FIELD PROJECT-BASED LEARNING TO ENHANCE STRUCTURAL DESIGN ABILITIES FOR CIVIL ENGINEERING STUDENTS

KAMSIAH MOHD ISMAIL

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Engineering Education)

School of Graduate Studies
Universiti Teknologi Malaysia

JANUARY 2014

To my late parents Long Esah and Haji Mohd Ismail

To my beloved FAMILY

Husband : Haji Musa

Children : Musliza, Mustasha, Khairul Hakim, Khairul Hazwan and Mustika

Son in-law : Adam Muza

Grandchildren: Mohd Afiq and Farra Alya

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent, the Most Merciful.

I would like to express this sincere appreciation to those who have made this research and the completion of this thesis possible. I first and foremost want to thank my supervisors, Associate Prof Dr. Marlia Puteh and Prof Dr. Shahrin Mohamad for their incredible encouragement, invaluable advice and guidance and support. Their helpful feedback has greatly facilitated my progress. I have felt much supported by all of you during this process, and I thank you for your time and suggestions.

I also would like to thank the design engineers of Azman Lim & Associates Sdn. Bhd. specifically Mr. Shahrin for allowing me to conduct the research in his venue and Ir. Pok for his technical guidance to civil engineering students for the purpose of the research. Their knowledge, suggestions and guidance are unparalleled. I have felt much supported by all of you during this process, and I thank you.

I want to thank those who have given me the opportunity to embark on this research, provided the means by which I could learn for this wonderful degree. Thanking Prof Dr. Rashid, Prof Dr. Salleh, Associate Prof Dr. Zamani and others for providing the support and advice over the years. “Sisters in EE” for their encouragement and continuing support throughout the study. Finally, my extended sincere appreciation to all my colleague especially in the Department of Civil Engineering, and others who have provided the assistance throughout the study.

ABSTRACT

Design courses need to embrace the exemplary nature of the civil engineering profession and to address the concerns of employers that engineering graduates are unprepared and poorly trained to face the engineering profession. The introduction of project-based learning is important because as a constructivist learning pedagogy, project-based approach emphasizes learning by doing via direct students' engagement in projects, performed either individually or in groups. The objective of this research is to investigate the extent to which the students' design abilities are enhanced through field project-based learning in structural reinforced concrete design course. The research was carried out on groups of student who were assigned design tasks at a local design firm. The data were collected through interviews, journal entries, direct observations and document analysis. These data were analysed using content analysis method and the results were later triangulated to increase the reliability and validity of the findings. The findings of the study have suggested that field project-based learning have enhanced students' self-directed learning, fostered their professional skills as well as promoting their lifelong learning skills. The design projects have also lifted the students' problem solving skill to an appropriate level. Another component of the finding involves the measurement for design projects. The findings have also indicated that stakeholders have high expectations of design projects in preparing students for workplace environment. Hence, it is imperative that an innovative instructional approach, which includes proper assessment for design course, is implemented in making design projects relevant to the students and the engineering programs.

