design solutions. A design based learning
environment assists curriculum to move into the twenty-first century with students being hands-on in their work, in addition to using problem solving skills, engaging in collaborative teamwork, creating innovative designs, learning actively, and engaging with real-world assignments. Figure 2.10 illustrates the design based learning process.

![Design Based Learning Process Diagram](image)

**Figure 2.10: Design based learning process**

### 2.7 Design Based Learning Education

Design based learning education is a form of project/problem based learning in which students gain knowledge while designing a solution (object or artifact or report) meaningful to the students. It involves collecting information, identifying a problem, suggesting ideas to solve it and evaluating the solutions given. Once students have chosen the problem to focus on, they design a solution to solve it. Finally, the students receive feedback on the effectiveness of their design both from the facilitator and from other participants. Design-based learning is especially used in scientific and engineering disciplines.

#### 2.7.1 Design Based Learning in Science Education

By engaging students in learning design, DBL provides an opportunity to experience individual, inventive and creative projects that initiates the learning process in relation to their preferences, learning styles and various skills. Yaron Dopplet [48] states that DBL is used to produce a curriculum that improves learning for all students in science education. Students are involved in solving a problem through a creative project and experience meaningful ideas that allows them to analyse a suitable solution for it. To provide students with better practise in design and technology, DBL has several advantages that meet social, economic and industry needs. It is also an active
learning process which makes students practice and recognize different learning styles and team based activity supports learning and sharing through cooperative methods [49, 51].

2.7.2 Design Based Learning in Biology

Biology is a required science course and students are encouraged to study subjects and learn by doing everyday science projects around them. These opportunities allow them to build, design and create their own products and prototypes, which come from their prior learning experiences. The key is that students need to integrate their knowledge in any design process. The design process is similar to a problem solving method. The Design Based Learning (DBL) approach is used to enrich student involvement in learning science and to include any design experience with it [52]. DBL is a type of learning where the problem is solved by student teamwork. DBL has been implemented in biology for a better understanding of science and technology, which is based on the performance of DBL units with good conceptual targets [53].

2.7.3 Design Based Learning in Secondary School Education

To increase the importance of creative and innovative thinking, project and design-based learning is used in secondary school projects. Holistic thinking, understanding, imagination, creativity, visualising problems and solutions are the fundamental skills of a designer [54, 55]. Project and design based learning approaches are used to transform these skills into active learning and to evaluate students’ progress in classrooms. In secondary school education, teachers are well prepared to undertake interdisciplinary teaching and to understand the disciplinary content through practising design education. Because of these design processes, students have the potential to mould themselves. The purpose of design education is to enhance learning in order to teach students to become active participants to solve the design problems around them [56-58].

2.7.4 Design Based Learning in Computer Science

When students work on projects, they share their ideas with other team members and they are encouraged by formal and informal classroom activities. Industry is looking for professionals with design knowledge, which is integrated with creative and innovative interdisciplinary thinking. In a classroom of more than a hundred students, lecturing may be a possible way of teaching but what will students learn? At the end of the teaching period, students will not recognize what knowledge they have gained. It is important to have a pedagogy style or approach such as design based learning, which is similar to project, and problem based learning. Through a design based learning
approach, design is driven by qualitative thinking, speculation, ideation, prototyping and specification [59]. Educators’ realise that many of our graduates lack communication skills such as verbal and writing skills. DBL is used as an innovative approach to equip those students with design skills, group skills, communication skills and project skills [59].

2.7.5 Design Based Approaches in Art Education

Design is a subdivision of art. Most of colleges in the United States deliver art education and design programs in all curriculums. By integrating design education within or outside the arts, the teaching and learning process has improved which prepares teachers and students for a design based learning approach. To achieve the goal of developing education, design educators provide practical strategies that exhibit the pedagogy of design education and problem solving processes. The goal of the design approach was not to change the whole curriculum of art education but for students to develop the ability to enhance and transform ideas through visualization, manipulation and the application of data to problem solving through design activities [60].

2.7.6 Design Based Learning in Engineering

Design based learning (DBL) is one type of project-based learning which involves students engaged in the process of developing, building, and evaluating a product they have designed [49]. In engineering science classrooms, DBL opens new possibilities for learning science. Working and completing design based activities can make students feel proud of their achievements, as well as building up their confidence as thinkers, designers, and that will benefit them through their education and life. Design based learning encourages a thriving learning context for students’ active participation and construction of knowledge instead of passively learning about engineering science from textbooks and lectures [50]. Overall, design based learning supports encouraging evidence that this project/problem based learning increases students’ science content knowledge and engagement working on the design challenge, enables students to transfer knowledge into another task, learn through collaboration, and develop students’ positive attitudes towards engineering design education.

At Deakin University, the engineering program involves Design-Based Learning, or DBL projects at different levels of course structure. It engages students in real-world assignments. It starts right from the first year of engineering [94, 95]. In the DBL projects students will work in a group of approximately four to six students on absorbing innovative issues. In this way, students will gain an
idea of the field of work and students will learn to work in a team and try to solve problems by using technical and psychological knowledge. This is important, because in the future students will often cooperate with people from other disciplines. Students will often be the bridge builder between (technical) specialists, the consumer and society. The Design-Based Learning program is a cutting-edge, inquiry-based curriculum that engages students in simulations and understanding of essential questions. Engineering science and technology are at the core of its challenging multi-disciplinary curriculum.

The design based learning engages students in complex real-world design challenges, encourages them to solve problems and make decisions, makes students responsible for accessing and managing information, fosters reflection and evaluation as an ongoing process, and creates a learning environment that tolerates error as part of the learning process, while encouraging change. DBL is a form of learning in which participants gain knowledge while designing an object or artefact meaningful to them. It involves collecting information, identifying a problem, suggesting ideas to solve it and evaluating the solutions given [85]. Once learners have chosen the problem to focus on, they design an object to solve it and finally, they receive feedback on the effectiveness of their design both from the facilitator and from other participants. This kind of learning is based on the constructivist theory, which stresses the active role participants play in the learning process. Design-based learning is especially used in scientific and practical disciplines. Integrating design and technology tools into engineering science education provides students with dynamic learning opportunities to actively investigate and construct innovative design solutions [50].

2.8 Conclusion

This chapter provides an overview of educators who teach engineering. It also explores the different types of problems, the problem solving process, the design process and different learning approaches such as problem-based learning, project based learning and design-based learning. The aim of all educational institutions is to educate students as graduate engineers, and equip them with the ability to work in industry with graduate ready skills such as creativity, innovation, teamwork, problem solving, observation, analytical thinking, communication, and prototyping etc. Every learning and teaching approach has its own special way of confronting engineering problems. In design based learning, students solve engineering problems by using design as a vehicle. Design concepts are also used as whole teaching processes to teach students physics, mathematics, chemistry and social science. Students are comfortable solving given problems but as a graduate
engineer, students are unable to create the problem. The ability to observe is a key skill for a problem solver. Using design based learning, students need to observe the social environment to understand and create a design problem.

From the above reviews on design-based learning in different educational disciplines, it is obvious the goal of the DBL approach is not to change the entire curriculum. The purpose of design education is to enhance students’ learning with creativity and innovation through interdisciplinary projects. Projects are considered a better way for teachers and students to interact. In a design based learning approach, teachers act as facilitators who encourage students to be self-directed learners. The aim of this thesis is to develop a framework for new learning and teaching model in engineering education.
Chapter 3

Research Methodology

3.1 Introduction

The previous chapter focused on literature about problems, different types of problems in engineering, the engineering design process, the problem-solving process and different types of learning approaches. This research mainly looks into project based learning, problem based learning and design based learning approaches practiced in engineering education. To enhance the innovation and creative skills of students’ ability to solve design problems in engineering practice, this research proposes a new learning and teaching model.

As part of the literature review, previously conducted research in the selected field was examined. Consequently, an application for candidature report will be written and submitted to outline and evaluate existing knowledge and to describe in more detail the identified gaps in the proposed research field, further defining and limiting the problem this proposed study is attempting to address.

To develop a framework of new learning and teaching model, this research looks at various learning and teaching approaches in engineering education. When considering the significance of students’ learning outcomes and the teaching requirements of staff in design education, this research intends to encapsulate the perspectives of students and staff about a particular approach. Engineering at Deakin University has used design-based learning (DBL) as one of its engineering learning principles for further development in teaching and learning. It is required to improve the learning and teaching process as a holistic approach from the perspective of students’ and staff over the entire degree program.
Chapter 3

The qualitative and quantitative paper based survey method is used to obtain students’ perspectives. Qualitative methods are useful for evaluating, developing program goals and for involving participants in the evaluation process to gain their insight and perspective [5]. Face-to-face interviews are used to obtain the perspectives of staff on the design based learning approach. Data collected from these interviews are from the experience of staff on design teaching and research.

The other aspect of this research focuses on industry’s requirement for engineering design. When engaging students with industry, students will acquire global perspectives and knowledge about the core attributes expected in future engineering jobs [60]. Thus, this research intends to collect the perspectives of people from industry about design based learning by using a qualitative and quantitative paper based survey.

3.2 Research Methodology

To develop a framework for new learning and teaching model, this research needs to obtain the perspectives of students’ and staff about design based learning through projects. The questions covered here to obtain students’ views were presented as paper-based surveys and staff perspectives were obtained by face-to-face interviews on design based learning in engineering education. The research consultation process needed ethics approval from the higher degree research ethics committee of the School of Engineering at Deakin University. This research also needed staff perspectives on design-based learning from other Australasian universities such as Australasian University A, Australasian University B, Asian University A and Asian University B.

3.2.1 Research Methodology for Students Perspectives

The survey questions are based on qualitative and quantitative analysis. The questions covered are designed to determine the students’ level of experience from their first to final year of undergraduate engineering. Other questions in the survey address the students’ background and level of experience or understanding in their education. The views of students’ on DBL in this research come from all levels of undergraduate engineering. From the quantitative and qualitative analysis performed, the results are analysed and presented from a students’ perspective about design based learning within the curriculum. The survey is paper based which was conducted by a third person not involved in the research project. The survey was given to more than 100 students in the first, second, third and final year of engineering and was anonymous and non-identifiable. These
results are from students’ own experiences and the results present various views, which include students’ knowledge and expectations. In turn this can inform the school to implement a design based education. In line with ethics process and procedures, a third party conducted the research survey. The questions were prepared to identify the challenges in teaching and learning and in particular to investigate student perspectives on the practice of design based learning. Figure 3.1 shows the flowchart of the process, which the paper-based survey was conducted with the cohort of students in undergraduate engineering. The data collected was anonymous and non-identifiable. The collected data was analysed to derive a quantitative outcome to show the students’ perception on design-based learning.

The survey questions used in the research were:

**Quantitative Questions**

1. Are you enrolled full time or part time?
2. What is your mode of study?
3. Do you work while you are studying?
4. Is your work engineering related?
Qualitative Questions

5 Could you please define “Engineering”?
6 Why did you choose to study Engineering at Deakin?
7 What does “Design Based Learning” mean to you? Please explain.
8 How could the School of Engineering include “Design Based Learning” in your curriculum?
9 How important is DBL to your career?
10 How important is DBL to your final year project?
11 Should DBL take place in teams of students or with individual students?
12 List up to 3 advantages and disadvantages for team DBL and individual DBL

Questions one to four are quantitative questions and based around the background of the students in terms of their study and work balance. Questions five and six look at the students’ understanding of engineering. The remainder of the questions (question seven to question twelve) focus on design based learning.

3.2.2 Research Methodology for Staff Perspectives

In many cases, academic staff are responsible for driving and setting high expectations in their classrooms. Sometimes staff are expected to teach subjects outside their expertise. This research is concerned with improving learning and teaching methods and feedback was sought from students on design-based learning. Additional feedback is also needed from staff members who teach and perform research in engineering design. The aim of this research is to also investigate the perspectives of staff on design based learning in engineering education through face-to-face interviews. Face-to-face interviews are based on qualitative questions that are analysed and presented in quantitative form. The questions covered here are designed to determine the perspectives of staff on design based learning through their own level of experience in teaching engineering design from the first to final year of undergraduate engineering. An interview question set was asked of each staff member that teaches and performs research in engineering design. The research assistant conducted the interviews and data collected was anonymous and non-identifiable.

Figure 3.2 shows the flowchart of the process for staff interviews conducted by the research assistant involved in this research. In line with ethics process and procedures, the research assistant sent an individual e-mail to every staff member in the School of Engineering. When a staff member gave an appointment time, the research assistant conducted a face-to-face interview. An interview question set was asked of each staff member that teaches and conducts research in engineering
design. The collected data was analysed to derive a quantitative outcome that shows staff perceptions on design-based learning.

![Diagram](image.png)

Figure 3.2: Staff interview process

The collected results were from the experiences of staff and present various views, which includes staff knowledge and expectations. In turn, this can inform the school to help implement a design based education. The questions were prepared to identify the challenges in teaching and learning, and in particular, to investigate the perspectives of staff on the practice of design based learning. From these results, research will lead to new teaching and learning approaches, thus enhancing student-learning outcomes.

The staff interview questions were:

1. Define Design based learning (DBL)?
2. What does Engineering Design mean to you?
3. Are aspects of Engineering Design taught in your unit? If yes, how?
4. Do you see Engineering Design as an essential learning element of an engineering program? If yes, why?
5. What do you think of some possible ways to teach design?
6. Does your curriculum involve design-based learning through projects?
7. Could you please list some of the skills attained by students through DBL in your unit?
8. How can Engineering Design projects helps to collaborate with industry?
3.2.3 Research Methodology for Industry Perspectives

This research is also concerned with industry requirements on design education. Industry and university collaboration is always a strength of an engineering curriculum as it mutually benefits both sides [61, 62]. Design based projects and activities act as a vehicle for strong collaboration between university and industry [63, 64]. This research is also concerned with improving industry collaboration and it needs the perspectives of people working in industry.

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. The majority of the participants who took part in the forum were design engineers, designers, architects, industrial design practitioners, project team leaders, teachers, lecturers, entrepreneurs from different disciplines and participants from Engineers Australia (Australia’s Engineering Accreditation Body). The findings from the research performed by the industry indicate learning is a combined source of students’ initiation to social, global responsibility and the expected skills from the industry. The data collected was anonymous and non-identifiable. The collected data was analysed to derive a qualitative outcome, thus showing industry’s perception on design-based learning.

3.3 Research Questions

This research focused on the development of a new learning and teaching model framework with emphasis on innovation and creativity as two important skills in engineering education. To achieve this, this thesis will investigate a number of case studies such as:

1. How are design projects practised in undergraduate engineering?
2. What are students’ perspectives on DBL?
3. What are the perspectives of staff on DBL?
4. What are the accreditation requirements on design education?
5. What are the industry expectations on engineering design?
6. What are the recommendations for design based curriculum?

The aim of this research is to develop an overall framework for the new learning and teaching model and also for developing the following framework guidelines.
a) Framework guidelines for students – it helps students to incorporate their learning process with creativity and innovation through design based learning in engineering education.

b) Framework guidelines for staff – it guides staff to setup and implement design projects at an academic and industry level. How to inspire design education in their disciplines is a challenging task.

c) Framework guidelines for industry – it encapsulates all aspects of industry requirements for graduate engineers, university collaboration and student-staff relationships.

d) Framework guidelines for academic leadership – it provides recommendations for faculties to engage in multidisciplinary tasks, learning spaces, design activities and to collaborate with industry.

3.4 Conclusion

The purpose of all engineering degrees is to provide strong grounding with principles of engineering science and technology. By learning engineering methods and approaches in an academic environment, graduates can enter the world of work and tackle real world problems with innovation and creativity. With the aim to enhance learning and teaching in the School of Engineering at Deakin University, this research will collect and analyse the perspectives of students, staff members and industry on the design based learning approach. This research will also use the perspectives of staff from other universities who practice design in engineering. With the data analysed, this research aims to develop a framework for the new learning and teaching model, which involves individual framework guidelines for students, staff, industry and academic leadership.
Chapter 4

Learning through Projects

4.1 Introduction

With different learning styles, students are able to express their skills and talents by working on projects. The aim of integrating design and technology tools into engineering education is to provide students with dynamic learning opportunities to actively investigate and construct innovative design solutions. The new learning and teaching model is focused on curriculum renewal to practice innovation and creativity for students who are learning to solve design problems through projects in engineering education.

The aim of the proposed research philosophy is to develop a new learning and teaching model in engineering education. Studying engineering not only involves learning scientific knowledge and technological skills, it also involves learning the language, established practices, beliefs, and professional values of engineering culture that makes a student an engineer. Problem solving is one of the important skills for students therefore the goal of all engineering programs is to teach problem solving skills to educate students as professionals. Industry is looking for professionals with design knowledge, combined with creative and innovative interdisciplinary thinking. As a result, the new learning and teaching model will focus on skills such as innovation and creativity in the engineering discipline. This research focuses on the development of a new learning and teaching model with emphasis on innovation and creativity as two important skills in engineering education. To achieve this, this thesis will use a number of case studies to explore the following questions:

1. How are design projects practised in undergraduate engineering?
2. What are the perspectives of students on DBL?
3. What are the perspectives of staff on DBL?
4. What are the accreditation requirements of design education?
5. What are the industry expectations of engineering design?
A number of these case studies have already been completed and this section presents the results of these case studies.

### 4.2 Learning through Projects

Learning is an active process of investigation and creation based on the learner’s interest, curiosity and experience and should result in expanded insights, knowledge and skills [8]. Graaff and Kolmos have summarised the main learning principles in three approaches, such as learning approach, content approach and social approach. The learning approach means that learning is organised around problems and is project based. The content approach especially concerned with interdisciplinary learning and the social approach is team based learning [65]. One institution’s approach to project based learning may possibly look very much similar to another institution with adequate variance in the teaching methods and learning outcomes. According to Kolmos in [65], assignment projects appear in the more traditional learning concept but the project or problem is centered around the notion of learning which gives the learner the opportunity to be involved in the learning process.

From this observation, university projects are mostly discipline projects that are pigeonholed by subjects chosen beforehand, whereas industry projects focus on problem projects that need a self-directed learning process. Establishing a new educational practice requires not only an understanding of new learning principles, but also an understanding of content-based curriculum issues, students’ collaborative-learning processes, and the development about new concepts of project based learning knowledge while establishing new organisational and institutional practices [9, 61] [66].

An engineering project activity is carried out either in conjunction with industry or the project simulates a real engineering work environment, thereby contributing to Work Integrated Learning (self-directed project based learning in small groups) [67, 68]. Many of the characteristics and benefits of project-based learning make it a relevant pedagogical strategy in engineering education where realistic problems can be posed. Design is the vehicle for learning and an inductive mode of teaching can be employed [69]. Project-based learning shifts away from teacher directed learning to more student centred learning activities that focus on real world issues and practices. By learning through projects, students have opportunities to interact with their colleagues and make new colleagues through cooperative projects [70, 71].
4.3 Project Types

4.3.1 University Projects

University projects require students to undertake their own fact-finding and analysis, either from research in a library, from the Internet or even through empirical data gathering. The written report that comes from the project is usually in the form of a dissertation, which contains sections on the project's inception, methods of inquiry, analysis, findings and conclusions. Engineering students have the opportunity to apply the concepts they learn in the classroom to hands-on projects with real-world applications. Students from all engineering majors enjoy the teamwork, problem-solving, and hands-on design that accompanies project opportunities from their first to final year. Projects often focus on creating innovative solutions to real-world problems, and students follow a process that mirrors the way engineers work in industry.

4.3.2 Industry Projects

Industry projects are project-based activities in partnership with an industry organisation. Students complete a research project focused on a given event or industry issue, problem or opportunity. Students mostly work independently on their selected topics. A teaching and learning approach is used when individuals conduct work activities (paid or voluntary) combined with intentional educational activities. The project involves a substantial research component. This can range from market research, such as a questionnaire, survey or focus groups, to observation, in-depth interviews or analysis of existing data. Workplaces may be in the private, public or not-for-profit sectors, ranging from multi-nationals, government agencies, or small to medium enterprises. The client will receive the final project report detailing the appropriate and actionable conclusions and recommendations. Students work to meet two sets of requirements; those of the industrial client and the university’s academic requirements. The university academic supervisor manages the scale and scope of the project. Students work on a project individually and if clients are willing to take on more than one student, they can have multiple projects completed in one year.

4.3.3 Community Projects

Community projects provide a unique opportunity to extend student learning and broaden experiences beyond the academic environment. Students will work closely with other students from different faculties to develop meaningful projects in support of university departments and
disadvantaged groups in the community. It is a teaching and learning approach that combines community based initiatives with intentional educational activities. These projects provide an opportunity to connect with other students from different faculties and become actively involved in the community. By undertaking these projects, students will not only be contributing their knowledge and skills towards helping others in the community, they will also gain a range of career related transferable skills such as networking, teamwork, marketing, supervising, coordinating, organising, and public speaking. The key emphasis in community project learning is that of shared benefit and interchange for the student, the university, and the community agency or enterprise. The experience will also provide students with an opportunity to develop useful career networks and gain a broader understanding of the social and cultural needs of various groups in the community.

4.4 Design Projects in Engineering Education

Students choose to study engineering for many reasons associated with the profession. One of these reasons is the chance to design, which means the purpose of engineering education in most cases is to graduate engineers who can design [10]. It is highly likely that students, as future engineers, will play an important role in addressing the key challenges of the 21st century, such as providing water resources, infrastructure and communication, food supplies and health services, and the development of new sustainable energy. Research suggests and recommends that engineers should experience a broad based undergraduate course and later develop their specialist skills through postgraduate study in their selected discipline [72, 73]. John Webster [74] recommends that engineering courses must be outcome-oriented and equip graduates for lifelong learning. In addition, he also suggests that in first year engineering, most of the time should be spent on the mathematical and scientific basics that underpin all engineering disciplines. If the curriculum is based around projects, the actual projects should be defined and structured by teachers in the first year for students to obtain fundamental knowledge. In the second and third year, students work on industry and/or community projects, and industry practice takes place in the final year [74-77].

Engineering programs started to include different forms of project and problem approaches to learning with capstone design units the most common implementation of project-based learning in engineering [42, 62]. To analyse how design is practised, this research looks at undergraduate engineering units with projects covered in the final semesters of a course level. The list covers every university in Australia with gathered information on teaching and learning approaches. Based on the teaching methods, learning outcomes and assessment measures, Table 4.1 shows the percentage of
project work done in a final year unit of study from various universities in Australia. The purpose of this study was to explore the learning of design through projects and its pedagogical structure. It summarises the different types of assessment methods undergone in a university project, industry project, or a community project.

Project learning emphasises process orientation, students’ initiative, and self-regulation. The student self-assessment should be a part of the assessment, especially in group based work projects. The final team mark comes from several assessments \[26][63-65]. This mark is then subject to adjustment for individual team members according to the quality and quantity of their contribution as determined by the project supervisor and their peers in the team. At the closure of the project, each student must submit a confidential peer review of all team members so the project supervisor can use this to determine the final project mark for each student. Figure 4.1 reports the difference in the overall percentage of students involved in various project types within the university, industry or the community. From the assessment criteria, it states that students took part more as individuals than within a group or teamwork based environment, particularly when trying to solve design problems \[82-84].

Table 4.1: Learning Design through Projects – Universities in Australia

<table>
<thead>
<tr>
<th>University</th>
<th>Project Work (%)</th>
<th>Assessment</th>
<th>Project Type</th>
<th>Project is based on</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Research</td>
</tr>
<tr>
<td>2</td>
<td>50%</td>
<td>Group Based Work</td>
<td>University &amp; Industry Projects</td>
<td>Design &amp; Development</td>
</tr>
<tr>
<td>3</td>
<td>80%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Infrastructure Design</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Professional project</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Aerospace Design</td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Research Project</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Design Project</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Engineering Project</td>
</tr>
<tr>
<td>9</td>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Design</td>
</tr>
<tr>
<td>10</td>
<td>100%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Integrated workplace</td>
</tr>
<tr>
<td>11</td>
<td>55%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Major Project</td>
</tr>
<tr>
<td>12</td>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Capstone Project</td>
</tr>
<tr>
<td>13</td>
<td>100%</td>
<td>Individual Work</td>
<td>University &amp; Industry Projects</td>
<td>Final Year Project</td>
</tr>
<tr>
<td>14</td>
<td>80%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Design Project</td>
</tr>
<tr>
<td>15</td>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Project</td>
</tr>
<tr>
<td>16</td>
<td>85%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Engineering Project</td>
</tr>
<tr>
<td>17</td>
<td>90%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Research Project</td>
</tr>
<tr>
<td>18</td>
<td>100%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Group Project</td>
</tr>
<tr>
<td>19</td>
<td>100%</td>
<td>Group Based Work</td>
<td>University Project</td>
<td>Integrated Design</td>
</tr>
<tr>
<td>20</td>
<td>100%</td>
<td>Individual Work</td>
<td>Industry Project</td>
<td>Industry Based</td>
</tr>
<tr>
<td>21</td>
<td>100%</td>
<td>Individual Work</td>
<td>University &amp; Industry Projects</td>
<td>Thesis (Major Project)</td>
</tr>
<tr>
<td>22</td>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>80%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Major Project</td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Project</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Project</td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>Individual Work</td>
<td>University &amp; Industry Projects</td>
<td>Project Development</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>Group Based Work</td>
<td>University &amp; Industry Projects</td>
<td>Project</td>
<td></td>
</tr>
<tr>
<td>90%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Project</td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>Individual Work</td>
<td>University Project</td>
<td>Engineering Design Project</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.1: Learning design through projects: Universities in Australia [85]

### 4.5 Why Industry Perspectives?

To increase productivity and to meet competitiveness in the global market, industry needs effective management practices, technical skills and the capabilities of a skilled workforce. More productive firms require highly skilled people across all levels. Employers conduct skills assessment, workforce development plans and formal training to upgrade employees’ knowledge and vision due to the high demands of clients and their advanced projects. Industry found this should be a continuous process to survive vast manufacturing targets, and therefore industry decided to take part in collaborative arrangements with universities. From previous research, it was shown about 43% of Victorian manufacturing employees do not hold post-school qualifications. As a result, there exists a skills shortage and fewer metal trade workers, manufacturing professionals, machine operators, engineers and technicians. Around half of all adult Australians have literacy and numeracy skills below the level considered necessary to function effectively at work [86].

Australian firms recognize they need to become even more efficient, productive, innovative and attuned to their customers’ needs. Previous research on the strategy of Australian companies to remain competitive over the next few years showed about 85% retention is needed for building the skills base of employees. Australian firms are looking for their employees with higher-level soft skills (willingness to learn, good communication and teamwork skills, plus problem solving skills),
solid basic skills (numeracy and literacy) and the right attitude. A previous research survey on work
shows companies experienced difficulties in securing the skills of employees in various
occupations, such as 46% for engineering professionals, 48% for technicians, 26% for other
professionals and 15% for IT professionals. This demonstrates that some difficulty is experienced
by these professionals due to a gap in their skill set [86, 87]. The exchange of knowledge and
experiences between universities and industry, the willingness of industry to engage with
academics, students and an engineering curriculum is a possible way to overcome this situation [74,
88]. There is also a need to focus on getting “real-world” industry-sponsored design projects for
students with help from industry volunteers. In addition, surveys of “student customers” to obtain
constant feedback about teaching effectiveness could also be helpful [89].

4.5.1 Industry Needs on Design

In an industry forum organised by the School of Engineering at Deakin University conducted in
Melbourne, Australia in 2012, a research study was conducted to investigate industry and academia
requirements for students’ focusing on design skills. The majority of 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 shows action is needed on the following skills such as creative & innovative skills,
industry engagement, design awareness, communication skills and project management skills.

Feedback also showed that 80% of industry representatives are looking to recruit graduates who
acquired design skills and 60% indicated they wanted graduates who acquired knowledge through
projects. For a sustainable design, teaching and learning through design based learning had best be
practiced through a university design project, a community design project or an industry design
project. All of these provide a practical approach to problem solving that integrates design with
manufacturing and real world projects with a global perspective [60]. The research is summarised
around a sustainable design model and is illustrated in Figure 4.2.
4.6 Accreditation Requirements for Engineering Design

Accreditation is the periodic assessment of an education program in any discipline against accreditation standards. Most higher education institutions identify a list of expected graduate attributes or outcomes incorporated in their educational programs that can accredited by an accrediting professional body such as Engineers Australia (EA) in Australia, the Accreditation Board of Engineering and Technology (ABET) in America, and the European Accreditation of Engineering Programs (EUR-ACE) in Europe. Implementing the graduate attributes in professional education programs varies from one institution to another. Each attribute has a range of elements that students must demonstrate depending on the requirements of the program structure. When identifying graduate attributes, particularly for undergraduate engineering programs in Australia, the program accrediting body (EA) initiates a set of attribute elements mentioned in ‘Stage1 competencies and elements of competency’. It states that an important engineering application is the ability to apply systematic engineering synthesis and design processes [10, 66]. ABET proposed the ‘Criteria for accrediting engineering programs’ to assure ‘the ability to design’ is one of the most important student outcomes that prepares graduates to attain the objectives of their educational program [11]. EUR-ACE Framework standards for the accreditation of engineering programmes states that ‘graduates should be able to realize engineering design consistent with their level of knowledge and understanding [12]. All three of these accreditation bodies focus on design processes, the ability to design, and engineering design practice as important attributes of an engineering outcome based education.
Figure 4.3: Accreditation requirements for engineering design

Figure 4.3 illustrates that a large amount of the overall accreditation competency elements from the three accreditation bodies, Engineers Australia (18%), Accreditation Board for Engineering and Technology (27%) and the European Accreditation of Engineering Programmes (34%) focus on design processes, ability to design, engineering design practice as important attributes of the engineering outcomes based education. By looking at the world accreditation bodies focus on design based learning as an approach for learning and teaching, this research identifies the need to enhance important skills such as innovation and creativity through a holistic learning process that incorporates design based learning features.

4.7 Conclusion

The new learning and teaching model focuses on skills such as innovation and creativity in the engineering discipline through investigation of various design projects in engineering, the perceptions of students on design based learning, and the views of staff on design based learning, in addition to industry requirements for design education. This research focuses on the development of a new learning and teaching model with emphasis on innovation and creativity as two important skills in engineering education. The following chapter discusses the results in detail from students, staff and industry perspectives on engineering design.
Chapter 5

National and International Case Studies

5.1 Introduction

Many universities in the Asia pacific region have used various learning and teaching approaches to enhance student learning outcomes. This research seeks staff members’ perspectives on design based learning approach from selected universities practicing design education in different ways. It looks into staff perspectives from Deakin University, Australasian University A, Australasian University B, Asian University A and Asian University B.

5.2 Case study of Deakin University, Australia

The School of Engineering at Deakin University has always tried to improve its engineering course unit delivery method to enrich the student experience and to produce a capable, job ready engineering graduate. To this end it has looked for new teaching methods that assist in this process. One such method is Design Based Learning (DBL). Unlike Problem Based Learning (PBL), DBL opens up learning activity so design skills must be learnt and applied [2]. Students must locate the resources required, and analyse any needs in order to create some design [3]. The method gives students the freedom to apply their design skills as they think best. DBL not only looks at the end product but also at the underlying process in creating that product [103]. Whilst this seems a valid unit delivery method for units, one key piece of information is missing: what does the student think about DBL? The perspectives of students, staff and industry are required to help validate, improve this method as a useful teaching tool.
5.2.1 Students Perspectives on Design Based Learning (DBL)

Student views on DBL in this section come from senior year undergraduate engineering students currently studying a DBL based unit. Senior year students were chosen for this initial survey as they have some experience with DBL. This limits the current survey to one cohort of students as a starting point for our research. The ultimate goal is to determine student perspectives about DBL and how their perspective changes over the years studying engineering, as students in earlier years may not be able to answer in an informed manner [104]. The way engineering students pursue their university degrees is somewhat different to the way engineering students carried out their studies a few years ago. As it can be seen from Table 5.1, 78% of the students surveyed work and study at the same time. Of the 78% working, 72% work part time, and 6% work full time. Only 22% of the students in this research study choose not to work while studying. All students who took part in this study were enrolled in full time study at Deakin University. This is illustrated in Table 5.2.

<table>
<thead>
<tr>
<th>Work Mode</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No work</td>
<td>22</td>
</tr>
<tr>
<td>Part time</td>
<td>72</td>
</tr>
<tr>
<td>Full time</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5.1: Students who work and study

<table>
<thead>
<tr>
<th>Enrolled in Deakin Engineering</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part time</td>
<td>0</td>
</tr>
<tr>
<td>Full time</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.2: Students studying full time and part time

<table>
<thead>
<tr>
<th>Engineering jobs</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>84</td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 5.3: Work related to Engineering

<table>
<thead>
<tr>
<th>Study Mode</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>On campus</td>
<td>83</td>
</tr>
<tr>
<td>Off-campus</td>
<td>11</td>
</tr>
<tr>
<td>Blended learning</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5.4: Students’ mode of study

It is interesting to see in Table 5.3 that only 16% of students work in an engineering related environment. Deakin University has about a third of its students studying off-campus [105]. As illustrated in Table 5.4, from the engineering students involved in this study, 83% of students are studying on campus whereas 17% of the students are in mixed mode (blended learning and off-campus learning). As part of the process towards identifying what DBL means to students, it was important to find out how students define engineering and why they decided to study engineering at Deakin. Figure 5.1 shows a large number of student responses (33%) define engineering as the use of science and technology that benefits society and integrates practical applications of science, 22% define engineering as problem solving and critical thinking, 22% define engineering as applying knowledge in the process of creating new things, 12% of students define it as a profession of
acquiring and applying scientific skills and 11% define engineering as creating complex structures or machines.

![Figure 5.1: Students definition of engineering](image)

A major perception of students about DBL, as illustrated in Figure 5.2, is the practical ‘learning by doing’ approach. The practical theme continues throughout student responses, particularly when asked what design based learning means. Figure 5.3 clearly illustrates the majority of students position DBL as a practical approach to learning as well as the integration of industry projects in the curriculum.

![Figure 5.2: Students perception of DBL](image)

Students were also asked about the influence of design based learning in their career as well as design based learning in the final year project of their engineering degree. From Table 5.5 and Table 5.6, it can be seen the majority of students believe DBL is necessary and will assist them in their professional careers as well as in their final year project. Table 5.7 illustrates that students prefer design based learning to take place in both modes; at an individual level as well as team
based. In addition, Figure 5.4 shows over 50% of students view some advantage of teamwork in design-based learning, which includes real world experience and interaction, plus development of collaborative, management and social skills.

![Figure 5.3: Students perception of DBL in the curriculum](image)

**Table 5.5: Influence of DBL in engineering career**

<table>
<thead>
<tr>
<th>DBL to your career</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not help</td>
<td>0</td>
</tr>
<tr>
<td>No effect</td>
<td>5</td>
</tr>
<tr>
<td>Possibly helps</td>
<td>17</td>
</tr>
<tr>
<td>Does help</td>
<td>39</td>
</tr>
<tr>
<td>Is necessary</td>
<td>39</td>
</tr>
</tbody>
</table>

**Table 5.6: Importance of DBL in final year project**

<table>
<thead>
<tr>
<th>DBL in Final year project</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not help</td>
<td>0</td>
</tr>
<tr>
<td>No effect</td>
<td>11</td>
</tr>
<tr>
<td>Possibly helps</td>
<td>27</td>
</tr>
<tr>
<td>Does help</td>
<td>33</td>
</tr>
<tr>
<td>Is necessary</td>
<td>27</td>
</tr>
</tbody>
</table>

**Table 5.7: Modes of DBL preferred**

<table>
<thead>
<tr>
<th>DBL mode</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All individuals</td>
<td>17</td>
</tr>
<tr>
<td>Mostly individuals</td>
<td>22</td>
</tr>
<tr>
<td>Half teams and half individuals</td>
<td>61</td>
</tr>
<tr>
<td>Mostly teams</td>
<td>0</td>
</tr>
<tr>
<td>All teams</td>
<td>0</td>
</tr>
</tbody>
</table>

The senior year students seem to have a basic understanding of DBL and an eagerness to engage in DBL during their studies, as shown in Figure 5.4, Table 5.5 and Table 5.6. This is encouraging to the School of Engineering who will try to foster a better understanding in students. The students’ perceptions (Appendix A) of DBL has an important value in their learning curriculum and encourages engineering at Deakin University to use it as one of its learning principles.
5.2.2 Staff Perspectives on Design Based Learning

5.2.2.1 Design Based Learning at Deakin University

Design based learning is one of the most important fields of engineering learning and teaching methods of the School of Engineering at Deakin. Deakin Engineering believes that it would enhance the learning experience of students. The School of Engineering is currently using these methods at different levels in various units. There is a need to verify these methods and to identify the best practice in these methods to ensure the best possible learning experiences for students. Staff members in the School of Engineering participated in face-to-face interviews about design based learning. From the perspectives of staff, it is possible to assess the current level of benefit to engineering students. The results shown below helped the school to assist staff to improve their teaching experiences.

5.2.2.2 Staff Perspectives on Design Based Learning

There are 25 staff members in the School of Engineering at Deakin University, with 18 out of 25 staff members participating in face-to-face interviews. Figure 5.5 illustrates staff perspectives about the meaning of design-based learning. A large number of staff responses (40%) define DBL as learning design through projects, 20% define DBL as learning through design activities, 20% define it as a focus on aspects of design and 20% define DBL as an active learning process.
Overall staff perceptions about design based learning shows every staff member has a unique understanding of the teaching and learning process with a focus on learning design in various aspects [106]. As part of the process towards identifying what DBL means to staff, it was important to find out what engineering design means to staff. Figure 5.6 shows that a large number of staff (30%) define engineering design as creating or designing something to benefit society, 20% define engineering design as a structured approach to an engineering problem solved through projects, 20% define engineering as using a design tool to engineer a creative solution, 20% define it as going through a design process and 10% defined it as using existing knowledge to create new things.

All engineering staff members believed engineering design is an essential element of an engineering program. When staff were asked about aspects of engineering design taught in their units, Figure 5.7 illustrates that 35% of staff said they teach it through application of design in projects, 30% mentioned it by teaching the design process with theory, 20% said they used aspects of engineering
design taught by teaching the development to design process, while it is interesting to see that 15% teach design methodology (Design for X) and participate in Engineers Without Borders projects.

Table 5.8 shows that 15% of staff members agree and 85% of staff members mostly agree that design is an essential element of an engineering program. These staff members teach and undertake research in engineering design in the School of Engineering at Deakin University. Staff were also asked about their perceptions on possible ways to teach design. Table 5.10 illustrates staff perspectives about possible ways to teach design, such as team based learning, activity based learning, analytical thinking and self-directed learning. From Table 5.9, it can be seen the majority of staff strongly accept their curriculum involves DBL.

Table 5.8: Engineering design as an essential element

<table>
<thead>
<tr>
<th>Engineering design as an essential element</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>15</td>
</tr>
<tr>
<td>Mostly agree</td>
<td>85</td>
</tr>
</tbody>
</table>

Table 5.9: Curriculum involves DBL

<table>
<thead>
<tr>
<th>Curriculum involves DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Transition status</td>
<td>5</td>
</tr>
<tr>
<td>Possibly yes</td>
<td>20</td>
</tr>
<tr>
<td>Strongly yes</td>
<td>75</td>
</tr>
</tbody>
</table>

Table 5.10: Possible ways to teach design

<table>
<thead>
<tr>
<th>Possible ways to teach design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team based learning</td>
<td>15</td>
</tr>
<tr>
<td>Activity based learning</td>
<td>35</td>
</tr>
<tr>
<td>Analytical thinking</td>
<td>20</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 5.11: Skills attained by students through DBL

<table>
<thead>
<tr>
<th>Skills attained by students through DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teamwork &amp; communication</td>
<td>30</td>
</tr>
<tr>
<td>Learning by doing</td>
<td>45</td>
</tr>
<tr>
<td>Problem solving</td>
<td>45</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>40</td>
</tr>
<tr>
<td>Creativity</td>
<td>70</td>
</tr>
</tbody>
</table>
Table 5.11 illustrates staff perspectives on the skills attained by students through DBL. The majority of staff members mentioned that creativity, learning by doing, problem solving, and self-directed learning are the most important skills attained by students through design based learning in their curriculum. In addition, Figure 5.8 shows staff perceptions about the collaboration of academics with industry. It shows that the majority (30%) of staff members recommend that practicing and improving design projects in universities helps engineering design projects collaborate with industry. Only 10% of staff believes collaboration between academics and industry will help students’ exposure to real world problems. The engineering teaching staff at Deakin University obtained an adequate understanding of DBL (Appendix B), as illustrated from the results shown above. This will enhance student learning and staff teaching processes to better align with the learning and teaching model. This research helps to foster curriculum development in student understanding and engagement.

5.2.3 A comparative study of students perspectives of design based learning in engineering education (Deakin University)

Student views on Design Based Learning (DBL) in this section come from 2012 and 2013 final year undergraduate engineering students in the School of Engineering at Deakin University. The goal of the study is to determine student perspectives on DBL and how their perspective changes over the years studying engineering. The way engineering students study their university degrees is somewhat different to the way engineering students studies many years ago. The tables 5.12 and 5.13 below show a comparison of perspectives for students in their final year in 2012 and 2013.
Table 5.12 illustrates that in 2012, 6% of students worked full time, 72% of students worked part time and only 22% of students chose not to work while studying. Of the final year students in 2013, 4% worked full time, 78% worked part time and 18% were not working. Overall, 18% to 22% of students in their final year choose not to work while studying. This shows that senior year students want to further engage in their studies to add more value to their future career. It is interesting to see in Table 5.14 that only 16% (2012) and 87% (2013) of final year students work in engineering related jobs that help them to get more practical experience and knowledge while studying. As it can be seen from Table 5.15, 83% of students were studying on campus, 11% were studying off-campus and 6% were participating in blended learning in 2012.

Table 5.16 shows the views of final year students on their definition of “engineering”. It is also interesting to see more than 80% of final year students had a similar definition of engineering. In 2012, students (22%) define engineering as a process of creating new things, solving problems and critical thinking, while in 2013 students (26%) state engineering is a practical application of science and technology to improve or create new things and 30% of students defined it as problem solving, creating solutions, and designing to solve problems. Overall student perceptions suggest that engineering is the use of science and technology that benefits society, and is the practical application of science. Design based learning was implemented more than ten years ago; nevertheless it is a concept that still needs further development. Therefore, in the work of Wijnen [47, 122] and Dopplet [48, 49], their intention was to characterise DBL as an educational concept in engineering education.
Table 5.16: Students definition of Engineering

<table>
<thead>
<tr>
<th>2012 Perceptions of final year students</th>
<th>%</th>
<th>2013 Perceptions of final year students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process of creating new things (apply knowledge)</td>
<td>22</td>
<td>Practical application of science and technology to improve or create new things</td>
<td>26</td>
</tr>
<tr>
<td>Solving Problems, critical thinking</td>
<td>22</td>
<td>Problem solving, creating solutions, designing to solve problems</td>
<td>30</td>
</tr>
<tr>
<td>Profession of acquiring and applying scientific, science skills</td>
<td>12</td>
<td>No answer</td>
<td>14</td>
</tr>
<tr>
<td>Use of Science and Tech to benefit society, practical application of science</td>
<td>33</td>
<td>Use of Science and Tech to benefit society, practical application of science</td>
<td>18</td>
</tr>
<tr>
<td>Creates complex structures or machines</td>
<td>11</td>
<td>Creative application of scientific principle to design or develop structure</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 5.17 shows the perceptions of students’ about the design based learning approach, which is the current curriculum methodology in engineering at Deakin. Approximately 18% to 44% of students in both years revealed DBL is learning in a particular manner, learning by doing, and is a hands-on project. 18% to 22% of students said DBL is project based learning (real world projects), and learning through projects (design projects). The perception of final year students on DBL provides encouraging signs for the engineering curriculum educators in the School of Engineering at Deakin University.

Table 5.17: Perceptions of students on Design based learning (DBL)

<table>
<thead>
<tr>
<th>2012 Perceptions of final year students</th>
<th>%</th>
<th>2013 Perceptions of final year students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No answer</td>
<td>11</td>
<td>No answer</td>
<td>22</td>
</tr>
<tr>
<td>DBL is a way of design based teaching</td>
<td>6</td>
<td>Learning through practical application of engineering (design problem)</td>
<td>38</td>
</tr>
<tr>
<td>Learning in a particular way, learning by doing, hands on projects</td>
<td>44</td>
<td>Learning in a particular way, learning by doing, hands on projects</td>
<td>22</td>
</tr>
<tr>
<td>Project based learning (real world projects), learning through projects</td>
<td>22</td>
<td>Project based learning (real world projects), learning through projects (design projects)</td>
<td>18</td>
</tr>
<tr>
<td>Getting involved with the practical application of engineering</td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A design based learning environment helps a curriculum practice career related skills for students, such as practical learning, problem solving, collaborative teamwork, innovative creative designs, active learning, and engagement with real-world assignments. Dopplet states that DBL is also an active learning process, which makes students practice and recognize different learning styles [49, 67]. DBL comprises team-based activities, which support learning and sharing through cooperative methods.
Table 5.18: Students perceptions about DBL in the curriculum

<table>
<thead>
<tr>
<th>2012 Perceptions of final year students</th>
<th>%</th>
<th>2013 Perceptions of final year students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>iLectures, Video lectures (tools and tech)</td>
<td>17</td>
<td>No answer</td>
<td>37</td>
</tr>
<tr>
<td>Practical Learning, Demos in classes</td>
<td>34</td>
<td>Practical learning, demos in classes, more practical less theory</td>
<td>26</td>
</tr>
<tr>
<td>Articles, journals, resources available online on D2L</td>
<td>5</td>
<td>Learning through projects, design techniques</td>
<td>7</td>
</tr>
<tr>
<td>DBL units show significant gain in scientific reasoning skills</td>
<td>11</td>
<td>Integrate with teaching (individual DBL units)</td>
<td>15</td>
</tr>
<tr>
<td>More project based learning, assessments and less exams</td>
<td>16</td>
<td>Labs, practical’s, lectures, tutorials, more assessments based on practical’s</td>
<td>15</td>
</tr>
<tr>
<td>Industry related projects for future needs</td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.18 indicates the perceptions of final year students about DBL in their curriculum, 34% in 2012 and 26% in 2013 experiencing DBL as practical learning, and demos in their classroom. More than 50% of all students in both years believed DBL was learning through industry related projects or learning through projects, design techniques. When students were asked about the influence of DBL in their future career, about 55% of final year students in 2013 and 39% in 2012 believed the influence of DBL does help in the engineering curriculum (Table 5.19).

In addition, Table 5.20 shows that 27% of students in 2012 and 55% students in 2013 perceived DBL as important in their final year project. It can be clearly shown in Table 5.19 that final year students in 2012 (39%) and 2013 (25%) recommend DBL as necessary for their future engineering careers. Almost 27% of 2012 final year students and 22% in 2013 strongly maintain that DBL is very important in their final year. Project and design based learning approaches are used to transform these skills into active learning and to evaluate student progress in classrooms. Lehmann [56] also declares the purpose of design education is to enhance learning in order to teach students to become active participants in solving design problems around them.

Table 5.19: Influence of DBL in future career

<table>
<thead>
<tr>
<th>DBL to your career</th>
<th>2012 (%)</th>
<th>2013 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not help</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No effect</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Possibly helps</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Does help</td>
<td>39</td>
<td>55</td>
</tr>
<tr>
<td>Is necessary</td>
<td>39</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 5.20: Importance of DBL in final year project

<table>
<thead>
<tr>
<th>DBL in final year project</th>
<th>2012 (%)</th>
<th>2013 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not help</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No effect</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Possibly helps</td>
<td>27</td>
<td>55</td>
</tr>
<tr>
<td>Does help</td>
<td>33</td>
<td>19</td>
</tr>
<tr>
<td>Is necessary</td>
<td>27</td>
<td>22</td>
</tr>
</tbody>
</table>
Table 5.21: Modes of DBL preferred

<table>
<thead>
<tr>
<th>DBL mode</th>
<th>2012 (%)</th>
<th>2013 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All individuals</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Mostly individuals</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Half teams and half individuals</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>Mostly teams</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>All teams</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

From the design workshop held in Melbourne by Deakin University [60], it was found the goal of the design approach was not to change the whole engineering curriculum, but it helps to change the learning and teaching approach around student centred learning. Through design activities, students develop their ability to enhance and transform ideas through visualization, manipulation and application of data to solve problems. Table 5.21 shows that 61% in 2012 and 62% in 2013 preferred DBL mode as half in teams and half in individuals. Table 5.22 illustrates student perceptions on the advantages of teamwork in design-based learning, which includes real world experience, teamwork and interaction. Only 11% of final year students in 2012 and 7% in 2013 mentioned they don’t have any idea about the teamwork DBL experience.