ABSTRAK

Kursus reka bentuk perlu memenuhi contoh amalan kelaziman profesion kejuruteraan awam kerana ianya dapat manangani kebimbangan pihak majikan berkenaan graduan kejuruteraan yang kurang bersedia serta kurang latihan untuk menghadapi cabaran profesion kejuruteraan. Penggunaan pembelajaran berasaskan projek adalah penting kerana berdasarkan pedagogi pembelajaran konstruktivis, kaedah pembelajaran berasaskan projek menekankan pembelajaran melalui aktiviti sebenar penglibatan pelajar melalui perlaksanaan projek yang dijalankan secara individu atau berkumpulan. Objektif kajian ini adalah untuk mengenalpasti sejauh mana peningkatan keupayaan pelajar dalam bidang reka bentuk yang dicapai melalui pembelajaran berasaskan projek di lapangan dalam kursus reka bentuk struktur tetulang konkrit. Penyelidikan ini telah dijalankan terhadap kumpulan pelajar yang diberi tugasan rekabentuk di sebuah firma reka bentuk tempatan. Data penyelidikan telah dikumpul melalui sesi temuduga, catatan jurnal, pemerhatian langsung dan penganalisaan dokumen. Kesemua data telah dianalisa menggunakan kaedah penganalisaan kandungan dan hasil kajian kemudian ditriangulasikan untuk meningkatkan tahap kebolehpercayaan dan kesahihannya. Hasil kajian ini mengusulkan bahawa pembelajaran berasaskan projek kerja di lapangan boleh meningkatkan pembelajaran kendiri pelajar, memupuk kemahiran professional mereka serta mencambahkan kemahiran pembelajaran sepanjang hayat. Projek reka bentuk juga didapati boleh menaikkan prestasi kemahiran menyelesaikan masalah di kalangan pelajar kepada tahap yang bersesuaian. Antara hasil dapatan kajian termasuk kaedah penilaian pada projek reka bentuk. Hasil dapatan kajian juga menunjukkan bahawa pihak berkepentingan menaruh harapan yang tinggi terhadap projek reka bentuk agar dapat mendedahkan pelajar kepada suasana persekitaran tempat kerja. Oleh itu, adalah penting bahawa pendekatan pengajaran inovatif, merangkumi penilaian yang wajar, dilaksanakan supaya projek reka bentuk adalah relevan kepada pelajar dan juga program-program kejuruteraan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABET	-	Accreditation Board for Engineering and Technology
CDIO	-	Conceive, Design, Implement, Operate
CLO	-	Course Learning Outcome
CSR	-	Corporate Social Responsibility
CST	-	College of Science and Technology
DDA	-	Diploma of Civil Engineering
DDA3164	-	Subject code for Structural Reinforced Concrete Design
FPjBL	-	Field project-based learning
HOD	-	Head of Department
MIT	-	Massachusetts Institute of Technology
MQA	-	Malaysian Qualification Agency
MS	-	Malaysian Standard
PjBL	-	Project-based learning
RQ	-	Research Question
SDL	-	Student Directed Learning
UTM	-	Universiti Teknologi Malaysia
UTMSPACE	-	UTM School of Professional and Continuing Studies

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The central and the most distinguishing activity in civil engineering is design (Dym *et al.,* 2005; Akili, 2007). Design has traditionally been an important part of an engineer's training (Hasna, 2008); it is either studied as a comprehensive subject or integrated as a project in the teaching and learning of civil engineering (Sobek II and Jain, 2004). Engineering design is a challenging subject matter due to the expected design abilities in the technical and non-technical aspects, which associate both the cognitive and affective domains (Mourtos, 2011). In fact, design courses expose the students with the activities that engineers do as well as the basic elements in real design projects (Akili, 2007).

Teaching civil engineering design courses through projects with the involvement of industries has increased in recent years (Akili, 2007). Moreover, graduates are now expected to be versatile (Ardington, 2011) and be able to apply higher cognitive skills such as analysing, summarizing and synthesizing information as well as thinking creatively and critically (Vogel, Wagner and Ma, 1999). In this context, a strong emphasis has been put on the need for an actual shift from teacher-centred to student-centred learning (Mills, 2002). So much so that the development of interpersonal and professional capabilities of students can be made explicitly in the learning experience (Fallows and Steven, 2000) through "learn by doing". In this way, students are able to relate the academic theory learnt and the professional practice practised at industry (Oliveira and Estima de Oliveira, 2009).

Despite the increased involvement of the industries in engineering design projects, both design faculty and design practitioners argue that further improvements on design education is necessary (Akili, 2007). Comments from the employers identified that despite possessing good technical skills, engineering graduates still lack interpersonal, organisational, and team working skills. Substantial pressure from the industries and professional bodies such as the Engineering Accreditation Council, Board of Engineers to contextualise and embed generic graduates attributes in undergraduate programs is evident in many reports (EAC Manual 2012). Hence, there is a grave need to improvise the engineering education pedagogies (Puteh, Ismail and Mohammad, 2010) to accommodate the students' need as well as the demands from industries in order to feature both the technical and the generic skills among the engineering graduates.