Table 5.22: Advantages of Teamwork in DBL

<table>
<thead>
<tr>
<th>2012 Perceptions of final year students</th>
<th>%</th>
<th>2013 Perceptions of final year students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>More discussion opportunities,</td>
<td>11</td>
<td>More discussion opportunities,</td>
<td>15</td>
</tr>
<tr>
<td>distribution of knowledge</td>
<td></td>
<td>distribution of knowledge</td>
<td></td>
</tr>
<tr>
<td>Good experience, time efficient</td>
<td>11</td>
<td>Good experience, time efficient</td>
<td>11</td>
</tr>
<tr>
<td>The work is divided, faster to give</td>
<td>5</td>
<td>The work is divided, faster to give</td>
<td>7</td>
</tr>
<tr>
<td>results</td>
<td></td>
<td>results</td>
<td></td>
</tr>
<tr>
<td>Team work, interactive knowledge</td>
<td>28</td>
<td>Team work, interactive knowledge</td>
<td>34</td>
</tr>
<tr>
<td>Develop collaborative, management</td>
<td>17</td>
<td>Develop collaborative, management</td>
<td>15</td>
</tr>
<tr>
<td>skills, social skills</td>
<td></td>
<td>skills, social skills</td>
<td></td>
</tr>
<tr>
<td>Real world experience, like industry</td>
<td>17</td>
<td>Real world experience, like industry</td>
<td>11</td>
</tr>
<tr>
<td>experience, build large projects</td>
<td></td>
<td>experience, build large projects</td>
<td></td>
</tr>
<tr>
<td>No answer</td>
<td>11</td>
<td>No answer</td>
<td>7</td>
</tr>
</tbody>
</table>

This indicates the present curriculum needs to change by implementing the DBL units in the first year of engineering programs. Students in 2012 (28%) and 2013 (34%) said they acquired interactive knowledge through DBL teamwork. While 17% of final year students in 2012 and 15% of 2013 final year students mentioned that it develops collaborative skills, management skills and knowledge of the social sciences. It’s interesting to see that 17% (2012) and 11% (2013) of final year students said they received the opportunity to manage large projects through real world
problems with industry experience. Overall, the views of students suggest that most of the essential graduate abilities are attained through the teamwork DBL mode.

Table 5.23: Disadvantages of Teamwork in DBL

<table>
<thead>
<tr>
<th>2012 Perceptions of final year students</th>
<th>%</th>
<th>2013 Perceptions of final year students</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less individual learning</td>
<td>16</td>
<td>Team members are not contributing</td>
<td>27</td>
</tr>
<tr>
<td>Time management</td>
<td>22</td>
<td>Independent learning not applicable, Relaying on other tasks</td>
<td>27</td>
</tr>
<tr>
<td>Culture, communication barrier</td>
<td>11</td>
<td>No individual effort, loss of time</td>
<td>15</td>
</tr>
<tr>
<td>Team members are not cooperated</td>
<td>40</td>
<td>Hard to make decisions and organize</td>
<td>16</td>
</tr>
<tr>
<td>Leadership qualities</td>
<td>11</td>
<td>Lack of consistence, slack students</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 5.23 illustrates the perceptions of students about the disadvantages of teamwork on design-based learning. Most students mentioned the problems that exist in teamwork are the lack of consistency, lack of communication; decision-making can be difficult, lack of co-operation and poor time management. It is clear that senior students in every year who practiced design-based learning were fully engaged in their studies. The results of the comparative study (Appendix A) show a positive increase of about 25% in the perceptions of final year students’ on design based learning in 2013 compared to 2012.

5.2.4 Aligning students views with staff perspectives in design based learning

Engaging students is an important aspect of the learning and teaching process because it enhances students to be self-directed active learners. To measure student engagement and the experiences of staff in the learning and teaching process, engineering at Deakin has used design based learning as one of its engineering learning principles. This research study examines students perceptions of DBL in their curriculum through a paper based survey given to a cohort of final year undergraduate engineering students. By conducting face-to-face interviews, the research also illustrated the perceptions of staff about DBL in the engineering curriculum. From the analysed results, this research shows that students and staff have adequate experience of learning and teaching engineering through a design based learning approach in an engineering curriculum.

5.2.4.1 Bridging the gap

A decade ago, many university staff used traditional methods and practices in teaching. With rapid technological advances, academic staff are starting to practice new learning and teaching model to meet educational requirements. On the other hand, students are unable to link their skills with the
professional learning curriculum. A gap exists between the learning expectations of students and the teaching approaches of staff [124-126]. Graduates are expected to be skilled and ready to work on industry projects early in their careers. From the initial stage of the academic curriculum, teaching staff and academic management are responsible for curriculum development [127, 120]. To bridge the gap between students and staff, this study examined the perceptions of both students and staff about design based learning (DBL) approaches in their curriculum. By integrating design and technological tools into engineering education, the aim is to provide students with dynamic learning opportunities so they can actively investigate and construct innovative engineering design solutions. This design based learning approach focuses on innovation and creativity where students learn through design based activities but are driven or oriented by the project.

Table 5.24: Aligning students and staff views

<table>
<thead>
<tr>
<th>Learning principles of DBL</th>
<th>Students views</th>
<th>Staff perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-directed learning</td>
<td>Learn to learn</td>
<td>Act as a facilitator</td>
</tr>
<tr>
<td>Activity based learning</td>
<td>Practical learning</td>
<td>Learning by doing</td>
</tr>
<tr>
<td>Interdisciplinary learning</td>
<td>Learning without borders</td>
<td>Common goal</td>
</tr>
<tr>
<td>Analytical learning</td>
<td>Thinking different</td>
<td>Unique solution</td>
</tr>
<tr>
<td>Team based learning</td>
<td>Collaborative learning</td>
<td>Social approach</td>
</tr>
</tbody>
</table>

Table 5.24 shows a commonality in the views of students and staff views about the learning principles of the DBL model. These learning principles were developed to provide a structure for the teaching and learning process and provide a strong base for an effective pedagogy. DBL is an overarching principle that incorporates all of the above learning principles. Figure 5.9 shows the focus of design based learning is to bridge the gap between the learning and teaching process of students and staff in engineering design education. With student and staff perspectives, this research mapped the results (Table 5.24) with the learning principles of design based learning model. The results shown above are a preliminary report, which is part of a continuing research process.
5.2.5 Focus on project, design, practice at Deakin Engineering

At Deakin University, students undertake common subjects in their first year and then choose a discipline to specialise in. This includes civil, electrical and electronics, mechanical or mechatronics and robotics engineering. This format allows students to make a more informed decision and to gain a broad base of knowledge in engineering. These undergraduate engineering courses are designed to meet the requirements of Engineers Australia (EA). This research study has looked into all 32 units of every discipline, the programs’ educational objectives, student outcomes, assessment methods and evaluation of different undergraduate engineering programs at Deakin University that shows how engineering design is practiced and incorporated as an important element of graduate attributes through a design based learning curriculum inspired by professional accreditation requirements. Figure 5.23 illustrates the percentage of design, project and practice in all four disciplines of Deakin’s engineering degree.

![Figure 5.23: Focus on project, design, practice in various disciplines in engineering at Deakin University](image)

The results were mapped through an analysis of each study unit of particular disciplines against the three professional accrediting bodies’ elements of competencies for professional engineers, as shown in Figure 5.23. Through qualitative analysis, the data was mapped against elements of competencies to obtain the percentage of design, project and practice.
The mapped results illustrate that every engineering discipline has design as its most important element or aspect, with Civil at 53%, Mechatronics and Robotics at 50%, Electrical and Electronics at 47%, and Mechanical at 37%. ‘Project’ work forms 37% for Electrical and Electronics, 34% for the Mechanical stream, 31% for Mechatronics and 25% for Civil engineering. The percentage of ‘practice’ is 25% in Electrical and Electronics, 25% in Mechatronics, 12% in Mechanical and 9% in Civil engineering. The above results show engineering at Deakin is providing good practice in design and technology through projects. The overall percentage of design is 47%, project 32% and practice 18% in all Bachelor degrees with engineering disciplines. Figure 5.23 shows a detailed outcome based category that maps the engineering programs of Deakin University to Engineers Australia, the Accreditation Board for Engineering and Technology, and the European Accreditation of Engineering Programmes. It describes the implementation phase of Deakin University’s accreditation alignment, with a focus on design-based learning in Electrical and Electronic engineering, Mechanical engineering, Civil engineering, and Mechatronic and Robotics engineering.

5.2.5.1 Outcome Based Mapping Matrix

The chapter also describes a detailed outcome based mapping matrix. For example, electrical and electronics engineering could be used to evidence the alignment of accreditation requirements with engineering learning outcomes. Based on the revised EA Stage 1 competencies, it is proposed that knowledge and base, engineering application ability, and professional and personal attributes are the key elements of competency and part of the integrative learning principle for all Deakin engineering graduates.

**Electrical and Electronics Engineering**

The Electrical and Electronics major within the Bachelor of Engineering was mapped against EA Stage 1 competencies and the elements of competencies for Professional Engineers. The purpose of this mapping was to identify the relative occurrence of the various Stage 1 competencies as evidenced by the assignment of unit learning outcomes against elements of competency. This mapping can demonstrate the potential capability development and capacity building of students as they progress through the course. This capability and capacity development is framed by the learning outcomes from the unit, the learning activities comprising the unit of study, and assessment tasks to allow students to demonstrate their learning. Therefore, a total constructive alignment was achieved.
Table 5.25 demonstrates how the learning outcomes from the Electrical and Electronics Major maps to EA Stage 1 competency standards and elements of competency. Looking at the Electrical and Electronics major, analysis reveals 31% of the overall learning outcome elements from course units contributed to students Knowledge and Skill Base (PE1). It is interesting to note that 12% of the overall unit learning outcomes related to competency are mapped specifically to comprehensive, a theory based understanding of the underpinning of natural and physical sciences, and engineering fundamentals applicable to the engineering discipline (P1.1), a conceptual understanding of the mathematics numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline (P1.2).

Research analysis reveals approximately 57% of the courses’ unit learning outcome elements of competency contributed to the Knowledge and Skill Base (PE1) and Engineering Application Ability (PE2) – the foundation of technical capability and capacity. Looking across the Electrical and Electronics Engineering major, analysis reveals a total of 26% of the courses’ unit outline elements of competency contributing to Engineering Ability (PE2). From the total 26%, 8% is aligned to fluent application of engineering techniques, tools and resources (P2.2), and 8% is aligned to the application of systematic approaches to conduct and manage engineering projects (P2.4).

A total of 43% of the unit learning outcome elements of competency contributed to personal and professional attributes (PE3). From the 43%, 10% alignment is across effective oral and written communication in professional and lay domains (P3.2), and 8% is across orderly management of self, and professional conduct (P3.5). This is a clear indication that engineering is a combination of
technical knowledge, engineering application ability, and professional and personal attributes. The above detailed outcomes based mapping matrix is used to evidence the alignment of accreditation requirements with engineering learning outcomes.

5.3 Case Study of Australasian University A

5.3.1 Project Based Approach at Australasian University A

Australasian University A was established 47 years ago and today it has around 20,000 students. In Australasian University A, the Bachelor of Engineering program has been offered for four years in four different disciplines such as civil, electrical, mechanical and mining. The structure of the engineering program is to have a 100% common first year, a 75% common second year with a 25% discipline stream component, 100% discipline based component in the third and final year. Students are expected to acquire, develop and demonstrate technical engineering knowledge and skills in every engineering discipline. By incorporating a project based learning approach throughout the engineering programs, it enhances the learning and teaching process [68, 69].

Project Based Learning is perceived to be a student centred approach to learning [30, 70]. It is predominantly task oriented with facilitators often setting the projects. Students need to produce a solution to solve a project and are required to produce an outcome in the form of a report guided by the facilitators. Teaching is considered as an input that directs the learning process. The problem is open ended and the focus is on the application and assimilation of previously acquired knowledge.

5.3.2 Staff Perspectives of Design Based Learning

According to Australasian University A, there is a need for this research to seek the views of staff members on design based learning in the School of Engineering and Technology at the university. About 14 staff members in the School of Engineering and Technology at Australasian University A participated in face-to-face interviews. It is interesting to see the views of staff on design based learning at Australasian University A. These staff members practice a project based learning approach in every unit of the engineering degree and have done so for a long time. Figure 5.11 shows the perspectives of staff on design-based learning (DBL). 37% believe DBL is learning through design activities, 21% believe DBL is an active learning process, 21% view it as learning design through projects and 21% defined DBL as focusing on aspects of the design.
Staff members were asked what engineering design means. Figure 5.12 shows that 36% believe Engineering Design (ED) means going through a design process, 21% reveal that ED is to create or design something to benefit society, another 21% explain that ED is a structured approach to solving an engineering problem, 14% of staff explain that ED is the use of existing knowledge to create new things and 8% define it as using a design tool to engineer a creative solution.

Figure 5.13 illustrates staff mentioning aspects of design taught in their engineering units. 28% teach the application of design through projects, 28% teach the process of concept development to design, 22% teach through design methodologies and 22% teaching through the design process with practical knowledge. Overall, staff members acquired their own way of teaching design in various activities. Table 5.26 shows that 100% of staff members accepted that engineering design is an essential element in an engineering curriculum. Table 5.27 clearly shows that 100% of staff members say their curriculum involves DBL. It is exciting to see from Table 5.28 that of all possible ways to teach design about 36% prefer active based learning, 14% practice through analytical learning, 36% use self-directed learning and 14% use team-based learning.
Table 5.26: Engineering design as an essential element

<table>
<thead>
<tr>
<th>Engineering design as an essential element</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agree</td>
<td>28</td>
</tr>
<tr>
<td>Mostly agree</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 5.27: Curriculum involves DBL

<table>
<thead>
<tr>
<th>Curriculum involves DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possibly yes</td>
<td>43</td>
</tr>
<tr>
<td>Strongly yes</td>
<td>57</td>
</tr>
</tbody>
</table>

Table 5.28: Possible ways to teach design

<table>
<thead>
<tr>
<th>Possible ways to teach design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active based learning (learning by doing)</td>
<td>36</td>
</tr>
<tr>
<td>Analytical learning</td>
<td>14</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>36</td>
</tr>
<tr>
<td>Team based learning</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 5.29 shows the perceptions of staff about skills attained by students through DBL. About 64% say students acquire analytical learning, teamwork, and communication skills, 42% believe students develop creativity and problem solving skills, 35% reveal students obtain technical and self-directed skills, and only 22% say students learn through doing. It appears that all of the above skills are required for a student to become a graduate and to work in an industry. Australasian University A has introduced project-based courses as 50% of the first year, with first year courses focusing on the development of team work skills in addition to communication, computing, and problem-solving skills. First year students are also introduced to engineering issues such as ethics, environmental and social factors [33].

Table 5.29: Skills attained by students through DBL

<table>
<thead>
<tr>
<th>Skills attained by students through DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical skills</td>
<td>35</td>
</tr>
<tr>
<td>Teamwork &amp; communication</td>
<td>64</td>
</tr>
<tr>
<td>Learning by doing</td>
<td>22</td>
</tr>
<tr>
<td>Problem solving</td>
<td>42</td>
</tr>
<tr>
<td>Self-directed learning</td>
<td>35</td>
</tr>
<tr>
<td>Creativity</td>
<td>42</td>
</tr>
<tr>
<td>Analytical learning</td>
<td>64</td>
</tr>
</tbody>
</table>
When staff were asked about how design projects help to collaborate with industry, (Figure 5.14) all staff members who participated in interviews mentioned the co-op program at Australasian University A. This co-op program helps students find a paid work placement for almost a year in their second and fourth year of engineering. About 28% say that industry collaboration helps students realise theory to practice, 28% believe it helps student exposure to real world problems, 22% wants complex problems turned into smaller design projects with industry collaboration and 22% accept that industry collaboration is through capstone projects.

Overall staff perceptions (Appendix B) on design based learning shows that each and every staff member found their own way of teaching engineering design using various different design activities at Australasian University A. It also reveals that DBL helps students obtain skills such as creativity, problem solving, technical and self-directed learning.

**5.4 Case study of Australasian University B**

**5.4.1 Design Practice at Australasian University B**

Australasian University B was established in the year 2000 and the predecessors established more than 100 years ago and today it has 27000 students. In Australasian University B, the Bachelor of Engineering is common to all majors (Electrical and Electronic, Mechanical, and Maritime Engineering). Using a problem based learning (PBL) approach in the context of an engineering program helps students become creative engineering designers [71, 72]. The engineering curriculum
practices PBL in the context of design activity and students need to apply theory to practice through practical focused engineering projects [73].

5.4.2 Staff Perspectives of Design Based Learning

Staff perspectives on design-based learning are clearly shown in Table 5.30. 100% of staff members stated that DBL is learnt through the design process, and through design problems and activities. Staff also describes DBL as using a methodology of design as a foundation for learning activity that guides students through a design problem. Students acquire knowledge through the process of design and the technology required to solve engineering problems.

<table>
<thead>
<tr>
<th>Staff perspectives on DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active learning through a design process</td>
<td>50</td>
</tr>
<tr>
<td>Using a design methodology for learning activity</td>
<td>50</td>
</tr>
</tbody>
</table>

When staff were asked what engineering design means, they described a creative process of developing engineering systems using the knowledge of engineering science. Designers need to understand the paradigm of engineers and engineers need to understand the paradigm of designers (Australasian University B staff views). Staff members believe engineering design is an essential element of their curriculum and also mention their curriculum involves design-based learning through various design activities. Table 5.31 illustrates staff perceptions of possible ways to teach design and Table 5.32 shows staff views on the skills attained by students through design based learning in their curriculum. At Australasian University B, staff members approach industry collaboration through design projects. Staff also mentioned how engineering design projects help to collaborate with industry. Through industry collaboration students obtain the opportunity to undertake industry-based projects with real world problems. At Australasian University B, staff recognised that Design based learning leads students into their future career placements and industry recognises the graduate's ability to fit into the job environment (Appendix B).

<table>
<thead>
<tr>
<th>Possible ways to teach design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teach design approaches to solve problems, teach through design projects, through design planning stage by experience</td>
<td>50</td>
</tr>
<tr>
<td>Teach design through the learning experience, teach through practical world problems, teach through case studies and models</td>
<td>50</td>
</tr>
</tbody>
</table>
5.5 Case study of Asian University A

5.5.1 Design Centric Curriculum at Asian University A

Asian University A was established in the year 2009 and today it has around 5000 students. At Asian University A, the curriculum is designed around cohort based learning and collaborative learning. The design centred education is focused on practice through design projects, self-study sessions, group discussions and independent activities. In the first year of engineering, each pillar provides foundation material with more advanced pillar subjects. Asian University A introduces the four-dimension design experience, 1D Big-D concepts, 2D integrative designettes, 3D thematic design projects and concepts vignettes and Big D outside the box and behind the scenes.

5.5.2 Staff perspectives of design based learning

In collaboration with Design centric university, Asian University A staff members have obtained an extensive range of experience in teaching design practice. It’s encouraging to explore staff perceptions about DBL. Figure 5.15 shows staff perspectives on design-based learning, with 7 staff members participating in face-to-face interviews. The researcher involved in this research visited Asian University A to acquire the views of staff on the design based learning approach. It’s very interesting to see that 43% of staff encapsulate DBL as active learning that is students observe and reflect (theory to practice), 29% experienced DBL as learning through design activities, 14% said is learning together by doing, and 14% believed it is a hands on approach through projects.

Table 5.32: Skills attained by students through DBL

<table>
<thead>
<tr>
<th>Skills attained by students through DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating potential design, recreate engineering products, personality characteristics, experiential knowledge, demonstrating creativity, multidisciplinary, analytical, problem solving, communication, professional responsibility, logical thinking and team activity</td>
<td>50</td>
</tr>
<tr>
<td>Collaborate, team based activity, transferable skills, project management, creativity, integrate design, understanding context, research, observe and communication</td>
<td>50</td>
</tr>
</tbody>
</table>
Asian University A has established a stable pedagogy and curriculum for design education and research. Staff members expressed their views on the means of engineering design with Figure 5.16 illustrating that 43% of staff explain ED as using engineering knowledge to solve design problems, 29% looks at it as design is creating something with engineering the analysis tool, 14% describe engineering design as a process of synthesis and analysis, and 14% say it is using technology through the design process. Design oriented project organised education deals with know how, in addition to the practical problems of constructing and designing on the basis of a synthesis of knowledge from many disciplines [74, 75].

When staff were asked about aspects of engineering design taught in their unit, it was motivating to look at the approaches used by staff to practice design (Figure 5.17). While 29% use design concepts and design based activities, another 29% of staff use the design process to solve problems, 14% teach design through 1D, 2D, 3D and Big D design projects, and 14% teach creative design integrated with experiential design. These views confirm that Asian University A is certainly focused on design centred curriculum, with the aim to enhance student-learning outcomes. The
purpose of design education is to enhance learning and teach students to become active participants to solve the design problems around them [56].

![Figure 5.17: Aspects of engineering design taught in your unit](image)

Table 5.33: Engineering design as an essential element

<table>
<thead>
<tr>
<th>Engineering design as an essential element</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes definitely</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.34: Curriculum involves DBL

<table>
<thead>
<tr>
<th>Curriculum involves DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes absolutely</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.33 and Table 5.34 show that staff members obtained similar views (100%) when they were questioned about engineering design as an essential element in their curriculum and whether it involves design based learning. Asian University A staff members look for different ways to teach design in engineering. Table 5.35 shows about 43% of staff teach design through standard pedagogy, with a hands on approach to design based activities, 29% teach using theory to practice with real world problems that include multidisciplinary design projects, and 14% say they teach through competition, team based projects to help enhance practical learning and learning through observation for students.

![Table 5.35: Possible ways to teach design](image)

<table>
<thead>
<tr>
<th>Possible ways to teach design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory to practice with real world examples and multidisciplinary design projects (Big D)</td>
<td>29</td>
</tr>
<tr>
<td>Through standard pedagogy, hands on project, design based activities</td>
<td>43</td>
</tr>
<tr>
<td>Through competition based, team based projects &amp; exhibition design</td>
<td>14</td>
</tr>
<tr>
<td>Learning through observation, problem analysis &amp; solving</td>
<td>14</td>
</tr>
</tbody>
</table>

Design education always sets out to have student content knowledge and the development of skills such as collaboration, critical thinking, creativity, innovation, and problem solving to increase motivation and engagement. Table 5.36 illustrates staff members’ views on the skills attained by
students when they engage in design-based learning. From the teaching experience of staff, it is clearly shown that Asian University A design centred curriculum enhances student learning around the skills listed below. More than 40% of staff members revealed that when students acquire creativity, innovation, self-improvement, awareness, mindfulness, communication and presentation skills through DBL.

Table 5.36: Skills attained by students through DBL

<table>
<thead>
<tr>
<th>Skills attained by students through DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototyping, testing</td>
<td>29</td>
</tr>
<tr>
<td>Hands on learning, learn from experience</td>
<td>43</td>
</tr>
<tr>
<td>Self-improvement, awareness, mindfulness</td>
<td>43</td>
</tr>
<tr>
<td>Communication &amp; presentation</td>
<td>71</td>
</tr>
<tr>
<td>Project management, teamwork</td>
<td>57</td>
</tr>
<tr>
<td>Analytical thinking</td>
<td>71</td>
</tr>
<tr>
<td>Creativity &amp; Innovation</td>
<td>57</td>
</tr>
<tr>
<td>Ability to observe, solving problems</td>
<td>57</td>
</tr>
</tbody>
</table>

Design education represents both serious challenges and outstanding opportunities. In fact, the intelligent and thoughtful design of the engineering curriculum should be the community’s first commitment [74]. Asian University A staff acknowledges that design projects help industry collaboration where students receive the opportunity to experience industry expectations, and future career possibilities. There is always a benefit to both industry and a university through design project collaboration. Industry and university collaboration seems to be actively growing when engineering courses are developed [76]. Figure 5.18 shows staff perceptions about industry collaboration. From the overall teaching experience of staff (Appendix B), it is clearly shown that Asian University A design centred curriculum enhances student learning around the design based learning approach.

Figure 5.18: Engineering design projects help collaboration with industry

64
5.6 Case study of Asian University B

5.6.1 Design practice at Asian University B

Asian University B was established more than 100 years ago and today it has 27000 students. In the Faculty of Engineering at the Asian University B, the Engineering Design and Innovation Centre developed a Design Centric Program. The Design Centric Program is a unique learning pathway that offers multi-year projects for students from different engineering disciplines to work together to solve design problems. Students spend 3 to 3.5 years working together in multi-year, multi-disciplinary projects. Teams of teachers from diverse backgrounds facilitate the students.

5.6.2 Staff perspectives of design based learning

To achieve the goal of developing education, design educators provide practical strategies that exhibit the pedagogy of design education and problem solving processes [60, 77]. Figure 5.19 shows staff perceptions on DBL, with 29% believing DBL is learning through design, 29% accepting it as learning through problem solving, 28% describe it as students learning through practical means (hands on) and 14% believe DBL is learning to enhance design. Figure 5.20 shows staff views on engineering design (ED). 29% say ED is using design with technical concentration for social need, more than 50% of staff believe the purpose of ED is to achieve knowledge, and identify and solve design problems using the design process. Figure 5.21 illustrates staff views on aspects of engineering design taught in their unit. 14% teach more skills rather than technology through interdisciplinary projects, 29% teach engineering principles and fundamentals focused on design and another 29% teach through projects based on the design centric program.

![Figure 5.19: Means of design-based learning](image-url)
Chapter 5

When staff members were asked whether engineering design is an essential element in their curriculum and whether the curriculum contains design based learning, every staff member (100%) accepted the above statement, as shown in Table 5.37 and Table 5.38.

Table 5.37: Engineering design as an essential element  

<table>
<thead>
<tr>
<th>Engineering design as an essential element</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes definitely</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.38: Curriculum involves DBL

<table>
<thead>
<tr>
<th>Curriculum involves DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Yes absolutely</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 5.39: Possible ways to teach design

<table>
<thead>
<tr>
<th>Possible ways to teach design</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through (hands on) practical work</td>
<td>57</td>
</tr>
<tr>
<td>Through design tasks, design activities</td>
<td>28</td>
</tr>
<tr>
<td>Learning through projects, problem solving</td>
<td>57</td>
</tr>
<tr>
<td>Students must experience the design process</td>
<td>43</td>
</tr>
<tr>
<td>Focus on design user centric</td>
<td>43</td>
</tr>
</tbody>
</table>

Design centric program created a learning environment that encourages students to be creative in team learning and in collaboration/cooperation across disciplinary boundaries. Table 5.39 shows that staff expect students to experience the design process through practical work (57%), through
design tasks and design activities (28%), and learning through projects and problem solving (57%). Table 5.40 reveals staff experience on the skills attained by students through design-based learning. Staff were assured that students attained creativity and innovation skills (71%), communication and teamwork skills (57%), project management and prototype testing skills (43%), and ability to observe, problem solve and think analytically (29%). Industry is looking for graduates who are ready to practice and perform essential competences such as practical knowledge, problem solving, teamwork, and innovative and creative designing of real world projects.

Table 5.40: Skills attained by students through DBL

<table>
<thead>
<tr>
<th>Skills attained by students through DBL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity and innovation</td>
<td>71</td>
</tr>
<tr>
<td>Analytical thinking</td>
<td>29</td>
</tr>
<tr>
<td>Ability to observe, problem solving</td>
<td>29</td>
</tr>
<tr>
<td>Prototype, testing</td>
<td>43</td>
</tr>
<tr>
<td>Project management, time management</td>
<td>43</td>
</tr>
<tr>
<td>Communication, teamwork</td>
<td>57</td>
</tr>
</tbody>
</table>

Finally, Figure 5.22 shows the views of staff on engineering design projects that help to collaborate with industry. About 43% reveal that the DBL approach is similar to industry requirements as it has strong collaboration, and mutual benefits from both industry and university. 14% of staff say that it guides academics to plan future projects and helps students to integrate with industry. With the Design Centric Program (Appendix B), staff encourage students to adopt a user centred approach in the Engineering Design and Innovation Centre at Asian University B.
5.7 Professional development

In many cases, academic staff are responsible for setting high expectations in their classrooms. Sometimes staff are expected to teach subjects outside their expertise and in some cases, academic staff may experience a lack of confidence in their ability to teach such subjects yet are unwilling to seek professional development [78]. These professional development opportunities provide staff with valuable opportunities to enhance their personal teaching qualities, which helps them to achieve and follow a successful learning and teaching process [99-101]. At Deakin University, staff are encouraged to practice teaching and learning approaches that influence, motivate and inspire students to learn. Deakin Learning Futures provides a range of opportunities, events and services for staff to enhance their capability to be effective educators. In order to enhance and continue the engagement of students in learning and create active learners in the classroom, teachers need to teach each other through professional development workshops [79-82].

The engineering teaching staff at Deakin University seem to have an adequate understanding of DBL, which is illustrated from the results shown above. This is encouraging to the School of Engineering, who will continue to enhance student learning and staff teaching processes to better align with the learning and teaching model. This thesis is part of ongoing research that helps to foster curriculum development in student understanding and engagement. 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, thus increasing their motivation and engagement.

5.8 Industry needs on design education

A research study conducted at an industry forum in Melbourne, Australia in 2013 investigated industry and academic requirements for students focused on achieving design skills. The majority of participants who took part in the survey were design engineers, designers, architects, industrial design practitioners, project team leaders, teachers, lecturers, entrepreneurs from different disciplines and participants from Engineers Australia (Australia’s Engineering Accreditation Body). The findings from the research performed indicated that learning is a combined source of students’ initiation into social and global responsibility, and the expected skills from industry. Industry is looking for graduates who are ready to practice and perform essential competences, such as practical knowledge, problem solving, teamwork, and innovative and creative designing of real-
world projects [128-130]. In addition, both educators and industry representatives stated that students lack motivation mostly from the learning and teaching style they have been exposed to. Thus, academics 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 [60, 83, 84]. Results indicate the following key skills are essential elements for a successful project/design based learning curriculum. They include creative & innovative skills, successful industry engagement, and an awareness of design skills in the early years of engineering. A summary of findings is illustrated in Figure 5.23.

![Figure 5.23: Views of industry and academia about design discussion](image)

By engaging industry with the academy, students will acquire global perspectives and knowledge about core attributes expected in future engineering jobs [85, 86]. In today’s large-scale industrial market, companies tend to prefer graduates with design skills attained using a project approach. Thus, universities should open their doors and accept the challenges of interacting with students with industrial experiences and expectations.

### 5.9 Conclusion

The research progress achieved would assist to develop and implement a framework for new learning and teaching model to solve design problems through accreditation inspired design based learning in engineering education. This research identifies the need to enhance important skills such as innovation and creativity through a whole learning process that incorporates design based
learning features. From the in-depth analysis of all program educational objectives, student outcomes, assessment methods and evaluation of different undergraduate engineering programs, students, staff and industry perspectives on engineering design, it is clearly shown design can be learned and taught through a design based learning approach in a convalescent way, which is inspired by accreditation requirements.
Chapter 6

The New Learning & Teaching Model: Project Oriented Design Based Learning (PODBL)

6.1 Introduction

The PODBL approach is focused on innovation and creativity where students learn through design based activities but are driven or oriented by a project. The Project Oriented Design Based Learning approach (PODBL) is a design centred approach driven through projects to assist learning and teaching. PODBL allows students to demonstrate professional capabilities expected of graduating professional engineers. Industry expects graduate engineers to be educated with skills, knowledge and attitudes that have changed over time. The purpose of the new learning and teaching model (PODBL) is not to change the engineering curriculum but to reform engineering learning and teaching through design centred curriculum.

The PODBL approach is looking to acquire the perceptions of current students, staff, and industry to remodel pedagogy without any distractions. It needs to be encouraging for students and staff members to understand the approach and to implement it in all design engineering classes. Development of PODBL framework includes framework guidelines for students, staff, industry and faculties. On the basis of previous recommendations by industry and academics, as well as from 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 (PODBL) model.

6.2 Project Oriented Design Based Learning (PODBL)

PODBL creates a boundary for student learning capabilities when programs are content driven and focused on engineering science and technology courses. PODBL is a structured framework, which
will overcome insufficiency of design practice related to the industry requirements. Figure 6.1 illustrates the framework of Project Oriented Design Based Learning. For quality learning and teaching, a curriculum needs student and staff participation, industry collaboration, management support and social involvement. The above framework has been developed with a diverse range of students’ views, staff perceptions, industry expectations and social needs. Chapter 5 discussed the analysed data gained from student perspectives using a paper-based survey, staff perceptions using face-to-face interviews, and industry views through industry-academic design forums. The PODBL learning principles provide a structure for the teaching and learning process. These principles are not standards or curriculum statements but they provide a strong base for an effective pedagogy. It ensures teachers’ involvement in teaching fulfills the expected standards of students. These five learning principles are all constructively aligned and are underpinned by constant engagement between students, staff, industry, faculty and for accreditation purposes.

When students are involved in solving a problem through a creative project, they will experience meaningful ideas that allow them to synthesis a suitable solution for it. It is a basic quality for a professional to deal with problems and to find solutions for the problems. Educational institutions need to teach and train students not only to be problem solvers but also to achieve innovative and creative skills. There are different kinds of problems that exist in engineering. Design problems are the most important that attracts young and imaginative students. Projects are considered to be the best way for student interaction with teachers [82, 135]. In addition to providing students with better practise in design and technology, Project Oriented Design Based Learning also has several advantages, such as good design that meets social, economic and industrial needs. This is an active learning process that makes students practice and recognize different learning styles that support learning and sharing through cooperative methods.

The new learning and teaching model, Project Oriented Design Based Learning motivates students and includes teaching into engineering design so more practical experience is gained and hence both academic and industry needs are met. Project Oriented Design Based Learning has been established to have a positive effect on students’ content knowledge and development of skills such as innovation and creativity which increases their motivation and engagement [91-94]. It is interesting research to develop a framework and implement a PODBL approach in meaningful ways. The research aim is to find an approach, a method or a framework that will balance teaching and learning by incorporating design, innovation and creative skills in engineering education.
Figure 6.1: The Project Oriented Design Based Learning (PODBL) framework
6.2.1 PODBL Learning Principles

Based on Engineers Australia Stage 1 competencies as well as industry input it is proposed here that fundamental knowledge and skill base, engineering application ability, and professional and personal attributes are the 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 research based learning, student driven learning, outcome based learning, analytical thinking and collaborative based learning. These five learning principles are all constructively aligned and underpinned by constant engagement between students, staff, community, industry, and government. Taking all this into consideration, the PODBL learning principles is illustrated in Figure 6.2.

![Figure 6.2: PODBL learning principles](image)

**Research Based Learning**

In engineering education, the focus of the curriculum structure is on different aspects of education such as creativity, research and innovation. In research based learning, students are involved in solving a problem through a creative project. This enables students to experience meaningful ideas, which allows them to analyse a suitable solution. An important key is that students need to integrate knowledge in any design process through research-based learning. The design process is similar to a problem solving method. In research based learning, staff and students work together in different fields through innovative oriented research projects. The innovative outcome of this research project is utilized for various societal needs. The education sector plays an important role
transferring the research results to real world application design. Academic knowledge and experience is a continuing investment in establishing permanent networks and communication between industry and universities.

**Student Driven Learning**

Through student driven learning, students research or investigate a project on an assigned topic by working independently, thus improving their personal development, problem solving, decision-making skills and technical competence. As self-directed learners, students are independent, self-disciplined, self-confident and goal oriented. Students as individual learners have to face challenges, such as aspects of learning, learning methods, resources and time management. The staff act as facilitators in this learning process. Staff help learners identify learning points, enhance inquiry, decision-making, and problem solving skills, and contribute to the skill of self-evaluation. Therefore, we see a transition from “listen to learn” to “think to learn”.

**Outcome Based Learning**

Outcome based learning is an outcome-oriented way to teach that encourages participants to get involved in intelligently designed activities and learn through their own experience. It involves activities such as research, decision-making and writing that motivates students to seek opportunities to acquire deeper learning [32]. It is an active process that places students in situations to make them observe, analyse, write and communicate, and be responsible for learning to be organized. Outcome based learning is an instructional method characterized by the use of real world problems as a context for students to learn critical thinking and problem solving skills, and acquire knowledge of the essential concepts of the course [34].

**Analytical Thinking**

A process where theory and practice come together to provide a unique solution that extends students’ lifelong learning. Students identify different approaches to solve problems through a decision-making process that creates logical conclusions. Analytical thinking is a methodical process of breaking down a problem through the application of knowledge and various analytical techniques. Analytical thinking is convergent, narrowing down to unique answers for a small number of ideas that can be further analyzed and implemented [136].
Collaborative-Based Learning

Collaborative-based learning is a social approach where learning takes place through dialogue and communication. The majority of the learning process takes place in groups or teams and students get the opportunity to develop their personal competencies. To select their own learning goals, students should analyse problems and frame questions with respect to the information they lack in order to solve the problem. Staff members act as facilitators for every student’s research project. Staff provide ongoing support for students to enhance their learning capability to work on industry based projects, internships, summer jobs, and campus recruitment. Gardner and Hatch [15] state that “Intelligence is the capacity to solve problems.” Therefore, students should learn to integrate knowledge from different disciplines and learn to select methods, theories and tools to arrive at a solution that is based on the chosen problem. By doing collaborative based learning, students achieve knowledge development, practical design and prototyping skills, and real world experience in an interdisciplinary environment.

6.2.2 PODBL Practicing Cycle

Project Oriented Design Based Learning (PODBL) is a teaching and learning approach (TLA) that is based on engineering design activities undertaken during a project. PODBL encourages independent learning and a deep approach to learning. It is also an approach that supports the development of information literacy and design thinking in the field of tertiary education – currently two of the key learning outcomes in engineering.

There are many versions of project based learning as well as design based learning. This new learning and teaching model is a unique combination of the two. PODBL indicates that students learn through real engineering design activities while driven by a project that has a defined deliverable that is presented to them by industry partners or academic staff. In our version, participants work in PODBL teams of four to six members with a facilitator. The same group meets regularly throughout the trimester to work on a series of design activities. The learning and teaching delivery is a combination of cloud and located learning activities. Cloud learning enables students to evidence their achievement. Units contain integrated short, accessible, highly visual, media-rich, interactive learning experiences rebuilt for the mobile screen, with integrated learning resources created by Deakin and other worldly universities and premium providers. Cloud learning will require students to be generators of content, collaborators in solving real world problems, and evidence their achievements in professional and personal digital portfolios. With premium cloud
learning experiences in place, students who come to campus will have the opportunity to engage with teaching staff and peers in opportunities for rich interpersonal interaction through large and small team activities.

Figure 6.3: The PODBL learning process

The PODBL cycle involves nine main steps. The steps are illustrated in Figure 6.3 and described below. Steps 1-6 and step 9 take place in a combination of both cloud and located learning, and Steps 7-8 are performed through located learning.

Step 1: Project Presentation
The project is presented to the team of students by the industry client (if project is industry based) or by the academic facilitator if the team and project are university based. The project outline, which is usually open-ended, is about half the length of a page. It is recommended that one member of the students’ team reads the project outline aloud to the group without comment at this stage.
Step 2: Problem Identification

This step is all about brainstorming the project. The student team could ask the following questions.

What do we know about this problem outlined in the project brief?
What do we need to find out about the problem?
What are the significant issues (teaching, learning, technical, social, economic and political)?
What do we need to learn?
What are the priorities? What is most important to learn?

During brainstorming, no evaluative comment is allowed. The aim is to simply get as many issues on the board or the cloud as possible so they can be prioritised, spilt/clumped, and researched in the next step. One person in the group needs to act as a scribe and write issues as they are raised.

Step 3: Concept Research

The first activity that needs to take place as part of this step is to identify, discuss, and assign the learning issues to each and every member of the team. Once this is done, each student in the team undertakes research into the assigned learning issue. Some of the questions that may arise are:

What are the essential learning issues (for everyone to follow up)?
What are the specific learning issues (for individuals to follow up)?
What resources are available?
Who will look up what (and report back to the team)?
What are the overlapping issues?

Each member of the team needs to understand they have agreed to research and what they have to contribute to the team. As students locate resources that are directly relevant to learning issues, other members of their PODBL team need to be advised by posting a message in the appropriate discussion forum on the cloud.

This message must include enough information to allow others to locate the resource (for books and journals, bibliographic details; for Web resources, the URL or Web address), a brief summary of the content of the resource (cutting and pasting the abstract of a paper is often useful), and a comment on why they believe the resource is relevant to the learning issue. In some cases, a digital copy of the document itself may be attached but this should be done without breaching copyright law and for this reason, it is not recommended to attach copies of scanned book chapters.
As these resources accumulate, members of the team use the online discussion tool to comment on and ask questions about the resources. Online discussion is an assessed task, with marks allocated on the quality and quantity of each participant’s contribution.

Step 4: ‘Design Brief’ Development
The ‘design brief’ is the key project planning document that specifies what the project has to achieve, by what means, and within what timeframe. During this step, the team of students uses the concept research ideas and findings to develop the ‘design brief’.

Step 5: Concept Selection
By evaluating research findings performed in Step 3, the team decides and selects the most appropriate concept to be used in order to develop their final design.

Step 6: Design Development
During this step the student team uses the selected concept in Step 6 to finalise and develop their design. This could include new ideas and additional features on top of the selected design.

Step 7: Modelling and Building
During this step the student team models and/or builds their design. Depending on the engineering stream, this could be done using hardware equipment, modelling software, and laboratory equipment.

Step 8: Testing and Evaluating
Once the design has been modelled and/or built, the team tests it and evaluates it against the set requirements and specifications. Laboratory equipment or industry tools may be used during this step.

Step 9: Product Delivery
The last step in the PODBL cycle is product delivery. This is when the student team presents their final product to the academic and/or industry member(s). The final product can be in the form of hardware, software, presentation, report, or other deliverables as set and agreed on by the team and the facilitator at the start of the project. The final product is assessed based on an agreed rubric.
6.2.3 Implementation of the Project Oriented Design Based Learning Model – A Case Study

The implementation of the project oriented design based learning (PODBL) model is a challenging and interesting task for engineering staff members in an engineering curriculum. PODBL implementation strategy is focused on improving student success, which follows the learning principles of PODBL model. The current undergraduate program in Deakin engineering consists of four distinct courses with varying degrees of overlap in the units of study or subjects taken within each engineering course. A third year unit is selected as a case study, which allows an educator to coordinate implementation strategies. The new learning and teaching model “PODBL” helps to manage student transition and improve student success in engineering education.

In Electrical & Electronics Engineering, Project Oriented Design Based Learning (PODBL) framework model is designed to support the transition from traditional lecture-based teaching to a project oriented design based learning approach. To design a framework and use it to implement in one of the study units in Electrical Engineering was considered a challenging task because the framework supported student centred learning, research based learning, design based learning, construction, testing, report writing and reflection, all of which are important aspects of the PODBL model.

The learning space that exists in the PODBL model has been specifically designed for engineering students who work in teams on PODBL projects. The students need well-developed generic attributes, including the skills associated with oral and written communication, working in teams, locating and evaluating information and project management. This emphasis on generic attributes is reflected in the accreditation requirements of Engineers Australia, the professional engineering body in Australia.

6.2.3.1 Planning of the Teaching Experiment

The implementation of Project Oriented Design Based Learning was performed in the 3rd year unit, Electronic systems and signals of the undergraduate electrical and electronics engineering degree. The current approach of students working on design projects was to be used as a benchmark to analyse, plan, and evaluate the experiment using the traditional approach. The advantage of this implementation is that the implementer of this experiment is also a supervisor in the undergraduate engineering, which is taught through PODBL.
Project Oriented Design Based Learning is generally regarded as a creative and innovative method for engineering education. When compared to traditional lecture-based or teacher-centered engineering curriculum, the PODBL model appears to inspire an enhanced learning environment for students. The conversion of one unit from the Electrical Engineering program to Project Oriented Design Based Learning (PODBL) is a gateway to enhance the relationship between the program and current University practices in the future. Table 6.1 below shows the semester overview of the teaching experiment.

Table 6.1: Semester overview of teaching experiment

<table>
<thead>
<tr>
<th>Week No.</th>
<th>PODBL process</th>
<th>Deliverable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Project Presentation</td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>Problem Identification</td>
<td></td>
</tr>
<tr>
<td>Week 3</td>
<td>Problem Identification / Concept Research</td>
<td></td>
</tr>
<tr>
<td>Week 4</td>
<td>Concept Research / Design Brief Development</td>
<td>Design Brief</td>
</tr>
<tr>
<td>Week 5</td>
<td>Concept Selection / Design Development</td>
<td></td>
</tr>
<tr>
<td>Week 6</td>
<td>Design Development / Modelling and building / Testing and evaluation</td>
<td></td>
</tr>
<tr>
<td>Week 7</td>
<td>Design Development / Modelling and building / Testing and evaluation</td>
<td></td>
</tr>
<tr>
<td>Week 8</td>
<td>Design Development / Modelling and building / Testing and evaluation</td>
<td></td>
</tr>
<tr>
<td>Week 9</td>
<td>Design Development / Modelling and building / Testing and evaluation</td>
<td>Design Presentation</td>
</tr>
<tr>
<td>Week 10</td>
<td>Design Development / Modelling and building / Testing and evaluation</td>
<td></td>
</tr>
<tr>
<td>Week 11</td>
<td>Product Delivery</td>
<td>ePortfolio</td>
</tr>
</tbody>
</table>

The student activity from week 1 to week 11 is listed below:

Week 1: The project is presented to students. Students start to form teams and teams are identified.

Week 2: Teams meet individually with the facilitator and brainstorm the project. Team members decide on individual concepts for research.

Week 3: Teams meet and discuss the concepts. Information is shared on Cloud Deakin. Teams update the facilitator on the concept research. Teams take the first step towards the development of the design brief.

Week 4: The information from the concept research is assimilated and the teams work together to produce the design brief document. The facilitator provides feedback on the design brief.

Week 5: The design brief is developed and teams move towards the selection of ideas and take the first step towards the design development of the final product.
Chapter 6

Week 6: Teams follow a cycle of design, model and evaluation for each individual component of the product. The facilitator’s role is to provide feedback and help the teams stay on track with the project.

Week 7: The cycle of design, model and evaluation continues.

Week 8: The teams continue the cycle and also begin to look at issues relating to the integration of individual components. Students also begin to prepare the presentation of the design.

Week 9: The teams present the design and the intermediate results. Each team member presents one component of the product, and the students start working on the final report and ePortfolios.

Week 10: Teams move towards integrating of all the individual components. Testing and evaluation of the final design is also completed. Students continue work on the final report and ePortfolios.

Week 11: Final changes are made to the design. The final product and ePortfolios are delivered.

6.2.3.2 Planning of Assessment

The principle of constructive alignment is that curriculum is developed so learning activities and assessment tasks are aligned with the learning outcomes intended in the unit of study. Thus, the assessment tasks and assessment methods are considered a critical issue in any learning and teaching curriculum. Table 6.2 summarizes the difference between a traditional model and the PODBL model in a 3rd year unit of Electrical and Electronics Engineering.

<table>
<thead>
<tr>
<th>Common first year unit</th>
<th>Traditional Model</th>
<th>PODBL Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>• Assignment 20%</td>
<td>• Design brief 25%</td>
</tr>
<tr>
<td></td>
<td>• Laboratory report 20%</td>
<td>• Design Presentation 25%</td>
</tr>
<tr>
<td></td>
<td>• Examination 60%</td>
<td>• ePortfolio 50%</td>
</tr>
<tr>
<td>Contact</td>
<td>• 2x1 hour Lectures</td>
<td>• 1 hour project meetings with each group team per week</td>
</tr>
<tr>
<td></td>
<td>• 1x1 hour Tutorial</td>
<td>• elive sessions</td>
</tr>
<tr>
<td></td>
<td>• 2 hour Laboratory per fortnight</td>
<td>• Online cloud concepts</td>
</tr>
<tr>
<td>Teaching</td>
<td>• Content driven, focused more on theory than practice</td>
<td>• Cloud concepts</td>
</tr>
<tr>
<td></td>
<td>• Teacher driven</td>
<td>• Research papers</td>
</tr>
<tr>
<td></td>
<td>• Assessment based on recollection rather than application.</td>
<td>• Design Briefs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Webinars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• You Tube clips</td>
</tr>
<tr>
<td>Project</td>
<td>• Not Available</td>
<td>• Project should help students achieve the learning outcomes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The content is aligned to the Project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The project should be able to drive the learning</td>
</tr>
</tbody>
</table>

Table 6.2: Comparison of 3rd year unit
In the PODBL model, the students are working in different teams of 5 to 6 team members. The students determine their own team and will be a combination of on/off campus students. The teams decide the roles assigned to each member and the staff member plays a dual role such of facilitator and client. PODBL indicates that students learn through real engineering design activities while driven by a project that has a defined deliverable presented to them by industry partners or academic staff. Table 6.2 shows the changes in assessment. The assessment tasks are being changed to Design brief 25%, Design Presentation 25% and ePortfolio 50%. The change from a final examination to class test will be a better measure of how the concepts taught have been understood because a final exam tests recollection more than understanding concepts taught in a unit.