There is an urgent need to change design education to meet the challenges of the 21st century as stated in Malaysia's Science and Technology Policy For The 21st Century, (2009). In this report, in order to achieve the vision of Malaysia to be a fully industrialized nation by 2020, it is necessary to produce engineering graduates who are technologically and scientifically strong, with good design ability. This justifies why engineering education stakeholders are deeply concerned with graduates who lacks skills in self-directed learning, communication, abstract thinking, problem solving and group dynamics (De Vita, 2004; Ward and Lee, 2002). The emerging trend of globalization and the rising challenges in the engineering field have demanded graduate engineers to be well-prepared with innovative approaches that are able to foster and support life-long learning.

According to Reidsema (2005), the exponential growth in information and knowledge over the last 40 years has serious implications for tertiary educators in engineering. This is because the lecture-based teaching model is no longer suitable to cater for the increase in technical content and the experiential nature of design learning. Moreover, the new paradigm for engineering design education is emerging as a multi-disciplinary, multi-mode, multi-media, and multiple-partner enterprise (Akili, 2007). These dilemmas provide a challenge for engineering design educators to revise their traditional teaching methods as there is a pressing need to equip engineering graduates with long term innovative solutions and prepare them for life-long learning endeavours.

Engineering has traditionally been taught as a series of separate courses. Due to this, engineering graduates will be expected to integrate the knowledge and understanding gained from this diverse and separate compartmentalised subjects, when involved in real world design projects (Chowdhury, Guan and Doh, 2005). In this case, students often experience difficulties in integrating the knowledge gained from these separate areas. In the traditional learning method, the lecturer gives lecture on the subject relating to the syllabus. Later, students' understandings were tested in the form of tests and final examination. One shortcoming of this situation is that lecturers are not able to test other skills such as communication and team skills in students. With regards to graduating students' capabilities, engineering industries requires high level of oral and written communication skills and other attributes such as professional skills and ethics. Such attributes are highly required for the success of professional engineers (Venkatesan, Molyneaux and Setunge, 2007). Student-centred learning tasks such as project-based design courses are necessary in order to allow students to integrate their knowledge with the practical aspect of the design course.

1.2 Background of the Study

The modern society is constantly changing with the rapid advancement in knowledge and skills (Mills and Treagust, 2003). Therefore, the improvement on the quality of design education in engineering is essential to meet the needs and the demand of competent engineering professionals (Mills and Treagust, 2003). In addition, industries require that employee posses and develop skills and abilities in order to survive in the global engineering environment. Simply mastering a single specialized skill is not relevant anymore. Thus, it is imperative to improve teaching and learning such as project-based learning (PjBL) in design courses in civil engineering in order to improve students' learning process.

A structural civil engineer is responsible for using his engineering background to plan and oversee various construction efforts in many different areas of the field. Design is what they do, they develop the schemes for construction of building, decide on how loads are distributed and to which they will be subjected, while remaining safe and serviceable to people. Yet, the building retains the aesthetic as required by architect. Students apply design principles and theories and will use this knowledge in practical situations to design the products; usually drawing and calculations are used to communicate the design to other party who will build the structure. Thus PjBL can be one form of teaching instruction, where students can practice and apply their knowledge in engineering. According to Gao, Demian and Willmot (2008), students should be able to integrate knowledge and skills in professional practice in line with the continuous industrial and organizational changes if they are exposed in the field project.