6.2.3.3 Student Analysis

The majority of the students are, on average, about 19 to 21 years old. Most have come to Deakin straight from school and studied engineering fundamentals in their respective engineering disciplines. Many will be the first in their family to attend university. For a number of students, they will come from a cultural background, and many will have a language other than English as their first language. From a well-structured school experience and university-learning environment, this mix of students must now work in teams in a PODBL environment. PODBL helps students construct their own understanding of knowledge through guidance of the project oriented design problem posed in their PODBL classes.

6.2.3.4 Staff Analysis

Staff development or professional development is the most challenging activity for engineering educators to implement and practice in a new learning and teaching model. It helps students’ gain contextualized knowledge and competencies in a collaborative learning environment. It is a critical task for engineering educators, especially for those who have practiced in a traditional lecture based
environment. The new learning and teaching model, such as PODBL, expects educators to act as facilitators of student learning in a design engineering curriculum. Figure 6.4 shows the workload of staff and students engaged in a PODBL process from week 1 to week 12.

![Figure 6.4: Workload of students and staff](image)

Figure 6.4 shows the workload (number of hours) for students slowly rising at a range of 0 to 10 from week 1 to week 6 and stabilizing at a level of 10 from week 6 to 12. The workload for staff is at a level of 8 (range), stabilizes until week 4 and slowly dropping from range 8 to 1 between week 4 and week 6. It then continued to be at a constant value of 1 until the end of week 12. The workload graph clearly explains the PODBL model is student directed learning where staff acts as facilitators. The students gradually engaged through active learning and teaching with the help of a staff member. Staff have a responsibility to assist students to gain the knowledge and skills to become effective learners.

6.2.3.5 Design project/problem for students

The third year unit, Electronics systems and signals is fundamentally aligned to learn many applications in signal processing and control. The students studying this unit need to apply fundamental theoretical ideas in the area of electronic signals and systems to enhance learning outcomes. The unit aims to produce students to understand the basic terminology and properties of electronic signals and systems. The aim of the design project given to students is to design a spectrum analyser. The design problem is “A sound engineer needs to mix a multi track recording session with a range of instruments”. In order to distinguish the range of each recorded instrument the engineer utilizes a spectral analyser; the spectral analyser in this case utilises 16 bands and provides the signal power in each band and the frequency range of each instrument.
6.2.3.6 Student response to PODBL implementation

Project Oriented Design Based Learning (PODBL) is a teaching and learning approach (TLA) that is based on engineering design activities undertaken during a project. PODBL encourages students’ independent learning and facilitates a deep approach to learning. It is also an approach that supports the development of information literacy and design thinking in the field of tertiary education. The cohort of students involved and who experienced the new learning and teaching model expressed their views about Project Oriented Design Based Learning (PODBL) below.

Student A: “Learning through application in the project has helped me learn the principles.”
Student B: “I enjoy the self-directed learning approach.”
Student C: “I would like every subject to run this way.”
Student D: “The practical approach through projects is good and would like to see it applied from first year.”
Student E: “I can see the relation between theory and application.”

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, thus increasing 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 initial experiment of PODBL implementation in a common first year unit of the electrical and electronics engineering program shows a cohort of student and staff involvement. It encourages others to practice the new learning and teaching model that influences, motivates and inspires students and staff to achieve a balanced learning and teaching process through PODBL.

6.3 PODBL Framework Guidelines for Students

Engineering education faces several challenges, such as improving teaching methods to enhance learning to assist students to acquire and apply their professional skills, propose methods to assess and evaluate teaching effectiveness with modifications if needed. On the other hand, industry began to complain about the inadequacy of career expected skills such as critical analysis, creative thinking, communication, team work and problem solving in engineering graduates [137].
Figure 6.5 shows the PODBL framework guidelines for students. In PODBL, students learn engineering design using projects through self-directed learning and learning by doing. Learning begins with first year design training projects (1-4 weeks in each trimester), which educates students about engineering principles, fundamentals and the learning design process. Staff act as facilitators, which builds student capabilities to identify problems and solve the problem through analytical thinking. Second year design engineering projects (1-6 weeks) are more challenging, where students need to interact with their environment to observe real world problems and the needs of society. Students have to realize that actual design problem exists in every aspect of their daily life. Advanced design projects in the third year of engineering help students to work on projects across multi-discipline boundaries to acquire interdisciplinary knowledge, communication, and teamwork skills.

![Figure 6.5: PODBL framework guidelines for students](image)

### 6.3.1 Students’ Role in PODBL

All engineering curriculum has the responsibility of educating students in their engineering disciplines. Students have responsibility for the quality of learning and teaching. In each learning process, a student learns at their own pace and in their own learning style to achieve educational objectives. Through a chosen learning career path, students obtain a great opportunity to gain self-
knowledge that helps them attain their full potential. The role of students in the Project Oriented Design Based Learning approach is as follows:

1. Ability to observe and react in a professional environment (self-directed).
2. Identify and solve problems with interactive knowledge.
3. Getting involved with the practical application of knowledge.
4. Being creative and innovative in solving design problems.
5. Be aware of industry graduate expectations and be career focused.
6. Seek support and guidance from staff members.
7. Contribute engineering knowledge to the needs of society.
8. Adapt to new values, customs, and learning styles in a working environment.

Ongoing personal and professional development helps students sustain life-long learning skills such as critical thinking, self-directed learning, interpersonal skills, self-confidence, creativity and innovation.

### 6.3.2 Learning through Projects in PODBL

Students are required to conduct research, demonstrate critical thinking and document sound analysis and judgement to support project decision-making. Students define and scope their project, apply technical knowledge, assess safety and risks, prepare a feasible plan and schedule the implementation of the project in the project implementation phase. Students are required to work and learn autonomously, prepare and adhere to work and reporting schedules, communicate progress, and prepare reports and presentations. Projects provide useful evidence for prospective employers regarding competence in areas of mutual interest. The PODBL process consists of the following projects in undergraduate engineering:

- a) Design training projects – 1\textsuperscript{st} year
- b) Design engineering projects – 2\textsuperscript{nd} year
- c) Advanced design projects – 3\textsuperscript{rd} year
- d) Professional engineering projects – final year

Learning through projects has a positive effect on student content knowledge and the development of skills such as collaboration, critical thinking, and problem solving which increases motivation and engagement. It is challenging for teachers finding it difficult to implement the system, to integrate technology into projects in meaningful ways. When we look at the method of learning
through projects, it benefits all stakeholders, such as students, industry, community, and the university involved. It provides a framework for embedding experiential and rich learning activities integrated with discipline based curriculum that improves employment and career outcomes. The benefits of Project Oriented Design Based Learning includes enhancing students' participation in the learning process (active learning and self-learning), enhancing communication skills, addressing a wider set of learning styles, and promotion of critical and proactive thinking.

6.3.3 Graduate Ready Skills – Contemporary Need

Industry is looking for graduates who are ready to practice and perform essential competencies such as practical knowledge, problem solving, teamwork, and innovative and creative designing of real-world projects [60]. 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, academics 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 are related to it. From industry’s point of view, the following key skills are essential elements required for a successful Project Oriented Design Based Learning curriculum. These include creative & innovative skills, successful industry engagement, and awareness of design skills in the early years of engineering. A summary of findings from a qualitative analysis of an industry-academia design discussion forum shows a need for action on the following skills:

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

By engaging industry with the academy, students will acquire global perspectives 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 a project approach. Thus, universities should open their doors and accept the challenges of involving students with industry experiences and expectations.

6.4 PODBL Framework Guidelines for Staff

Staff teaching an engineering curriculum have the responsibility to ensure students acquire clear, accurate and timely information concerning relevant program structure, practice, teaching quality and learning outcomes. It is always a challenging task for staff to change their pedagogy practice to a new learning and teaching model. In PODBL, staff practice engineering design in different ways and can easily adapt to it. The readiness of staff for PODBL is shown in Figure 6.6.

![Figure 6.6: Staff - PODBL framework guidelines](image)

This shows overall framework guidelines for staff to practice a PODBL approach in engineering education curriculum. With initial interest, and existing experience in learning and teaching, staff are encouraged to implement and practice PODBL in their respective program units called “Curriculum alignment”.

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6.4.1 The Role of Staff in PODBL

Excellent learning and student engagement is a positive experience and also a result from quality teaching. Over many decades, researchers believe students will engage more deeply and learn more thoroughly when their teachers care about them to educate, learn, communicate and be innovative in the classroom. Academics need the perspectives of students to analyse their experience in practicing and learning a particular approach. It also helps teachers to understand the level of expectation of students in their area of expertise. A teacher must ensure that course design, program structure, teaching and learning assessment should help learners to learn. The role of staff in PODBL is as follows:

a) Developing and presenting consistent and creative resources for student learning.
b) Implementing Project Oriented Design Based Learning approach to learning and teaching engineering course units.
c) Communicating with students to meet their objectives and expectations for self-directed learning.
d) Enhancing learning outcomes and teaching methods by actively engaging students.
e) Inspiring and motivating students through project driven design based learning.

6.4.2 Professional Development

In academia, students and staff are supposed to work together in order to achieve a balanced learning and teaching process. By using different teaching and learning approaches, teachers are aware of escalating the student knowledge to fulfill current technology needs. In many cases, academic staff are responsible for setting high expectations in their classrooms. Sometimes staff are expected to teach subjects outside their expertise and in some cases, academic staff may experience a lack of confidence in their ability to teach such subjects yet are unwilling to seek professional development [78]. These professional development opportunities provide staff with valuable opportunities to enhance their personal teaching qualities, which helps them to achieve and follow a successful learning and teaching process.

At Deakin University, staff are encouraged to practice teaching and learning approaches that influence, motivate and inspire students to learn. Deakin Learning Futures provides a range of opportunities, events and services for staff to enhance their capability to be effective educators. In
order to enhance and continue the engagement of students in learning and create active learners in the classroom, teachers need to teach each other through professional development workshops [79].

Peer review of teaching is a well-established practice in many academic environments. In Australian universities, the aim of peer review teaching is to enhance learning and teaching. In peer reviewed teaching, staff members obtain an opportunity to share their professional responsibilities that enhance learning and teaching approaches. The benefits of peer reviewed teaching for individual staff members are shown below:

a) Improving professional relationships with colleagues.
b) Developing teaching practices from peer feedback.
c) Sharing broader knowledge of curriculum and implementing new teaching ideas.
d) Enhancing student assessment and learning outcomes.

6.4.3 Leadership for Learning and Teaching

Teachers have various levels of curriculum leadership qualities. A number of values and personalities make certain individuals ideal for leading teachers. An active teacher is an open minded and respectful person who obtains optimistic relationship with peers, students and parents. Teachers are always practicing how to improve their teaching techniques. Persuasiveness, open-mindedness, flexibility, confidence and expertise are fundamental attributes of a good teacher. However, working with other staff members is different from working with students. The ability to collaborate with others is an outstanding quality of leadership. To undertake a leadership role, people need to be an expert in curriculum planning, peer mentoring, assessment design and data analysis. The teacher leadership qualities are as follows:

a) Passionate about learning and teaching.
b) Initiating a peer-mentoring program – personal and professional development.
c) Researching alternative classroom assessment methods and presenting these to management.
d) Lead an initiative to formulate new learning and teaching methods for students.
e) Developing procedures for staff to enhance their teaching abilities in the classroom.
f) Encouraging best practices for student assessment and support ongoing changes to assessment practices.
g) Developing various approaches to enhance the relationship between staff and students.
h) Creating pathways to industry collaboration and encouraging peers to support industry projects.

6.4.4 Course Enhancement

Course enhancement is a systematic approach taken with all courses undergoing the process of creating course learning outcomes and standards. The course learning outcomes describe graduates’ knowledge and capabilities they should acquire and be able to apply, and demonstrate at the completion of their course. Course learning outcomes and standards are derived and instructed by the relevant professional bodies. For example, the Australian Qualifications Framework (AQF) is the national policy for all regulated qualifications in Australian education and training. It provides all the standards for all Australian qualifications. In the higher education sector, the Tertiary Education Quality Standards Agency (TEQSA) provides national consistency in the regulation of higher education.

At Deakin University, students undertake common subjects in their first year and then choose a discipline to specialise in. This includes civil, electrical and electronics, mechanical or mechatronics engineering. This format allows students to make a more informed decision and to gain a broader base of knowledge in engineering. These undergraduate engineering courses are designed to meet the requirements of Engineers Australia.

6.5 PODBL Framework Guidelines for Industry

The real value of industry collaboration is to create benefits for society. Universities focus on educating students as professionals while industry concentrates on giving opportunities to students to experience real world problems in a competitive environment. The core interest is different for both industry and universities. Academics pursue the practice of teaching theory to practice through research projects in an engineering curriculum. Industry expects graduates with career readiness skills such as problem solving, analytical thinking, and designing to work on real world projects.

Industry expects creative and innovative academic practice that gives students valuable practical knowledge. The university-learning environment in engineering is not enough for students to become an engineer. The practical role of engineering is needed through working on real world problems in an industry environment. Industry-university collaboration seems to be actively increasing in the development of engineering education in various parts of the globe. The close
relationship between industry and university is a vital component of engineering pedagogy in Australia. Figure 6.7 shows the PODBL framework guidelines for industry.

![PODBL framework guidelines for industry](image)

**Figure 6.7: PODBL framework guidelines for industry**

### 6.5.1 Industry Role in PODBL

Industrial companies are working together with educational institutions to renew and redirect engineering education [76]. To increase the productivity and to meet the competitiveness in the global market, industry needs effective management practices, skills and capabilities of a skilled workforce. More productive firms require more highly skilled people from the top level to the bottom level. Due to the high demand of more advanced projects from clients, industry conducts skills assessment, workforce development plans and formal training to upgrade employees’ knowledge and vision. They found this to be a continuous process in order to survive vast manufacturing targets. Therefore, industry decided to take part in collaborative arrangements with universities. The role of industry in Project Oriented Design Based Learning is as follows:

a) Develop a global partnership for engineering and technology development.
b) Work towards a long commitment with universities.
c) Develop relationships with national/international engineering networks.
d) Obtain realistic expectations of student projects.
e) Provide training programs for students.
f) Provide sponsorship to attract high quality graduates.

6.5.2 Collaboration with University

The collaboration of industry with university aims to approach practical knowledge applied with scientific knowledge created by academics to create innovative outcomes. It is necessary to establish a knowledge flow between industry and university that enhances collaborative knowledge on both sides. Table 6.3 summarises the following key points for academics collaborating with industry and industry that seeks to collaborate with university staff members.

Table 6.3: Motivations for collaboration

<table>
<thead>
<tr>
<th>Motivations for collaboration</th>
<th>Academics views</th>
<th>Industry views</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>To achieve knowledge development about practical problems useful for curriculum enhancement.</td>
<td>To develop new product and processes.</td>
</tr>
<tr>
<td>2)</td>
<td>To create internships and job placement opportunities for students.</td>
<td>To improve product quality by enhancing research and development progress.</td>
</tr>
<tr>
<td>3)</td>
<td>To obtain insights in the area of staff members own research.</td>
<td>To maintain an ongoing relationship with the university.</td>
</tr>
<tr>
<td>4)</td>
<td>To examine the practical application of current research for future needs.</td>
<td>To conduct blue-sky research and to recruit graduates.</td>
</tr>
<tr>
<td>5)</td>
<td>To share government funding on small and big research projects.</td>
<td>To conduct fundamental research with open research ideas.</td>
</tr>
</tbody>
</table>

Academia is a provider of graduates to industry. Universities have always enhanced partnership regulations to work with industry. This research analysed the views of staff and industry representatives to propose an industry and academia-training agenda, which is shown below in Figure 6.8. The agenda includes industry partners acting as mentors for academic staff members to clarify what industry problems exist and what is needed to resolve these issues. Projects can be developed to resolve these issues will occur through industry advisory group meetings, industry based workshops, design discussion forums and identity focus groups.
6.5.3 Social Need and Engagement

Industry is looking for graduates who are ready to practice and perform 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 mostly from the learning and teaching style they have been exposed to. Thus, academics must focus on teaching engineering science rather than engineering and should undergo practice rather than theory in the classroom. By engaging industry with the academy, students will acquire global perspective about the core attributes expected in future engineering jobs. In today’s large-scale industrial market, companies tend to prefer graduates with design skills attained through the project approach. Thus, universities should open their doors and accept the challenges of interacting with students with industrial experiences and expectations.

6.6 PODBL Framework Guidelines for Academic Leadership

A sound pedagogy is a strong foundation for effective teaching practice. This helps to design course structure, articulate learning outcomes, develop course activities, enhance student interaction with staff, and modify teaching methods. The academic leadership is responsible for managing and implementing sound pedagogy for effective learning and teaching. A curriculum design with appropriate infrastructure will always recognize and encourage students to learn and utilize practical knowledge in engineering and technology.
The responsibility of an academic leadership is to reconstruct traditional ways of teaching to today’s new educational environment. Academic leadership needs to understand the importance of connection between staff, students and industry. Figure 6.9 shows framework guidelines for academic leadership in PODBL. It briefly describes the role of faculty towards staff members, students and industry. This PODBL is more aligned with faculty expectations to overcome the challenges in teaching that enhances student-learning outcomes towards the future needs of society.

6.6.1 Academic Leadership in Relation to Staff

Staff have a responsibility to students to gain the knowledge and skills to become effective learners. Staff have to ensure students maintain professional and ethical behavior required by the profession and society. It is a vital role for staff members to guide and assist students to meet basic engineering criteria in order to meet future career expectations and industry requirements. A staff member must adhere to the following statement of professional responsibilities:

a) Demonstrate the highest standards of professional behavior and be courteous when interacting with students.
b) Devise and document teaching and learning programs, policies and programs toward student needs.

c) Undertake appropriate ongoing professional development to promote competence in curriculum development, delivery and evaluation.

d) Collaborate with industry by involving industry in academic teaching and use industry mentors for student projects.

e) Develop joint learning spaces for students, staff and industry.

f) Provide staff placements in the industry environment.

6.6.2 Academic Leadership in Relation to Students

Academic leadership and student relations are essential to develop a student's academic self-confidence and enhance their learning outcomes in the curriculum. It creates an encouraging professional and friendly environment for both students and staff members to be active. Academic leadership is always taking an interest in the academic progress of students who make significant contributions to academic professional development. When students are well known and friendly with any one of their faculty members, they feel successful and inspired in their education. Most interactions between faculty and students is in the classroom environment where informal interactions outside the classroom tend to be more motivated, engaged and actively involved in the learning process. The influences of faculty relations with students are:

a) Enhancing their academic self-confidence and engagement.

b) Improving skills such as communication in a group, confidence in competing with others, problem solving and analytical thinking.

c) Enriching intellectual and personal development in a learning environment.

d) Bridging the gap in the relationship between faculty and students.

e) Developing academic motivations, career guidance, self-approachability and connectedness.

6.6.3 Academic Leadership in Relation to Industry

Industry and university partnerships aim to approach practical knowledge applied with scientific knowledge created by academics, which leads to an innovative outcome. The academic advisory boards (IAB) at Deakin University in the School of Engineering always help to ensure academic responsibility towards the changing needs of industry. Academic advisory boards meet university staff members to review the curriculum, discuss industry trends and opportunities for collaboration.
Industry liaison management identifies industry and government partners who can participate in research projects utilising the tools and other research outcomes from university. Industry liaison management (ILM) demonstrates the following activities:

a) ILM meets regularly and organizes workshops, engineering exhibitions, and special discussion forums that bring together research teams and industry partners to explore collaborative projects.
b) Encouragement and active support for the inventions of academic staff.
c) Managing intellectual property (IP) issues, patent rights in industry and university research projects.
d) Contributing to society through promoting knowledge transferred to technically innovative products.

6.7 PODBL Framework Guidelines for Accreditation bodies

Accreditation is a periodic assessment of an education program for any discipline against the accreditation standards. Appropriately trained and independent practicing engineers from both industry and academia will be peer reviewers for a professional accreditation panel. Graduate attributes are the required benchmarks for students to attain their specific qualities and abilities within a higher education institute. The Australian higher education institutions identify a list of expected graduate attributes or outcomes that are incorporated into their educational programs to be accredited by Engineers Australia.

Engineers Australia is a professional accreditation body for graduate and higher education programs in engineering. When students graduate from an accredited engineering program, they are required to be assessed by the relevant professional accrediting body to become a qualified engineering graduate. There are many research studies that justify the benefits of design based learning (DBL) in engineering education. By looking at the world accreditation bodies’ focus on design based learning as an approach for learning and teaching, this research identifies the need to enhance important skills such as innovation and creativity through a holistic learning process that incorporates design based learning features [96-98]. From the in-depth analysis of all program educational objectives, student outcomes, assessment methods and evaluation of different undergraduate engineering programs at Deakin University, it is clear that engineering design can be learned and taught through the Project Oriented Design Based Learning approach in a convalescent
way, which is aligned with accreditation requirements. The PODBL framework guidelines for accreditation bodies are as follows:

a) Develop a requirement that academics should have appropriate industry experience.
b) Provide flexible requirements for industry engagement.
c) Have a diverse accreditation panel in regards to age, culture and discipline.
d) Consideration of government incentives.
e) Establishing national resource centres to support industry engagement with universities.

At Deakin University, students undertake common subjects in their first year and then choose a discipline to specialise in. This includes civil, electrical and electronics, mechanical or mechatronics and robotic engineering. This format allows students to make a more informed decision and gain a broad base of knowledge in engineering. These undergraduate engineering courses are designed to meet the requirements of Engineers Australia (EA). This research looks into the program educational objectives, student outcomes, assessment methods and evaluation of different undergraduate engineering programs at Deakin University. It shows how engineering design is practiced and incorporated as an important element of graduate attributes through Project Oriented Design Based Learning curriculum aligned with professional accreditation requirements.

### 6.8 Conclusion

The Project Oriented Design Based Learning (PODBL) approach is encouraging because it allows current students, staff, and industry perceptions to remodel pedagogy without distracting from the curriculum. It is inspiring for students and staff members to understand the approach and to implement it in all engineering design courses and programs. The PODBL framework guidelines for students, staff, industry and faculties are a pathway that leads to a sustainable design practicing education. On the basis of previous recommendations by industry and academics, as well as national and international research, it is very important and critical that we identify a framework that is unique to engineering education based on a Project Oriented Design Based Learning (PODBL) model. This design-focused approach is proven to make engineering more attractive to students. When it comes to excellence in engineering education, Academic leadership has the opportunity to enhance student learning outcomes, teaching methods and educational development using the Project Oriented Design Based Learning (PODBL) model.
Chapter 7

Conclusions & Future Work

7.1 Introduction

Engineering explores theory, science, scientific methods and calculations about creativity and innovation expressed through technology. The relationship between engineering and technology is the ability to observe. The aim of this research is to develop a framework for a new learning and teaching model for engineering at Deakin University known as Project Oriented Design Based Learning (PODBL). In the process of developing a framework, this research focused on collecting and analyzing the perspectives of students, staff members and Industry about a design based learning approach to explore teaching expectations and learning outcomes they experienced.

Project Oriented Design Based Learning in engineering education is an overarching learning principle proposed in this research project and is set to satisfy many requirements of the revised accreditation criteria in Australia and around the world, as well as the industrial needs for the next generation of engineering graduates. This chapter presents the final discussion on the major research findings, along with some assumptions used throughout this research. The chapter concludes with ideas for future work ideas that may expand the current research findings.

7.2 Major Findings

The objectives of this research together with the corresponding findings are listed below.