More than a decade ago, Felder *et al.,* (2000) revealed that, "…*many engineering classes in 1999 are taught in exactly the same way that engineering classes in 1959 were taught*". This is a shocking revelation especially to the engineering educators. Mills and Treagust (2003) further criticized that the existing teaching and learning strategies in engineering programs is out dated and needs to become more student-centred. This has prompted a number of researchers (Droppelt, 2003; Dym *et al*., 2005; Gao, Demian and Willmot, 2008; Smith *et al.*, 2005; Thomas and Busby, 2003) to work on identifying the most suitable and affordable teaching approach applicable for engineering education worldwide. PjBL is the answer for resolving the critical issues of engineering education because it mirrors the professional behaviour of an engineer (Mills, 2002).

In traditional engineering education, lessons are commonly dominated by hour-long lectures (Mills, 2002). For example, the lecture on the Structural Reinforced Concrete Design is taught in a transmittal mode with little active participation from students. These lessons are mainly designed for the development of technical knowledge and skills. Skills developments such as personal and interpersonal skills are given little focus as described by Mills (2002). Teck (2009) argued that this traditional approach is inadequate to prepare the graduates with expertise in their field of qualification as well as with highly developed interpersonal, personal and transferable professional skills attributes. A change of approach in project implementation is emphasized to prepare students for scenarios, which mimic those faced by engineering practitioners (Montufar-Chaveznava, Yousuf, and Caldelas, 2008). PjBL has helped students to conceptualise engineering fundamentals in order to develop holistically acceptable solutions for engineering design problems as mentioned by several authors (Woods *et al.,* 1997; Gibson, 2005; Mills and Treagust, 2003). Project-based learning such as field-project exposes students to professional situations in either exploring a project or a problem with more than one way during problem identification and project implementation. The PjBL approach employs a problem as the driving force for learning the fundamental principles that are required to find a solution

Projects can operate in diverse contexts, such as fieldwork, or class approaches by using a single lecturer or course team that uses traditional methods of teaching. Lecture-based teaching is a dominant approach in project-based learning because it is efficient in providing students with large amounts of information in short amounts of time (PBLE, 2003). However, such overuse lecture-based in project may create a situation where students are disengaged with learning (Wurdinger and Rudolp, 2009). For example, students lost their attentions in the class due to long lecture hours. If institutions and educators want to improve the learning environments, they should consider engaging students with more active methods of learning, which would inspire and motivate students to engage in PjBL. Wurdinger and Rudolp (2009) reaffirmed that students are most excited about learning when they are actively involved in the learning process through group discussion, hands-on experience and practical application of the theory learnt in the classroom. Sax *et al.,* (2002) and Levine and Cureton (1998) claimed that students prefer active methods such as problem solving that can expose them to constructivist learning (Tam, 2000).

Felder and Brent (2005) claimed that students process the information presented to them in different ways. They would normally adopt their own learning preferences to better understand certain concepts (Felder and Brent, 2005). In certain cases, they might utilize learning approaches, which they may not be initially comfortable with. According to Felder and Brent (2005) and Cassidy (2004), students are usually taught in a manner, which they prefer or less preferred. This will gradually lead to an increased comfort level during the process of learning and boost their motivation to learn a difficult subject.

Several authors have described that PjBL has shown to be effective in increasing student motivation and improving students learning skills such as problem-solving and thinking skills (Arumala, 2002; Akili, 2007). Motivation of students is influenced by the learning activities in PjBL and the skills developed by learning through projects (Hilvonen and Ovaska, 2010). The motivation will indirectly help students, so that they are ready and confident when they are ready to begin their careers (Akili, 2007). As a result of motivation of students, this PjBL approach provides a context that makes learning the fundamentals more relevant and, hence, results in better engagement of learning by them. Since the project-based learning is commonly carried out in groups, it is natural that the quality of teamwork influences the motivation of individuals.

There are several reasons that rationalize the application of PjBL approach in design courses in engineering programs. Firstly, project tasks are closer to professional reality (Mills and Treagust, 2003) and relate to the fundamental theories and skills of an engineer. Secondly, almost every task in an engineering profession involves the development of projects bearing the differences in time scales and levels of complexity. Not only that, project component also address critical issues of engineering education as it fosters student-centred learning, The collaboration experience promote team working, communication and problem solving skills (Gao, Demian and Willmot 2008; Prince and Felder, 2006; Sheppard and Jenison, 1997). Thus, the successful completion of projects brings about the integration of all areas of undergraduate training in the design process, which an engineer has been exposed to.

1.2.1 The Research Gap

Each of the design process models by Khandani (2005), Oakes (2004), Volan (2004), Nicolai (1998) and Mourtos (2011) promotes a distinctive design process via convergent-divergent thinking (Nikolai, 1998), crucial in design work. Not only that, the models advocate iterative cycling through which the design process is repeated several times and foster the development of better and improved solutions. However, these models are insufficient in integrating the students' abilities in design. Abilities such as team working and communication are not integrated in these models despite the emphasis by the accreditation bodies such as Accreditation Board for Engineering and Technology (ABET, 2000) and Malaysian Qualification Accreditation (MQA, 2007) on these components. In addition, Nguyen (1998) and Zaharim *et al.* (2009) stressed the importance of professional skills in assessing engineering students' work. Even though these skills are addressed in the course learning outcomes of the engineering programs, these skills are not clearly assessed in the engineering project evaluation.

This study therefore, aims to address these gaps in the literature by investigating the inadequacies of the design process models by addressing the design abilities of the students that are essential when executing the design process. It is also aimed at addressing the deficiency in assessing the teamwork and communication components in design projects.

These gaps are also reflected in the challenges and shortcomings of the current PjBL approach at College of Science and Technology as below:

1. The projects presented to the students are not authentic.

2. Students are not exposed to the real project work and the real issues and challenges that arise from the project. Some lecturers are not aware of the challenges in project work, as they do not have the experience working in the construction industry.

4. There is no input from the construction or design consultant on the project as the linkage between the industry and the university is vague.

5. The current assessment on design projects does not consider the generic skills such as the team working and communication skills demonstrated by the students.

6. The design course is too focussed on engineering science and technical courses without providing sufficient integration of topics or relating them into industrial practice.

7. The current design course does not provide sufficient design experiences to students.

8. Incorporating field project in design would allow opportunities for students to develop communication skills and teamwork experience.

9. To develop awareness amongst students of the social, environmental, economic etc.

10. The current teaching and learning strategies in design is out dated and needs to become more students-centred.

For this study, the field project-based learning (FPjBL) approach is used to directly address some of the problems in the above issues with students are directly linked with the design industry. FPjBL is increasingly adopted in various courses in higher education and has been said to increase learning effectiveness (Hilvonen and Ovaska, 2010). In engineering education, there has been a long history of using project work to integrate disciplines and motivate students (Heitman, 1996; Heywood, 2005). Thus, the design project is used as the vehicle to enhance the design abilities of engineering education students.

1.3 Statement of the Problem

The structural design courses are crucial for the success of students in civil engineering program (Shepherd, 2003). Moreover, during the last several years, the progress in pedagogy in design education has led the new methods of teaching and learning in design project. Traditional approach to structural design education in Structural Reinforced Concrete Design is content-driven where it places a heavy emphasis on lecture-based delivery, which focused on problems intended for the students to apply the theory. This scenario is supported by Hung and Choi (2003) that courses in structural design courses placed too much emphasis on technical theory and too little on the application and integration of real engineering problems. Moreover, the knowledge of theoretical concepts from traditional teaching does not ensure that students can solve real industrial problems (Hasna, 2008).

Design projects in structural design courses are also given varying emphasis by different lecturers in higher institutions as mentioned by Manry, Bray, and Phoha (2012). Most lecturers have difficulties in finding the balance between theory and practice. Majority of the lecturers would provide familiarity with design codes as part of the education is clearly inadequate as it offers insufficient authentics design exposure to students (Mills and Treagust, 2003). Therefore, many students lacked the background knowledge of design skills and abilities in projects (Avery, *et al*., 2010). Therefore, it is essential to take students outside the classroom and increase their exposure to engineering practice through projects such as case studies, problem-solving workshops, visits to major companies and sites, and other interactive sessions as suggested by Kartam (1994).