- Framework of Project Oriented Design Based Learning (PODBL):

Chapter 6 presented the framework for PODBL model. It explored a framework for learning and teaching to solve design problems through Project Oriented Design Based Learning in engineering education. The specific intention of this research was to obtain an approach, a method or framework
that balances the learning and teaching relationship by integrating creativity, innovation and communication skills in Project Oriented Design Based Learning in the curriculum for engineering. PODBL curriculum leads to the education and preparation of students to be problem solvers. For quality learning and teaching, a curriculum needs the participation of students and staff, industry collaboration, management support and social involvement. This PODBL framework was developed with diverse views from students and staff plus industry expectations and social needs about engineering design. The PODBL learning principles were developed to provide a structure for the learning and teaching process.

• PODBL framework guidelines for students:

The guidelines for the Project Oriented Design Based Learning framework aims to improve teaching methods to enhance learning, help students to acquire and apply their professional skills, and propose methods to assess and evaluate teaching effectiveness with possible modifications. It helps to fulfill industry expectations about graduate ready skills such as critical analysis, creative thinking, communication, teamwork and problem solving. Through guidelines for the PODBL framework, students obtain an opportunity to gain self-knowledge that helps them attain professional skills and qualities as an engineering graduate. It is an interesting and challenging task for the teaching process and teachers find it difficult to implement the system and integrate engineering and technology into projects in meaningful ways. PODBL looks at the method of learning through projects as a benefit for all stakeholders such as students, Industry, community and university. The overall benefits of PODBL is to enhance students’ participation in the learning process, enhance communication skills, address a wider set of learning styles and promote critical and proactive thinking.

• PODBL framework guidelines for staff:

PODBL is a challenging task for staff to practice and change existing pedagogy. It encourages staff to practice teaching and learning approaches that influence, motivate and inspire students to learn. The guidelines for the PODBL framework assist staff members to ensure the course design, program structure, teaching and learning assessment will help students to learn. By practicing framework guidelines, staff and students are supposed to work together in order to achieve a balanced learning and teaching process. Academia believes that quality assurance in teaching and learning is a shared responsibility of teaching staff and academic managers. Both teaching staff and academic managers are responsible for ensuring program development, management, teaching and
assessment enhances student engagement in the learning process. Through outstanding curriculum practice, Deakin engineering aims to ensure the continuing high quality of programs and their objectives. A sound pedagogy can review and evaluate learning and teaching processes, support individual staff development, and improve performance and opportunities for innovation in teaching. PODBL provides a structured guideline for staff to facilitate and enhance learning and teaching performance. It also provides services and infrastructure to enrich and support the learning outcomes of students.

• PODBL framework guidelines for Industry:
The PODBL framework guidelines for industry create opportunities for students to experience real world problems in a competitive environment. The framework was approached from the perspectives of students and staff and the focus broadened to include industry views. The university focuses on educating students as professionals while industry concentrates on providing opportunities for students to experience real world problems in a competitive environment. Industry always expects graduates with career ready skills such as problem solving, analytical thinking, and the ability to work on real world projects. Industry also expects creative and innovative academia practice that gives students valuable practical knowledge. PODBL framework guidelines help industrial companies and educational institutions to work together to renew and redirect learning and teaching approaches towards work integrated learning.

• PODBL framework guidelines for academic leadership:
PODBL has developed a culture of learning and teaching in new ways. It has changed the relationship between learner and teacher and has also had an impact at the organisational (academic leadership) level. PODBL creates an encouraging professional and friendly environment for both students and staff members to be active. To achieve sustainability in engineering education, many educational institutions constantly face challenges. When adopting a new learning and teaching model, an institution needs to change or update their curriculum policies. The implementation and transition of this new learning and teaching model is possible after a brief discussion among the staff and faculty. The PODBL framework guidelines help the faculty adopt the benefits and importance of sustainable engineering education in order to make changes to existing institution policies.
7.3 Assumptions

On the basis of previous recommendations by industry and academics, in addition to national and international research, it is not only important but also critical that we identify a framework that is unique to engineering education based on a Project Oriented Design Based Learning model. By looking at the world accreditation bodies’ focus on design based learning as an approach for learning and teaching, this research identifies the need to enhance important skills such as innovation and creativity through a holistic learning process that incorporates design based learning features. From the in-depth analysis of the objectives from all educational programs, student outcomes, assessment methods and evaluation of different undergraduate engineering programs at Deakin University, it is clear that engineering design can be learned and taught through a Project Oriented Design Based Learning approach in a convalescent way that is aligned with accreditation requirements.

The goal of the design approach was not to change the whole curriculum of engineering design education but for students and staff to develop the ability to enhance and transform ideas through new learning and teaching model. To ensure the continuing high quality of engineering programs, it is important to:

- Review and evaluate teaching and learning processes and outcomes.
- Review and monitor the academic management of courses, including teaching and performance.
- Support individual staff development, performance and opportunities for innovation in teaching.
- Provide services to enrich and support students learning.
- Provide industry collaboration opportunities for students future careers.

7.4 Future Work

Project Oriented Design Based Learning (PODBL) 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. It is a challenging task for academic staff to implement a PODBL approach and integrate technology into projects in meaningful ways. Studying engineering involves not only learning scientific knowledge and technological skills, it also involves learning the
language, established practices, beliefs, and professional values of the engineering culture that makes a student an engineer. Future work using the PODBL approach involves the implementation of PODBL in the School of Engineering at Deakin University. It covers the actual delivery of the learning and teaching process in every engineering unit through PODBL. Prior consideration of PODBL implementation will inform a number of practical issues related to learning and teaching methods. The effectiveness of teaching was evaluated through peer observation of teaching, learner feedback questionnaires, informal feedback, and achievement of student learning outcomes. The feedback from the learners and teachers was collected and analyzed to evaluate the efficiency of the new pedagogy.

Engineering education and technology occurs at the Centre for Advanced Design in Engineering Training (CADET) proposed at the Waurn Ponds campus of Deakin University. CADET is 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 University’s engineering degree programs. CADET will emphasise design based learning within group projects, virtual modelling and prototyping. These skills are at the heart of 21st Century engineering challenges and will serve as a magnet for engineering and related professions. This design focused approach has proven to make engineering more attractive to students, especially young women who must be better served in technical education.

The objectives of the CADET are to:

- Increase the awareness and attractiveness of engineering as an education and career option, particularly for women, and for those in regional schools;
- Under the one roof provide state-of-the-art engineering design, modelling and prototyping facilities, and project based studios;
- 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.

The CADET is capable of resolving these challenges. Underpinning CADET is the recognition that engineering in Australia 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 plays 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 traditionally have not had access to such opportunities due to geographical and educational limitations in access and education. A facility like CADET will require alignment between the physical infrastructure along with the learning and teaching mode of delivery. The educational framework that supports CADET is a Project Oriented Design Based Learning (PODBL) philosophy as described briefly in Chapter 6.
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Appendix A

Students Perspectives (Research Data)

B.1 Students Perspectives - Deakin University

B.1.1 Engineering means

Participant 1 – “Practical applications of knowledge”.
Participant 2 – “Applications and study of practical sciences”.
Participant 3 – “Practical application of science”.
Participant 4 – “Designing and constructing”.
Participant 5 – “The creation of ways to face practical problems”.
Participant 6 – “create the things which existed or naturally happened in this world”.
Participant 7 – “Building, constructing and creating things”.
Participant 8 – “the ability to create new things which didn’t previously exist to provide value”.
Participant 9 – “Building, designing, improving things”.
Participant 10 – “Problem solver”
Participant 11 – “Engineering is a field that helps make the world easier, cleaner and more efficient”
Participant 12 – “the application of science and knowledge to solve problems”.
Participant 13 – “problem solving, Innovation”.
Participant 14 – “Engineering is solving design problems”.
Participant 15 – “building or designing new things”.
Participant 16 – “a way of creating something that does not naturally occur”.
Participant 17 – “study/work in design/calculation of physical world”.
Participant 18 – “designing and developing to better the world”.
Participant 19 – “the practical application of knowledge to solve a problem”.
Participant 20 – “the practical application of science and technology”.
Participant 21 – “finding a solution to a problem’.
Participant 22 – “design/build based on standard + technology”.
Participant 23 – “figuring out how to solve real world problems and to turn designs in to reality”.
Participant 24 – “creating a new product/solution from new materials”.
Participant 25 – “it is a field that designs and shapes the new future”.
Participant 26 – “the study of environment and science to overcome problems”.
Participant 27 – “means of solving problems to enhance and produce necessary living materials”.
Participant 28 – “using the environment or man-made objects to benefit the society”.

B.1.2 Design Based Learning (DBL) means

Participant 1 – “Practical learning to enhance theory”.
Participant 2 – “Applying a practical approach to the theory”.
Participant 3 – “Relating theory with practical”.
Participant 4 – “Learning by being given problems to create a design solution for”.
Participant 5 – “design knowledge of theory”.
Participant 6 – “learning through creation, incorporates both creative and analytical methods”.
Participant 7 – “it makes learning with enough knowledge to make your work better”.
Participant 8 – “studying in a special designed environment”.
Participant 9 – “learning by designing stuff”.
Participant 10 – “learning which is tailored by design”.
Participant 11 – “doing design work throughout the course (projects)”.
Participant 12 – “learning through doing design projects”.
Participant 13 – “design and learn, learning based on design”.
Participant 14 – “entering an industry of engineering revolving around design’.
Participant 15 – “learning according to a design process”.
Participant 16 – “a method of working on problems, designing before doing”.
Participant 17 – “learning programs manufactured around design”.
Participant 18 – “I haven’t heard the term before”.
Participant 19 – “using real life examples to learn”.
Participant 20 – “developing practical solutions to local and global problems, problem solving”.
Participant 21 – “analysis and design of systems and structures”.
Participant 22 – “learning how to design as you are designing’.
Participant 23 – “learning through doing”.

Appendix A
Appendix A

Participant 24 – “learning based on design eg: structured, planned”.
Participant 25 – “designing something to do a task as a learning exercise”.
Participant 26 – “learning based on design”.
Participant 27 – “you design what you are learning or physically shown what is being taught”.

B.1.3 School of Engineering include “Design based Learning”

Participant 1 – “Setting up more practical application to theory taught”.
Participant 2 – “create a mechanical part confirming to certain parameters”.
Participant 3 – “need more practical instead of exams”.
Participant 4 – “It allows information to be communicated a lot easier”.
Participant 5 – “having units through DBL”.
Participant 6 – “more hands on or demonstration work and design assignments”.
Participant 7 – “design curriculum helps students to get most out of it”.
Participant 8 – “designing circuits in practical’s before making them in 1st year”.
Participant 9 – “more practical’s”.
Participant 10 – “learning by doing something”.
Participant 11 – “learn more generally/conceptually on design”.
Participant 12 – “apply DBL to different units”.
Participant 13 – “more project based work for real world applications”.
Participant 14 – “small projects that are relevant to industry”.
Participant 15 – “Practical hands on labs that include using PCB circuits”.
Participant 16 – “have frequent practical’s which deal more in depth with a topic”.

B.1.4 Advantages of Design Based Learning (Team)

Participant 1 – “Improve communication skills”.
Participant 2 – “leadership skills, team building skills”.
Participant 3 – “Probably closer to real industry work, Bigger projects are possible”.
Participant 4 – “focus and help each other, more interesting”.
Participant 5 – “more help, more ideas, better learning”.
Participant 6 – “Teamwork skills, different inputs”.
Participant 7 – “combined knowledge”.
Participant 8 – “less workload per person learn teamwork”.
Participant 9 – “help each other out”.

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Participant 10 – “can work problems out together, more ideas”.
Participant 11 – “represents the workplace environment and develops teamwork skills”.
Participant 12 – “communication and organization skills’.
Participant 13 – “sharing of ideas and concepts”.
Participant 14 – “group knowledge, easier sometimes, more resources”.
Participant 15 – “promotes teamwork, prepares for outside world”.
Participant 16 – “thinking together working with people experiences”.
Participant 17 – “shared load, more ideas, shared cost’.
Participant 18 – “collaboration, delegation like in industry”.
Participant 19 – “less workload, better work produced, more ideas”.
Participant 20 – “can learn from each other, more exciting”.

B.1.5 Disadvantages of Design Based Learning (Team)

Participant 1 – “Can be bad in team members’ performance”.
Participant 2 – “not every team member got the same work load”.
Participant 3 – “sometimes hard to communicate, work may not split fairly, team members can be unreliable”.
Participant 4 – “agreements and disagreements, bad communication”.
Participant 5 – “someone could be lazy relying on other people”.
Participant 6 – “might not work well together”.
Participant 7 – “lazy people don’t help someone ends up doing everything”.
Participant 8 – “members get lazy”.
Participant 9 – “have to consult everything’.
Participant 10 –“easier not to be involved”.
Participant 11 – “Engineering is mostly a group effort”.
Participant 12 – “sharing ideas can’t keep originality of work’.
Participant 13 – “members of group might do less work”.
Participant 14 – “relying on others”.
Participant 15 – “some people are very hard to work”.
Participant 16 – “conflicts of personality, unequal effort”.
Participant 17 – “people may not do the work, lack of communication, heavily rely on others”.
B.1.6 Advantages of Design Based Learning (Individual)

Participant 1 – “Self-reliant”.
Participant 2 – “self-motivation”.
Participant 3 – “time management”.
Participant 4 – “more time to manage yourself working”.
Participant 5 – “It’s only your fault if it doesn’t get done”.
Participant 6 – “DBL can help individual without relying on others”.
Participant 7 – “No need to rely on others, change ideas whenever you like”.
Participant 8 – “Builds engineering knowledge”.
Participant 9 – “initiating to work”.
Participant 10 – “originality of work”.
Participant 11 – “take your own direction”.
Participant 12 – “learn more, more personal opinions”.
Participant 13 – “let you fully construct your own ideas”.
Participant 14 – “explore own interest, range of activities”.
Participant 15 – “self-motivated, can’t be let down by team members”.
Participant 16 – “in control of every aspect, can gather info quicker”.
Participant 17 – “won’t get distracted”.

B.1.7 Disadvantages of Design Based Learning (Individual)

Participant 1 – “Doesn’t promote communication skills”.
Participant 2 – “motivation can be hard to achieve with other components”.
Participant 3 – “less help, more work”.
Participant 4 – “lots to do, takes a long time”.
Participant 5 – “could be confusing”.
Participant 6 – “more work, no one to help you”.
Participant 7 – “lot of pressure if you struggle”.
Participant 8 – “harder to do more work”.
Participant 9 – “can’t get many ideas usually, limited thinking”.
Participant 10 – “more work load, less ideas”.
Participant 11 – “less learning opportunities from others”.

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B.2 Students Perspectives (Senior Year) - Deakin University

B.2.1 Engineering means

Participant 1 – “design and understanding of materials, to improve on objects”.
Participant 2 – “application of applying knowledge to real world problems”.
Participant 3 – “problem solving and creating solutions”.
Participant 4 – “creating something as a solution to a problem”.
Participant 5 – “improving technology and concepts and making them useful in everyday life”.
Participant 6 – “creating and solving real world applications”.
Participant 7 – “A practical application of science”.
Participant 8 – “creating and designing to solve problems”.
Participant 9 – “improve, design and build practical application of science”.
Participant 10 – “Engineering is the practical application of science and technology”.
Participant 11 – “problem solving”.
Participant 12 – “the study of maths and science to build useful things for humans’.
Participant 13 – “Engineers create and design the world”.
Participant 14 – “building something by human’.
Participant 15 – “design + innovation of items + things used in society”.
Participant 16 – “creating and solving issues”.
Participant 17 – “the use of science and technology to create innovative designs”.
Participant 18 – “practical application of science and technology to improve or create new technology”.
Participant 19 – “using science and technology to solve problems”.
Participant 20 – “it is the creative application of scientific principle to design or develop structure”.
Participant 21 – “modelling the physical world”.

B.2.2 Design Based Learning (DBL) means

Participant 1 – “learning by hands on experience”.
Participant 2 – “the application of scientific and mathematical principles to practical use”.
Participant 3 – “learning through practical means”.
Participant 4 – “applying knowledge in an exciting way”.
Participant 5 – “hands on learning”.
Participant 6 – “creating what did not previously exists”.

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Participant 7 – “learning based on practical and design work”.
Participant 8 – “designing your own projects and solution with guidance”.
Participant 9 – “involving practical learning”.
Participant 10 – “hands on learning”.
Participant 11 – “large design projects with not enough teaching”.
Participant 12 – “learning material through the design of a project”.
Participant 13 – “study centred on design”.
Participant 14 – “some skill that required for design’.
Participant 15 – “learning in a more practical way, by doing things”.
Participant 16 – “teaching through doing”.
Participant 17 – “more practical applications rather than everything being theoretical”.
Participant 18 – “design problems instead of engineering problems”.
Participant 19 – “long, difficult assignments that usually involve unreasonable designs”.
Participant 20 – “learning by doing”.
Participant 21 – “better learning”.

B.2.3 School of Engineering include “Design based Learning”

Participant 1 – “have more real world practical’s”.
Participant 2 – “more units with DBL”.
Participant 3 – “project based learning”.
Participant 4 – “more worked examples”.
Participant 5 – “labs and practical”.
Participant 6 – “integrate it with accompanying step by step teaching”.
Participant 7 – “projects and teach some design techniques”.
Participant 8 – “more hands on work”.
Participant 9 – “doing more practical activities”.
Participant 10 – “more practical’s less theory”.
Participant 11 – “design practical classes”.
Participant 12 – “part of tutorials and may be included in lectures as example questions”.

B.2.4 Advantages of Design Based Learning (Team)

Participant 1 – “real world practice, real team based”.
Participant 2 – “can have teams but mark individually”.

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Participant 3 – “exposed more ideas, weak areas strengthened by other team members”.
Participant 4 – “through individual units”.
Participant 5 – “guidance, group thought”.
Participant 6 – “collaboration, group learning”.
Participant 7 – “shared ideas, shared work”.
Participant 8 – “collaborative knowledge, many hands”.
Participant 9 – “team skills, people management”
Participant 10 – “larger project, more fun prepared for future team work”.
Participant 11 – “work together, build teamwork”.
Participant 12 – “shared knowledge, good team experience”.
Participant 13 – “can just slack off and let team do all the work”.
Participant 14 – “difference of views portrayed, learning between groups”.

**B.2.5 Disadvantages of Design Based Learning (Team)**

Participant 1 – “not everyone contributing”.
Participant 2 – “hard to make decisions”.
Participant 3 – “lecture behind, sometimes harder to group”.
Participant 4 – “slack students, lack of consistency”.
Participant 5 – “hard to organize, more time wasted”.
Participant 6 – “you could just watch everyone do all the work”.
Participant 7 – “arguments, laziness of other team members”.
Participant 8 – “independent learning is not applicable”.
Participant 9 – “might have a slack team and need to do all work”.
Participant 10 – “different opinions”.

**B.2.6 Advantages of Design Based Learning (Individual)**

Participant 1 – “all work is your own and based on how you achieve”.
Participant 2 – “less frustrations, can’t hide behind others”.
Participant 3 – “self-paced, own mark, own idea”.
Participant 4 – “learning own way”.
Participant 5 – “more time to work, requires more knowledge”.
Participant 6 – “full project control consistency”.
Participant 7 – “learn and challenge yourself”.

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Participant 8 – “good alone experience, being active, no arguments”.
Participant 9 – “independent learning”.
Participant 10 – “fair, each students is assessed on own work”.
Participant 11 – “broken down problems, figure out yourself”.

B.2.7 Disadvantages of Design Based Learning (Individual)

Participant 1 – “sometimes overwhelming with no support given”.
Participant 2 – “limit to knowledge”.
Participant 3 – “more work”.
Participant 4 – “lack of other opinions, requires lots of time”.
Participant 5 – “can get stuck and frustrated + ideas of everyone are not brainstormed”.
Participant 6 – “no second opinions, no group experience”.
Participant 7 – “sometimes increased workload”.
Participant 8 – “may not understand yourself”.

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Appendix B

Staff Perspectives (Research Data)

B.1 Staff Perspectives - Deakin University

B.1.1 Design Based Learning (DBL) means

Participant 1 – “DBL is an active learning process where student given a design problem they need to solve which they have to come up with ideas or workout what they need to find out to actually able to solve it. Apply design processing in doing it to find out the solution”.

Participant 2 – “DBL is something appropriate for engineering course, or engineering course focusing on some aspects of design or industrial design where the classroom tasks is centred around the designing something a product and the background knowledge required to pick up the whole things on”.

Participant 3 – “DBL is a process of allowing a student by trying to design an artifact to learn some outcome that is desired”.

Participant 4 – “It is a part of learning and teaching process. It introduces a problem to design to get a solution for an end user and as well as the environment. DBL is to emphasize engineering principles through design”.

Participant 5 – “It is the learning process that happens through the process of designing something or working thru a project. Taking an idea something engineered and well defined. Teaching students the fact that an engineering product is well defined, well thought and processed thru many steps of refinement to get a stage for specific purpose”.

Participant 6 – “DBL is using design principles whether that’s 7 steps or 8, 9 steps design process to facilitate student learning via the conduction of the project (research or design projector project around learning itself)”. 
Participant 7 – “You learn something thru designing certain elements. You try to design distribution system network, so you learn what are the process involved, components involved thru designing a real system”.

Participant 8 – “Everything in engineering is DBL. Every learning exercise is design based or development based”.

Participant 9 – “DBL is about where students taken a project or task to be active in their learning by finding a solution for a problem. Where the solution is known or not known but it is about going thru a process of design to have a tangible outcome”.

Participant 10 – “It’s a project based and a design based learning process”.

Participant 11 – “Design is a conventional term; it is most practical approach to handle the particular problem to understand various aspects”.

**B.1.2 Engineering Design means**

Participant 1 – “Engineering design is going through a design process to come up with a concept, going through a design process to get a design or prototype that may not necessary as a product, a coming with an idea, verifying, testing to improve it according to the specifications”.

Participant 2 – “Making things or designing products”.

Participant 3 – “ED means the design of any piece of technology, which uses the principles discovered inside. To create and implement something that is useful to the benefits of the society”.

Participant 4 – “It is a design satisfies an end user, which is economical and environmentally sustainable and delivers the outcomes”.

Participant 5 – “Is using a design tool to engineer a creative solution. ED shouldn’t nearly be use codes and standards but should include elements of creativity and also include aspects of entrepreneurship to a certain extend of global consideration. Needs to be much more centred in engineering, which includes it in engineering principles as an aspect of design”.

Participant 6 – “Engineering Design is actually, when you develop a structure. You have to learn about the function of each component. When you construct the component, we have to follow all standards, specifications, and criteria. That all should incorporate in Engineering Design”.

Participant 7 – “ED is creating solutions for the problems in an engineering context. It is a really structured approach to problem solving. It is overcoming the tech problem with a tech solution”.

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B.1.3 Aspects of Engineering Design Taught

Participant 1 – “Yes, Engineers spend lot more time in designing not necessarily products but designing process or anything else to understand a process to get a solution”.

Participant 2 – “Yes, in 3rd year Mechanical engineering unit, certain amount of design based on that. Mainly selective materials required to the design requirements of the design components making. Apart from exam, major assessment task is design a product, students present a basic design and go thru a series of steps what type of material is appropriate for that component designing in manufacturing”.

Participant 3 – “Yes they are, I actually teach the design process that involves 7 steps in it for creating a design as well as the application of design to various projects”.

Participant 4 – “Yes it is, all of my units have several aspects of engineering design. From the concept development to process design as well as the optimization part of it”.

Participant 5 – “Yes many of them. 1st year engineering unit dealing with engineering graphics and design. Engineering graphics is a communication language for students to design. It’s a tool used by students to communicate a design process (blue print, product views). 4th year unit advanced design methodologies, we are talking about design for X is design for excellence, assembly, disassembly, environment, manufacturing, recycling, and safety. When you design something, you are thinking of everything before getting a product. Failure mode analysis subject – design, plan and predict the causes of failures before the getting product. 4th year unit Actual development product process student generate a concept (design process) to satisfy the customer needs as end product”.

Participant 6 – “Yes, engineering design communication in year1 that included engineers without borders project. Further fundamental analysis includes design centred approach to deliver the material. In Capstone design projects (it’s up to the students to do the design work in a final year project)”.

Participant 7 – “Yes, in 4th year unit, engineering design tool where student learn about designing a drinking water treatment plant. Where the water is coming from, how you transmit, process the water pollutants and various things are included in it. Various design parameter are involved. Students have to incorporate all criteria requirement before doing the design. From 2nd year we teach structural design, concrete design, geotechnical design and water design. So we cover all aspects of design from 2nd year to final year”.

Participant 8 – “Yes definitely, I really talk to students what the problem is? I try to teach open-ended problems to solve with very much engineering focus. I try to open up the problem so they can do it. Obviously in my subjects, the focuses are much defined. Yea aspects are definitely included”.
B.1.4 Engineering Design as an Essential Element

Participant 1 – “Yes it is. Students to do it themselves, important part is to reflect it on how they did, looking back at what went right or wrong and do it again. Tell students how do to it”.
Participant 2 – “That what an engineer does, they find problems and they make design to solve the problems. Solving problems for designing something”.
Participant 3 – “Most definitely, all of engineering is about design. Engineering is about problem solving of problems, ideas, thoughts that people have that cannot currently do. Engineers need to come up with a solution by using principles of science”.
Participant 4 – “Yes it is, Engineering is design. So design engineering has to be embedded in every aspects of learning elements of every engineering program. Engineers are designers, designers of diff aspects of components, which are utilized by community”.
Participant 5 – “It’s a broad subject. It is a product that you can touch it, tangible. Website is not an engineering design product. For engineers’ things like touchable, engineered, discrete is a product. The process of making this product is engineering design”.
Participant 6 – “I don’t see it for all programs but I see it differentiate for certain programs. It depends on the contacts, university, and program. It’s situational deepened as the amount design is incorporated”.
Participant 7 – “Definitely, because the students learning theory in several units. They have put this knowledge to design and practice thru hands on projects”.
Participant 8 – “We need to teach creativity to students to overcome the problems, because in real world you are not going to get the answers from textbook. In real world, they have to think about creativity, sustainability and resource management. So engineering design is 100% essential”.

B.1.5 Possible Ways to Teach Design

Participant 1 – “Possibly, one main assignment in 3rd year. Based around designing a material and processing manufacturing to get a final outcome. There are possible different numbers of ways to approach it; there is element of design in it. We got mini version of that in 2nd year but much sort of small case study type, design excises”.
Participant 2 – “3rd year subject that requires students to have a design of something. I like them to reuse a design from earlier subject if they wish. They do a design project 20%. The emphasis of the project not design but the emphasis how they a take the design and select the material for the design. I more interested what are the steps they taken from the design”.

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Participant 3 – “Best way of teaching design is get someone to do a design. I do DBL quite a lot in my teaching. A person can be taught theory how to do a design but unless when they try to apply knowledge. Until they do it, they don’t learn it”.

Participant 4 – “The possible way to teach design is to embed the concept of design and Problem solving aspect of it and problem identification aspect of it. Also to give students opportunities to evaluate diff options and justify selection rather than defining outcome is. It could be open-ended design with various solutions”.

Participant 5 – “Try to mix on/off campus students working together, they can learn how to communicate, learn how to deal with products, post components between each other, time constraints. This is something will happen in industry environment. Some they share the task with off campus and on campus”.

Participant 6 – “Design has really difficult to teach. In engineering terms, we do design template that got number of steps that student understand design process. Unfortunately the way engineers think is different from designers think. In 1st year, case study based material (design with bad design)”.

Participant 7 – “By conduct design classes, teaching already covering theory thru units, another unit is to teach design. During design make students to apply all their acquired knowledge and help them with additional information. From 2nd year, we take them to real sites, construction sites, and road cons sites. So they can learn practical aspects and actual design. We bring the industry people to teach or train the students about the industry environment problems. Take them to labs for practical experience.

Participant 8 – “Teaching design is thru open problems not structured problems like point A to point B. within the concept of subject, you have to find the mechanism. I really want them to find the solution for the problem (end result). Heaps of ways to teach but it really depend on individual academics. Demonstrations, hands on learning are another ways. I focus on 3rd and 4th year subjects. Probably lowest 30% of the cohort is struggling when they approach final year”.

B.1.6 Curriculum Involve Design Based Learning

Participant 1 – “Yes, the idea is they are able to look at the problem in new approach, which they might not do before. They need to know exactly what knowledge they need to know. But they need to know how to do that through a process or they should know where to get the tech knowledge to do the process to get a solution. Evaluating it whether it is the right option and prove it”.
Participant 2 – “Main skill in 3\textsuperscript{rd} year unit, not teaching the design itself but teaching the student from the design how to have a systemic approach to selecting the materials and the means of manufacturing component. It will give them some systematic skills in intelligent way of selecting material and the manufacturing process for the design”.

Participant 3 – “Yes it does. Our degrees design stream running thru them. In mechatronic, few units involve designing in some sort of artifacts. 1\textsuperscript{st} year principles, 2\textsuperscript{nd} year small projects, 3\textsuperscript{rd} year projects whole semester, they apply knowledge thru designing in the fourth year capstone project”.

Participant 4 – “Probably yes, it depends on how you define design learning through projects. Design doesn’t have to be project based, But different elements of project requires design approaches. The project is not only the design but also the implementation and delivery part of itself. Design is part of project but project can’t be a part of design”.

\begin{enumerate}
\item a) Yes it does, 1\textsuperscript{st} year course with design project. Student work in collaboration.
\item b) Yea, the units mentioned above. I teach the design through projects.
\item c) Yea I changed my both units to DBL approach next year. I got really large project 60%. I really push this design thru projects. We are motivated to the soft learning research based design approach.
\end{enumerate}

\textbf{B.1.7 Skills Attained by Students through DBL}

Participant 1 – “Creativity, that the idea, I guess that sort of way we came up in the 3rd year unit (mini final year projects). Teaching them through projects that Student what they need to do”.

Participant 2 – “In my units, DBL allows students able to apply knowledge to design and find solution for problems. They actually learn how to design, put it together, how it goes wrong and how to debug it or troubleshooting skills. By giving them a project, take from a problem through design to the solution”.

Participant 3 – “Students have to teach the students how to evaluate a design in different aspects (community)”.

Participant 4 – “Through Design, Project management skills, evaluation skills, understanding various standards, communication skills”.

Participant 5 – “Through design process (iterative process), hands on practice (assemble, disassemble), using catalogue (design), concept generation, they find out the design flow using CAD”. Learning design through small projects based on design they assemble and disassemble.

Participant 6 – “Problem solving, troubleshooting, reverse engineering, learning by doing, able to apply their acquired skills”.

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Participant 7 – “Problem solving, process ranking, alternate ranking, design ranking, value engineering, creativity, sustainability in design”.

Participant 8 – “Able to see overall problem with entire spectrum, management skill, analyzing skill, problem solving, teamwork, communication skills. Creativity is important, you can create a solution for any problem outside the box with some constraints”.

Participant 9 – “Creativity, engineering and creativity are going hand in hand. Engineers are professional problem solvers. Engineering is a creative industry. Collaboration skills, individual assignments with individual assessment. Analytical knowledge, time consuming, individual creativity”

**B.1.8 Engineering Design Projects helps to Collaborate with Industry**

Participant 1 – “We talk to them about what kind of requirements help from the universities in the form of small projects to students as a part of their study. Lot of we like to collaborate with industry for new research, projects. They want problem solving for technical knowledge, what people done before some solutions quite suited to engineering students to learn”.

Participant 2 – “An industry employer wants engineers who can design things. They want Students spent time in universities in designing things and they want them to employ”.

Participant 3 – “By doing a design project, we can get from industry in final year. Industry can give new problems to academic students to design solution and give them back to industry. Students can see what types of design projects are available in industry. It leads the students to Creativity; it depends on open-ended design projects according to the requirements (cost restrictions, size, and weight). They can come up with different solution”.

Participant 4 – “I am not sure about engineering design projects will help do that. If you take an industry problem come with a solution that does not add value for an industry. So there are two ways that you come up with a design and try to engage it with industry or you take an industry problem and come up with an alternative solution. Identify and try to improve the current design projects for industry and academic”.

Participant 5 – “Feel like working in industry. Students finish the project with all constraints. Practicing through projects like in industry environment. I want to go the industry and to look at some crucial problems. Give to students and we will get 50 different solutions and in team work 10 different solutions. They have to understand every constraint while designing a product. When I am thinking about creativity, I want to limit to a framework, constraints and answer the question. They can come up with new ways of product solution”.

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Participant 6 – “Industry needs help from university to solve complex problems. Complex problems can be breaking in to smaller design projects”.

Participant 7 – “Engineering projects, in final year. Students do an engineering project unit. They can go to industry and discuss with them about the problem. They can formulate the problem and solve it. So they get the experience with the industry. The academic will talk to an industry about a problem (project) and try to give to teamwork for students without any payments but practical experience”.

Participant 8 – “Get the students exposure to the real world, get them to work on industry problems, it’s limitless. Industry people to come in to university. To show the students how they do it. 1st and 2nd year expose them to industry ideas”.

B.2 Staff Perspectives – Australasian University A

B.2.1 Design Based Learning means

Participant 1 – “DBL means getting students to learn design process, design concepts, concepts of design, design process in to the learning process. There are 2 processes, 1 is learning process and 2 is concept of design and design process. Match the 2 together”.

Participant 2 – “Students learn through a given design, they do their own research. DBL should be in high level of degree course. My field is microelectronics, I teach microcontroller. I am talking about microcontroller design projects for 3rd year student basically they should know analog and digital electronics knowledge before they come to the course. During this time I teach them the computer language used for microcontroller plus microcontroller basics. It’s better to have this knowledge before they use DBL, PBL approaches. They should use all prior knowledge to put them in design (e.g.: designing a product in industry)”.

Participant 3 – “DBL is looking at the design that provided and analyzing in a quantitative sense. So that you can understand the design factors that go into the design and it’s not in this context, it would be an abstract. It would be a tangible design looking at, tangible object”.

Participant 4 – “For example, Fire engineering would be deterministic analysis then designing from there. So I guess DBL is more relevant here by taking the criteria to design a room and model the room and set fire to the room to see what going to happen. Structured engineering in 1st year, geotech 1st year, fire engineering in final year’.
Participant 5 – “It’s a new term to me DBL. DBL is that you use design as a basis for the students learning. They are learning thru a design process. So their learning comes out of that. It would be similar to project based learning”.

Participant 6 – “DBL is a concept of teaching the curriculum content. Design in the way of teaching fluid dynamics, both in traditional and project-based learning (PBL). PBL that requires a set of attributes set of learning objectives to be obtained. A number of objectives which is teamwork, defining the problem, working in a remote situation how you interact, how you seek a solution not in a traditional way. DBL is a combination of those elements that we design and incorporate in a program. In a project having student activities to enforce them to gather those skills and attributes”.

Participant 7 – “Give students the complexity. There is a different aspect. It gives students appreciation of the complexity of engineering practice. Integrating their interdisciplinary knowledge to address particular problems & issues in a project. It’s absolute learning to be an engineer and it also about really understanding technical side of engineering. The difference between design based engineering from others courses are presented in the context of discipline knowledge. With design is more an open-ended problems encountering the real world problems not in the textbook”.

Participant 8 – “DBL is PBL & Pjbl (together), good engineering education is always based on problem based and project based nothing innovative here engineering is practical, program, it is always problem based, project (industry practice)”.

Participant 9 – “DBL – I teach no. of courses practically based. Control systems analysis and design – tech analysis, project management. It’s about designing the question. DBL- it is more to do trying to teach aspects but also communication representation as well”.

Participant 10 – “From my background of architecture studies, as an architect. DBL, students’ needs to have a project defined, a structure that required. Students need to undertake a design of the spaces, to get that spaces they have to work actual structure type, define everything. By doing actual design studies which my group and I did in late 80’s. We learned practical knowledge a lot. Through design process with a hands on product. Design based is actually designing”.

B.2.2 Engineering Design means

Participant 1 – “Engineering design is going from the problem statement through to a solution that the stakeholders need or a client need”.

Participant 2 – “Engineering design is always not investigations. Putting existing thing in a non-existing way to create a new thing. It’s not inventing new thing, creating a thing from an existing projects to fulfill the requirements. To improve a design to get a new solution”.

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Participant 3 – “Engineering design in general sense, it is a quantitative analysis of a structure that going to fit for intended purpose and stand with the anticipated loads within an acceptable analysis criteria”.

Participant 4 – “Engineering design is a process of being able to identify the real problem. A client will come to me with an ill-defined problem, they had symptoms and I had to try and find out what was the real problem that needed to be solved in order to get rid of the symptoms. So to identify what the real problem and looking at wide range of ways to solve the problem, coming up with range of potential solutions, comparing with the original problem and find the best solution for that particular situation and then redesign it with the clients expectations, coming up with final design and details. At the end, the final product will be in the form of report, drawing for an engineering design, physical model or computer model. To me that’s design process”.

Participant 5 – “Yes, most definitely. Because I think that the basis of it any engineering really designing a product or an artifact using a design process. It may be problem or basic process that you are using that will help you to practice as an engineer. I really became very aware of how really specific this design process is or how it is central in engineering”.

Participant 6– “Engineering design, engineering has lot of complex issues like learning fundamental theorem, fundamental principles to the application using it and also in professional manner, also in the journey of learning. Therefore that engineering has different way of teaching, one way is that design based, project based, problem based. So we believe that Engineering. Design is important allowing students to learn engineering professionally with communication, global interaction and far being competing beyond the way (be innovative). Engineering design can address the elements of engineering as a part of the teaching and learning”.

Participant 7 – “Engineering design – as an engineer you are expected to identify a problem or an issue that poorly design. With engineering design process is defining the problem etc. it’s about pulling together research and investigation. Design got both aspects – pre technical stuff that you defined and followed up with technical solution”.

Participant 8 – “Engineering design is not only tech skills, it includes communication, standards, multiple design, drawings, tech theory behind it. Sustainability in design, efficiency in design, maintenance”.

Participant 9 – “Engineering design hands on stuff, an engineer is someone with whom you collaborate at earliest possible stage of project. Design project, I expect that engineer should have good design knowledge. My idea of engineering design is to be collaborating with client to fulfill their needs”.

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B.2.3 Aspects of Engineering Design Taught

Participant 1 – “Yes, I teach a course called engineering design. So I go through all the stages of the design process with my students. There are 2 courses, we go through design process and we integrate management process. Engineering design and management planning – conceptual design & project management, engineering design and management orientation – detailed design projects (modeling of design) & implementation of project (hands on project) and Capstone projects – synthesizing the courses in 1st and 2nd year rather than in final year of the program. So students got introduce to design process in 1st year and 2nd year and they learn professional skills, approach to solving problems. The concept is to teach professional& overview type courses in 1st and 2nd year and more tech content is delivered in 3rd & final year”.

Participant 2 – “Yes, exactly. Our engineers are working in a field facing so many new problems. Design course gives them background knowledge and basic understanding of how to tackle the problem, how to get knowledge from outside”

Participant 3 – “Yes, the concepts are generally quite far into people when they start, I think a lot of worked examples, and visuals- so the visual learners can learn thru visualize. I guess this should be available more for 1st and 2nd year students later on their learning ability will increase more self-regulating and reflective learning”.

Participant 4 – “Yes sure, I taught engineering design as a subject to 2nd and 3rd year student. I taught that as design process like component design, system design, in both associate degree and bachelors program. Currently the course, which is engineering plant, and equipment that uses engineering design as a basis for teaching. I end up putting minor or major project in it. Even our 1st year students within project based learning course, which is 50% of their time in each term. Those design projects are designing a concrete brick. They also do industry projects, which are got often design-based projects”.

Participant 5 – “Yes, there are like. I am teaching four courses. One of them is dedicated project based and others are traditional but with the combination of projects, activities. So there are aspects of design in any unit, which got group presentations, interaction. It delivered mixed and combined to address particular set of objective that students have to achieve as a learning outcome. In PBL, students have to define a problem as well as finding the problem. The solution is not the scale, the method and approach is important. Design subjects are in 3rd & 4th year. Design is with PBL, problem based”.

Participant 6 – “Yes, it’s really important. It’s a challenge that how you understand the problem. The design work is more of designing the elements of the structure”
a) Yes, I teach all on design, 3 design subjects
   - Engineering drafting 1st year
   - Machine component design 2nd 3rd
   - Design of a new machine final year completely as design.
   - Bulk materials handling
b) Yes, fundamentally engineering design is central of engineering.
c) Yes, they introduce in structural calculations. The actual design is definitely introduced.

B.2.4 Engineering Design as an Essential Element

Participant 1 – “Yes, design focus is a good way; students see design focus and apply it to their own problems (any assignments, small design projects). Projects to teach design, individual assignments, group work (50/50), little bit individual work, group work (more multidisciplinary), individual work is discipline specific projects. Assessment – 100% portfolio (journal, workbook, framework document for engineering drawings, student to write a reflective paper on a topic in engineering and management)”.

Participant 2 – “Yes, for e.g. in embedded microcontroller course. In the first 5 weeks students are given small tasks to get familiarize with the processor and they can handle the small assignments. Each functionality of the microcontroller project is practiced through these assignments. They do it in tutorial classes. For off-campus providing video classes through black board systems, Skype, video interactions). We send them individual kits so they practice at home. By week 5 they are fully equipped with the knowledge to complete the project. It’s an open-ended project. The university designed kits given to students by the lecturers, technicians. Example, small design project such as solar tracking system, Go Kart cars (intelligent algorithms designed by students)”.

Participant 3 – “It’s challenging task. Lots of scale and skills required for academics to teach it. In terms of content develop, facilitating, problem defining. It’s through workshop, lab component, no exams, writing reflective journals with feedbacks, projects (address) with fundamental application etc. It’s a Combination of projects, group discussion and lab, journal portfolio or teaching 50% PBL and 50% traditional. The difficulty is if the academics are not trained well”.

Participant 4 – “Yes, with a no of elements. In a design course, design 1 and design 2 in 2nd year but we don’t have lot of technical stuff able to do some application. But in design process, design 1 focusing on looking at the needs of the project. Design 2 is about developing a technical solution for a problem. There are aspects to document their analyzing of design. This type of design skills also
integrated in to the courses. Students sort do their design work in teams, they have to investigate all aspects of design”

Participant 5 – “Yes, if you want to be an engineer, you must know engineering design. If you can’t read, the design or drawing of a machine or if you can’t interpret it, take parts out of the drawing assembly and make a detailed drawing. You are not an engineer”.

Participant 6 – “Yes, efficiency using standards. Design a particular circuit with a particular standard. Engineering is global. Continuously, tech skills come from 1st year physics, you teach fundamental. 2nd year materials course – students using multiple materials”.

Participant 7 – “Yes, it is. Whatever aspect of engineering you are doing. Whatever the focus of engineering design I believe is important”.

**B.2.5 Possible Ways to Teach Design**

Participant 1 – “We don’t explicitly use the Term design based learning. I think it’s there. When I give assignment, tasks to my students. I ask them to use a problem solving approach, design approach to solve the problem”.

Participant 2 – “It’s a Good practice in 3rd year to design project operational plus they have to produce the user manuals, service manuals and operational manuals for every product. It’s like a finish product from company”.

Participant 3 – “I used range of ways to teach design in many years. When I was started to teach as an academic, I was very traditional. Then I got design textbook followed chapter by chapter. Then I got project-based approach, which was giving the design problem of the project. This is open ended, ill defined, all the info missing problem. The student got the context in a way that they learn. That’s how I preferred to teach design”.

Participant 4 – “The challenge is that to balance the design with the tech side and theory side. Teaching design fundamental, analytical (industrial design), real world experience (problem), practical (industry design process)”.

Participant 5 – “I developed my own methodology; design that is systematic design technique which teaches through design process”.

Participant 6 – “Practical way (open ended problems), basic understanding, standards knowledge, logical thinking, good design and bad design, guest lectures (practitioners), best practice”.

Participant 7 – “The idea is to have hypothetically real project, purpose a design structural solution, structural design real projects”.

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**B.2.6 Curriculum Involve Design Based Learning**

Participant 1 – “Lot of professional skills, communications within the teams and inter teams, group work, 1 team must interact with other team. They extend their skills which they already learn them in 1st year make sure they reinforce in 2nd year. In 3rd and 4th they should remember and use it. Technical skills, creativity, open ended ideas, analytical, best design (least worse)”. 

Participant 2 – “Some of it does, particularly when we involved in the building design courses obviously. Where they are designing engineering necessarily town planning (I guess the fundamentals are still same)”. 

Participant 3 – “Co-op degree, 2 years in university and they go out to industry 6-8 months paid work. Industry placement is part of the program. They are work place skills, practitioners as engineering, practice design”. 

Participant 4 – “Yes, through projects open ended problems, students define through the whole design process”. 

Participant 5 – “Yes, in year 1 engineering skills 1 & 2. In Year 2, design 1 & 2. Its team based, problem based learning. There are small design projects. They have number of project where they have to do design (industrial design) other engineering design. Design process through projects (team work, problem solving). Client need – fund required – design stage – review – final solution”. 

Participant 6 – “Yes, all about projects, assignments”. 

Participant 7 – “Yes, final year project as a classic example. Practitioner’s off-campus experience. Co-op students got real life experience. 2, 6 months placement give them real work experience. We have laboratories. (Open-ended, recipe type), assignments got design question’. 

Participant 8 – “Yes, for several subjects in building environment programs have small projects. It’s not all about design but level 1, 2, 3 in 1st and 2nd year. There should be actual design and fewer calculations”.

**B.2.7 Skills Attained by Students through DBL**

Participant 1 – “In 1st year Skill 1, skill 2 subject, in 2nd year engineering design & management planning, design & management implementation. We don’t teach students how to use the S/W. It’s their individual learning to practice. They swap the designs between groups to review others design. Team based, individual learning exists using project based learning with problems”.
Participant 2 – “The students learning should be more creative, Analytical skill, exposing design to meet the client outcomes, cost of a project, communication. It should equip students to be able to function in a work environment just simply learning”.

Participant 3 – “Communication, teamwork, problem solving, analytical”.

Participant 4 – “Team work, communication, professional achievement, analytical, real world experience. Technical level – practicing (deep understanding), teamwork, communication, investigation – analytical, revising, learning about work engineering office and environment”.

Participant 5 – “For design – the students can work as a draft person. They can interpret any assembly drawing
- Assembly product, machine
- Machine component design analysis
- They learn designing new machine”

Participant 6 – “Creativity, analytical, communication skills, technical communication, language communication, tech writing, graphical writing, designing skills, logical thinking, criticism (design)”.

Participant 7 – “They learn how to address the needs of the client, certain degree of programs, they learn how to design, understand the structures, design based means understand design problems, interact with engineers”.

B.2.8 Engineering Design Projects helps to Collaborate with Industry

Participant 1 – “I don’t do directly with industry, but I do have some Guest lectures from industry. Helps the students to know theoretical in to practical. It is setup and organized by the university for longtime”.

Participant 2 – “Many ways to get industry to involve with university. Search for industry, people, for guest lectures. In capstone project, student design something. We invite the industry engineers to comment on their design, get the parameters for projects from industry for simulations. Outstanding project – advise them to industry”.

Participant 3 – “We should be equipping graduates to be industry ready or work ready. The industry needs to have some input what we are actually teaching. So that we provide what industry needs. That means the collaboration with the industry allows 2 things they are it allows us to structure our content to be more practical for industry and it also allows the students to integrate, expose them to
industry thru more supported environment. They should get experience about how industry works, it really practical pragmatic way of teaching”.

Participant 4 – “It gives 1st year students working in industry, add value to them and to industry. Small projects from industry given to students. Real world projects working for real client. Students are not constrained. Industry can gain a lot. Motivating for students to work on real problems”.

Participant 5 – “It is relevant to the DBL or PBL approaches. Industry needs true professional engineer which engineer can communicate, articulate, is innovative. Projects design is highly appreciated by the industry people. Students in 2nd year & 4th year they got o the industry, they spend 6 months industrial employment (co-op programs) fully paid employment. It’s come through proper interview, we have industry sponsors. They get real exposure of industry, process, design, power industry and overseas too”.

Participant 6 – “In 2nd year – student go for placement, which helps them to get work environment knowledge. In 1st year skill 2 (try to get projects from industry) more likely industrial design exercise, projects. Many students do their co-op placements – understand about engineering work. In final year projects, they ended up with a design projects (work place based). They do investigation of traffic analysis (project). Workplace provides the context, procedure, methods, industry based design”.

Participant 7 – “Only one of the major capabilities of engineer. I have at least dozen of companies got conduct with me. For project, small problems. Australasian university is a heavy industrial hub”.

Participant 8 – “1st year courses – engineering skill courses. We actually link with industry, so students get industry projects. Then different times, students have to design. Practical problem. Capstone project which got guest lectures, final year – industry based projects. Industry help us to help students to know real world problems”.

Participant 9 – “Main advantage with engineering design is having done actual projects, getting practical experience, more interactive with any collaboration with industry, it will give them an experiential base that of design and the implications. Design experiencing in work placements, more effective, collaboration is so important”.
B.3 Staff Perspectives – Australasian University B

B.3.1 Design Based Learning means

Participant 1 – “Main advantage with engineering design is having done actual projects, getting practical experience, more interactive with any collaboration with industry, it will give them an experiential base that of design and the implications. Design experiencing in work placements, more effective, collaboration is so important”.

Participant 2 – “DBL from industrial designer, I heard about PBL, Pjbl and Studio based learning. Design led learning; DBL is basically everything you learn as design that you have a problem, well-defined problem that is a part of a project. Project is part of studio and design is work in the studio. DBL is like studio-based learning. Creating a mindset about design, it’s about the project”.

B.3.2 Engineering Design means

Participant 1 – “Engineering design means creative process of developing engineering systems rather than product. Design process is creating an artefact. Creating something doesn’t exist before. Ed is particular discipline of engineering using design as scientific base to support that creative activity. We can create solution. We need the science technology to make more efficient, more effective. To improve overall performance of the systems. You need to apply engineering science knowledge to improve your original design solution”.

Participant 2 – “Engineering design is an activity use to plan a project or a product, service which we preferred. Creativity is the heart of it. Inventing the future. Engineering is about tech used for creating a design, it’s about creation. Engineering is about making a thing real with physical functional outcome. Designers are almost engineers. Design thru DBL. Designers need to understand the paradigm of engineers and engineers need to understand the paradigm of designers”.

B.3.3 Aspects of Engineering Design Taught

Participant 1 – “Yes, that’s my particular focus for last 25 years. There is referring to design science in addition to engineering science subjects. Engineering design is to bring tech into a solution and for me cross over to other discipline. Engineering design from year 1 to final year in UK. When program bachelor of science migrated to bachelor of engineering, it required an element of engineering design as a core unit. Now engineering design is taught in every engineering programs in UK”.

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Participant 2 – “Yes, we teach engineering but there is no calculation, with same principles. We are teaching basic about design in engineering”.

B.3.4 Engineering Design as an Essential Element

Participant 1 – “Yes, the key thing is an engineering program have been developed. Students need to experience design; majority of the engineers working in industry will be part of some product development. The historic knowledge based on engineering. Engineering design is cross cutting activity; it’s a critical thing. It has its specific design process, tools and tech are used in it. Teach design also in management point of view, managing process. Teaching Engineering design, we need teach structure the process in a systematic way and the other aspect is designing the engineering system as a product”.

Participant 2 – “Yes, I would argue. Design thinking for management students. Teach design to engineering, they will be good designer and creative. This skill is transferrable. Collaboration, creative thinking, problem thinking, project thinking. Design will make engineers better engineers. Everything is a project”.

B.3.5 Possible Ways to Teach Design

Participant 1 – “Give students an experience on Design, give them opportunities to create a design, guide them to create it thru design process. Students need to lead in design approach for whole problem solving. They become master of design by practice, practice. Use design process for every problems, thru projects and design projects. Through design planning stage by experience”.

Participant 2 – “For example, iPhone is come out of design and engineering. Learning design is from experience, need to design projects, engineering design projects design a mechanism, design can be defined, doing real world problems, hands on design by practicing, teach design by teaching and taking students in to it, by case studies, by models. Thru projects, collaborating people, by group work and short exercises, teach creativity”.

B.3.6 Curriculum Involve Design Based Learning

Participant 1 – “Yes, it is. Most projects would initially with particular learning approach such as DBL. Industry defined projects to give a real life experience, highly constrained challenges. Real significant demands on students to get on it (through projects). The project became as a vehicle in

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the whole discipline. One project one application, team based project. Integration comes from the student, so they have to get everything all together. Whole vehicle integration”.

Participant 2 – “Yes, it does we are design school around projects work out problems, design socially driven engineering”.

**B.3.7 Skills Attained by Students through DBL**

Participant 1 – “Learning objectives for whole program – Total Design – Engineering design textbook. Independent learners, PBL created confidence in independent learning, develop their knowledge and skills independently. Create potential design, recreate engineering products, and compose systems, management skills, personality characteristics, experiential knowledge, social knowledge, transfer knowledge, demonstrate creativity, creating solutions to design problems, attitudes and values, be self-critical, respect the engineers team activity, Multidisciplinary, analytical, communication, problem solving, reflective learning review our approach, time management and professional responsibility, organized technical, gather information and logical thinking, interactive discussions”.

Participant 2 – “Collaborate, team based, transferrable skill, project management, creativity, integrate design, be critical, be creative, be adoptable, get empathy, you need challenge, understand context, research, observe and communication, analytical”.

**B.3.8 Engineering Design Projects helps to Collaborate with Industry**

Participant 1 – “Industry work on projects, they often need design improvements, agenda, see how we approach it. Smaller companies need help to design this products, assembly type materials. Curiosity driven investigations, university got knowledge that help you the industry, people industry are limited by the context that the way they work. Different ways of looking at the problem. So we would do studio-based study in year 2, group assignments, use project weeks, no lectures. One week one project. Similarly 3 year program individual projects, industrial visit. We are project led, got industrial placement. We are doing relevant projects to industry. Company recognizes graduates easily for the value of money they spent on projects”.

Participant 2 – “Companies integrating design with engineering together. Industry work on projects, it become as an interface between the student and industry. Student get diff perspectives, they get real world experience, really useful for them for future career. Gives meaning, gives credibility, and
Appendix B

gives reality to the students. To know what the real needs are there. It can be really positive. They have certain expectations from students. Support education”.

B.4 Staff Perspectives – Asian University A

B.4.1 Design Based Learning means

Participant 1 – “Firstly design is a broad term. Different persons will give you diff answers depends upon their area of expertise. To most of people design is something nice. We for focusing on engineering design”.

Participant 2 – “It’s an active learning that the students will go thru and KOLB learning style model where the student will observe and reflect, DBL means let us student apply what they learn in class right in to a design project. DBL in Asian university, 1D deign – design spent what u learn in class from day 1, 2D - we try to integrate design from2 disciplines, 2D multidisciplinary, 3D is capstone project and 4D Big D. Fresh more curriculum pedagogy”.

Participant 3 – “Big D the other science of design. Basically looks at design methodology approach, learning problems. Whole design process. Its hands on approach thru projects. Capstone project, which is multidisciplinary team, based where the problem is given by industry”.

Participant 4 – “DBL is learning together with doing. Learning from books you have to do hands on activity. Asian university is promoting this. Real world problems are included in this class ODE then implement lot of models”.

Participant 5 – “DBL is similar to PBL, in this case the problem is a design task. So you need to design something which kind of open ended problems that scaffolds the learning around that”.

Participant 6 – “DBL design is prompt discipline. Design as a Big D. this could be product design, architecture design, we want student to know not only creating an idea but also how to work it on as a product, service or system. Design with creativity, innovation and entrepreneurship. DBL is going thru full value change in different stages. Students to use knowledge hands together. We call active learning, product based learning”.

B.4.2 Engineering Design means

Participant 1 – “Engineering design is basically solving a problem; whatever the problem is that bring something to talk about called innovation and creativity. Difference between innovation and creativity. Creativity means basically create something you produce, generate and assemble
something you never seen before. I have a piece of paper and started drawing something in it is
creativity. This is creating something what is the use of this. Nothing that is creativity. Innovation –
creating a new solution for the same problem. It is not innovation is whatever I do that produce
tangible result for the people use”. “Innovation = idea to invoice is collecting money. No buy no
value so if there is value for it, which is innovation. Geff Nicolson said that before. R&D is putting
money and creates idea, I & Enterprise taking the idea in to more money”.
Participant 2 – “Engineering design is basically Design using the technology because everything is
engineering and Analyzing a particular product is also engineering in banking, social media is
engineering too”.
Participant 3 – “Engineering design means is to design something based on functional requirements
for the use of engineering knowledge you gain in solving problems”.
Participant 4 – “Engineering design is more of an approach comes with an appropriate solution”.
Participant 5 – “Engineering design is to design the technology itself, design process itself, use of
electronic circuits to design certain devices, improve design process of a product”.
Participant 6 – “Engineering design, design is that creating something and Engineering is the
analysis. Adding design to the end of engineering is engineering design”.

B.4.3 Aspects of Engineering Design Taught

Participant 1 – “Design based learning – to teach student some knowledge in physics, mathematical,
chemistry and social science. Here all we using are design concepts to chain the whole thing
together. All subjects are not necessarily related together, they are all separated. Use design to learn
all this things”.
Participant 2 – “Yes, in the introduction design subject. It taught Design process ways to identify
problems and find solutions, analyse solutions, find customer needs. It’s a combination of
interactive lectures and cohort based activity. Architecture design is diff from Engineering design
approach. Engineering design is more functional; Architecture design is more form and meaning.
Making meanings for design’.
Participant 3 – “Yes based on definition. It starts with design learned about prototyping skill set.
They also learned about different definition for approaches”.
Participant 4 – “Yes but in the module, thru systemization. Here they taught how to design a
system. Design optimization concept, 1-week project is team based. 2D design”.
Participant 5 – “Yes obsoletely, For example students get freshman course, design level, engineering practical pillar, cross pillar, 1st semester 1D 2D design projects. All classes must have design-based activities”.

Participant 6 – “Engineering design means process of synthesis and analysis, goes on”.

B.4.4 Engineering Design as an Essential Element

Participant 1 – “Students will be asked to design the canon and test the canon and know the result. Now what they learn from it. Humanity and social science, design is something that involving hand. DBL involve all this things. All this practical knowledge learning will become design centric curriculum. Yes it is, this is the only thing we do. Because if you teach me design how it fits in to my discipline then it is interested”.

Participant 2 – “Yes, it is definitely”.

Participant 3 – “Yes, definitely. Engineering problem solving, it’s not only technical part only it is also include all sorts of things in it”.

Participant 4 – “Yes, I think it as to be. It really as to be”.

Participant 5 – “Yes, design can be taught to be creative design and experiential design. If we give creative design integrated with experiential design that what we are looking forward to it”.

Participant 6 – “Yes, I agree it is very important. Service product system, design can be taught in a fun way without losing the vigor, quality of the undergraduate program”.

B.4.5 Possible Ways to Teach Design

Participant 1 – “Because of compartmentalization you only know this much (say if you are computer science engineer). Any design to work we have to observe. Go to exam, test paper exactly given to you nothing on it. You are only able to answer when someone give you a problem. You are useless. You create a value see the problem and solve it. Engineers are good at solving a problem when it’s given but engineers are not good at creating the problem. Where is the problem definition come from, it come from definition. You need observation. Any design happen come from observation. There may be some trigger somewhere. IPhone, iPod. He is solving a person self-esteem problem. The whole design based application is integrating lots of things together. Ability to observe”.

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Participant 2 – “teach it thru competition which is done in another design centric university. Individual Competition based, 2nd like exhibition design, team based projects in Asian university A. This technique driving the design. Students work in groups what they achieve is usually more”.

Participant 3 – “Standard pedagogy, hands on practice, hands on activities, thru design activities.

Participant 4 – “You have to do it. Design is more complicated so observe, analyse, by doing it you actually understand it that happens. Make sure problem definition is important, do it again and again design process, communication. Thru design-based activities, industry client requirements don’t change; faculty project can adjust for changes. Make sure design centric industry contacts”.

Participant 5 – “Big D - 4 dimensional. Theory to practice, real world examples, and disciplines based projects, multidisciplinary projects, design can be taught so that student should articulate what they learned. Big D whatever you learn in the class you can bring it in to the real world”.

Participant 6 – “By practice, students going thru designing something from an idea all the way to delivery of a prototypes”.

B.4.6 Curriculum Involve Design Based Learning

Participant 1 – “Teaching designs, design cannot be taught because design is an artistic creativity may be come up with it. Artists can be creative that why artist die very poor. By observation, by an idea, by experimenting it, you have to encapsulate whole learning into it that’s important. Then the design of the whole pedagogy is very important”.

Participant 2 – “Yes highly, Asian university A is very design based learning. We have design-based projects thru out the years 1D – Big D”.

Participant 3 – “Yes we do, open ended questions, free to design. Learning, observing, technical knowledge, analytical, team work, communication”.

Participant 4 – “Yes 3 projects in the courses 2D 1D 3D and we try to make hands on lab components to involve design”.

Participant 5 – “Big D designer, Yes. Cutting the boundary between subjects, cutting the boundary between industry and university, cutting the boundary between pillars”.

B.4.7 Skills Attained by Students through DBL

Participant 1 – “You have to design from day1. Students’ attention time is less than 20mins. Younger students pay attention even shorter. If he is interest in something they will do it continuously. Lecture is not direct relationship to getting the mark. Exam get the mark. Skill is very
subjective. There are hard skill and soft skill. Lots of skill – ability to observe, observe the environment and observe themselves, meditation self-improvement and awareness, mindfulness”.
Participant 2 – “Skills – time management, confidence have an idea and get it out, implement it”.
Participant 3 – “Skills – prototype skills, soft skills, understanding, motivation, analytical”.
Participant 4 – “All our courses based on design”.
Participant 5 – “Skills – general design thinking skills, communication, looking at context, creativity, explore more ideas, presentation skills, testing”.
Participant 6 – “Hands on learning, learn from experience, prototyping skill, communicate the design, work in team, solving problems”.

B.4.8 Engineering Design Projects helps to Collaborate with Industry

Participant 1 – “Peer to peer learning in our curriculum for design based. 3 instructors, 50 people and 6 projectors. Learn from group discussion. Instructor move around. Go and ask there are so many problems are there. Sit and watch the problems. Approach the company. Yes students are working in industry projects. It’s about you go out to get it. Most of the professor doesn’t want to talk to industry. Coursework Design small lectures, mostly Q&A (students will find out) Encapsulates all learning you want to do. Design Centric”.
Participant 2 – “Industry always need to solve many problems, they offer some program. Industry come down to class tell them about specific problems, students get more experience from it, good relation for future career. Benefits both ways”.
Participant 3 – “Industry poses the problem and the university engaged to do the project, the impact of the design is positive. Designing solutions should meet industry expectations then industry is ready to collaborate”.
Participant 4 – “It will help both sides. Go out get projects from industry, industry also come to you if u got good projects”.
Participant 5 – “Easy, very easy to attract industry. Switching manufacturing methods, interesting projects that are supported by industry, students’ experience, if you do it well industry line up outside your door. Industry do real stuff”.
Participant 6 – “Our design curriculum is tried to link the knowledge with real world. Many industry want to solve their problems, they are interested in. cross the boundary”.
Participant 7 – “We do have some projects with industry; they need us to provide an alternative solution for a real world problem. Definitely it has a role’.
B.5 Staff Perspectives – Asian University B

B.5.1 Design Based Learning means

Participant 1 – “DBL is Asian University B is more traditional. Present the problems first to the students. Start with design and move on to learning. We have design centric program 80% traditional 20% with Design Centric curriculum.
Participant 2 - To pick up any knowledge through design something. Designing engineering component or engineering solution, simple design.
Participant 3 - Learning to enhance design, enhance to make things. They learn design in diff aspects, to prototype is DBL for me.
Participant 4 - Students learn thru practical means, thru design based use their hands on to do something and at the same time learning the concepts to develop.
Participant 5 - DBL is based on certain problem to design for something, we learn thru solving that problem.
Participant 6 - DBL is learning through hands on means, to make things.

B.5.2 Engineering Design means

Participant 1 – Engineering Design is must involve elements of technology, user interfacing, engineering design have a technical component so we deal with engineering. Engineering design in design centric curriculum our projects are focused on complex problems.
Participant 2 – Engineering design that which achieves your knowledge in engineering.
Participant 3 – Engineering design means is a design with technical concentration given to it.
Participant 4 – Engineering design means there is an intention to come up with something, is to solve the problem. Engineering is using design in the right way some of issues we encounter in daily life. Engineering solutions to solve problems.
Participant 5 – Engineering design is different to different people; it is a certain process to identify certain problem. Using design process to identify the problem. Designing the solution to achieve a certain go.
Participant 6 – Engineering design means sketch with tech concentration given to it. Could be social, good and safe design.
B.5.3 Aspects of Engineering Design Taught

Participant 1 – Yes, to develop with enthusiasm, experience soft skills tech skills. We deal more with skills rather than technology. We deal with everything we need. It is interdisciplinary. Project management and project organization which team building multidisciplinary nature to the teams. So projects are multidisciplinary. We do have 3 primary strategies.

i. Future transportation systems
ii. Smart sustainable cities
iii. Engineering and medicine (bio engineering program).

Participant 2 – Yes, design centric program is already focus on design. We ask students to work on problems from their trying to use engineering principles, fundamentals to design a solution.

Participant 3 – Yes, of course in Design centric program. Before doing engineering design they have to identify the problem. Here student spend time working on what they should be work on as a problem.

Participant 4 – Yes, DCC go thru design thinking class. Philosophy of methodology of design (design process) is learned. Design is specific to diff disciplines

Participant 5 – students to get more centred on needs of society, much earlier on, multi perspective problems, solving problems, by experience, hands on, thru projects.

Participant 6 – Yes, of course DCC program. Students need to identify the problem to be solved. Students given project.

B.5.4 Engineering Design as an Essential Element

Participant 1 – Project management, lots of technical specifications, core engineering skills, core engineering knowledge. Students know theory well but there is no practical knowledge.

Participant 2 – Yes, definitely. By designing is the best of way learning. Give or identify a problem they go thru the design solving process. Engineering and medicine subjects. Engineering solutions for medical problems. Get students to go to the hospitals to observe the problems that currently faced and able to get the solution. Design is incorporated in to the environment. Engineering for medical applications.

Participant 3 – Yes, we are training engineers. We not only teach them but also train them.

Participant 4 – Yes, it is not only for engineering program. It should be done in every engineering programs. Design should be taught much earlier. DBL should be done earlier on.
Participant 5 – students to get more centred on needs of society, much earlier on, multi perspective problems, solving problems, by experience, hands on, thru projects.

Participant 6 – Yes, we are training engineers.

**B.5.5 Possible Ways to Teach Design**

Participant 1 – Focus on user centric, by try to get the students to understand the reason for design, try to understand problem by problem definition rather than just design. Design focused manner-using technology. By industrial design is diff from design.

Participant 2 – Students to experience themselves is the best way, many design methodologies, pick up a problem and learn it thru design solution, learn thru projects.

Participant 3 – To teach design they have to design things, the design things they need to make, assignments, tasks, they learn the different aspects of design. Through doing and hands on. We are very project based in DCP. Lectures are done in home departments.

Participant 4 – involve practical work, not thru lectures and in theory, you have to apply what you learned, and students must experience the design process.

Participant 5 – students to get more centred on needs of society, much earlier on, multi perspective problems, solving problems, by experience, hands on, thru projects.

**B.5.6 Curriculum Involve Design Based Learning**

Participant 1 – Yes we do.

Participant 2 – Yes, we want students to definitely design a solution or product. Product will help them to visualize their design solution. 2nd year project starts until 3 years’ time to finish. Paper prototype in 2nd and engineering prototype in 3rd and senior year – build more complex product. Design work thru 2-4th year.

Participant 3 – Yes, it does that is the heart and soul of DCP. Projects earliest in middle of 1st year until final year to graduate. Prototyping starts from the beginning. From beginning they have to think and ideate to have the prototype in high resolution. We act as facilitators. It’s through projects.

Participant 4 – Yes, in all departments we have. In capstone design projects in final year. DCC have projects from 2nd to final year bigger project. More complex projects, multidisciplinary, most of time they need knowledge expertise from different discipline. Problem will be focused broadly in DCC.
B.5.7 Skills Attained by Students through DBL

Participant 1 – soft skill, ability to communication, learning aspects of diff disciplines, user communication, management skills, time, budge try skill, work with diff people, learn hard skills technical build prototypes, being to able to learn from mistakes.

Participant 2 – Skills require are to observe, solving problems, able to look at the problem, analyzing problems, soft skills, hard core engineering skills, CAD, vendors communication etc.

Participant 3 – Lots of sketching, 3d cadding, printing, prototyping, milling, machining, innovate, 12 presentations allover 4years, communication, team based learning.

Participant 4 – the ability to observe, to ideate, to prototype, to assess the solution and to improve the solution and go thru activity process. They learn thru design thinking. The ability to communicate and present their work, analyse plan their project, peer learning in team.

Participant 5 – more sensitive to societal needs, confidence to communicate, team based, time management.

B.5.8 Engineering Design Projects helps to Collaborate with Industry

Participant 1 – Students are more marketable as graduates. Students are able to integrate quicker when they start working with industry. They realize the value; we don’t collaborate in tight manner.

Participant 2 – Industry always looking for ideas, by collaborating university with industry many solutions can be found for a problem. Engineering projects that we work are going to be relevant to industry as well. Student can on real problem with the industry. At the same time industry get more minds to look in to the problem facing. It’s a mutual benefits from the both sides. Design based projects is going to have a strong collaboration between the university and industry.

Participant 3 – Yes we do have industry collaboration. Both ways getting projects from them with some constraints. DCC is diff from traditional. Challenges they can see, give them more exposure, visits sites as part of the curriculum.

Participant 4 – Industry have aware of their challenges for society facing, important things need, Engineering design projects based on the needs of the industry. Projects will address the needs of the industry. Industry can also help us to solve and give us guidance in future projects. Gain a lot input from industry. Industry helps us the designing purpose, benefits on both sides.

Participant 5 – Projects common platform for industry to engage. We are getting student to go into the university. PBL or DBL is similar to industry requirements. Students start to see beyond the books. DCC got collaboration with industries. Industry got timelines for projects so student can learn.
Appendix C

Industry Perspectives (Research Data)

B.1 Industry Perspectives – Deakin Design Forum
Design Deakin Workshop, Deakin City Centre, 10 July 2012

1. Today in design technology, look for different attributes of design - Ref. www.pbs.org/objectified.

2. CADET – Aim is to Integrate Engineering and Design with Industry Inclusion (from year 9 to PhD).

3. Professional engineering education should encourage an application-oriented framework.

4. Singapore university of Tech and Design, National University of Singapore and Aalto University, school of engineering are Good in Design teaching and Learning.

5. EA insist all curriculums should have Project Work of a design nature.

6. Project based learning and Design based learning (pedagogy used for Solving design problems) Is design part of Innovation? Or is innovation part of design or both?

7. Learning is combined source of Student own initiation, Social and global responsibility and Expected skills from industry.

8. Learning principles should be very open to student learning environment.

9. To get practise based learning, Industry based learning and Integrative learning (Project → Motivation → Outcome) → PROJECT ORIENTED DESIGN BASED LEARNING.


11. Professor Gordon wray says, many students lack of motivation, effectively learning class standards.

13. From the result of engineering design school survey, there is lack of practical skills, aptitude skills and Management skills. (EA mechanical college in 2012).

14. In Australian industry, 80% they want to recruit professionals ready with Design Skills after graduation and 48% want to recruit through projects.

15. Because of lower manufacturing, design is exported to other countries. To achieve the transformation in industry and to use more talented engineers, design based curriculum is applicable for motivation of students, teaching engineering science, to get practical experience.

16. Graduate school of engineering design and manufacturing is best outcome to solve the above problems in design learning. It can be done by
   a) Capstone creative design course
   b) Integrate design with manufacturing
   c) Undertake real world projects
   d) Hands on approach to problem solving
   e) Designer – in – residence Concept.

What Industry Looking for

a) Core attributes from Students
b) Confidence in teaching (Staffs) & Learning (Students)
c) Industry involved in curriculum
d) Very global perspective – Student should think globally
e) Universities in Australia should be Design focused like New Zealand
f) Design had tough time in Australia because of cultural barriers in curriculum and macro-economic factors.
g) Design should be connected to Innovation (elements of design and innovation)
h) Education system should not be conservative in Australia
i) Should build the awareness of Design
j) Universities should not ignore the challenge to interact the students with Industry
k) Students need to learn strategy, understanding of clients (sociology study) which can help to eradicate the communication gap (concentrate on commercial aspect and design skills)