Rapid growth of infrastructure development in Malaysia recently has increased chances of job opportunities to many graduates. In order to keep up with the demands, universities hold responsibility to produce students with sufficient background and excellent qualification. An assurance for the performance of students is highly dependent on the standards, preparation and exposure to the practical training, especially in design courses. Design projects in design courses can be used as a medium for students to bridge the theory they learnt into practice. Due to the global environment and continual technological and organizational change in the workplace, graduates are expected to develop relevant skills and abilities in order to survive (Hasna, 2008). They are expected not only to be knowledgeable in their disciplines but they are also expected to perform professional practices as well. As such, in order to keep pace with these demands of commercial realities of industrial practice in engineering, graduates shall be ready for the changing of work environment in the industries since their demand is changing with time (Noordin *et al.,* 2011). PjBL is the best method to resolve the issue, which involves active learning and early exposing students to engineer's job in industries (Noordin *et al.,* 2011). In addition, the projects could provide students with valuable experience if they can experience working at industries.

Students should be equipped with structural designs knowledge that is dealt not only with structural design theory and concepts but also with various analytical tools and design methods. It should also instil students' problem solving skills such as critical thinking and reasoning abilities. While doing the projects, students would develop a consistent understanding of their learning process in problem solving, analysis, synthesis and evaluation (Arciszewski and Lakmazaheri, 2001). In addition, they can apply their acquired knowledge to solve real-life and authentic design problems through project-based learning.

According to Steward (2007), the integration of project-based learning in engineering design education has fewer structured learning activities. For example, the self-directed learning tasks are guided through consultations with lecturers. At this instance, students are normally presented with guided instructions so that they are able to achieve the desired course learning outcomes for a particular design course. Thus, this kind of implementation of current education system is seldom successful in attaining some of the objectives of the course learning outcomes (Platanitis and Pop-Iliev, 2010). This is due to the fact that the project-based learning implemented does not promote the active learning that require students to be self-directed in their learning and to take 'ownership' of their own education. Many projects in design courses always dealt with 'real world' problem (Akili, 2007). One goal of PjBL as stated by Mergendoller (2006) is to allow students to manage the development of their long-term life-long learning skills (Hilvonen and Ovaska, 2010; Helle, Tynjala-Olkinuora and Lonka, 2007; Thomas 2000).

PjBL seems to be the best method to resolve this issue as early students' exposure to an engineer's job at industries can provide them with valuable experience working as engineers at industries (Noordin *et al.,* 2011). Graduates are able to practice the desirable skill expected of them such as communication, teamwork, leadership and management. These desirable skills are expected of our graduates and are critical in professional careers. Therefore, providing a comprehensive engineering design experience such as field project-based learning is an extremely important part of any undergraduate engineering program. Moreover, Accreditation Board for Engineering and Technology (ABET, 2000) Criterion 4 requires that;

> "*students be prepared for engineering practice through the curriculum, culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints*"

PjBL influences the motivation of students (Hilvonen and Ovaska, 2010). While communicating the fundamental knowledge of design, students can be optimally motivated if they see design education as personally relevant to their interest. In PjBL, since students are self-regulated, they would facilitate and motivate their learning. Evaluation of project-based courses as reported by Savage, Vanasupa and Stolk (2007) show increases in student motivation, as well as engagement in their learning. Students demonstrated greater self confident and improved learning abilities (Shepherd, 2003) that provide the opportunity for them to reflect and involve their beliefs and values (Mergendoller, 2006). These beliefs and values are indirectly increase students' achievement in their personal goal and development; consequently increase their motivation and engagement.

Teaching a course in engineering design well has always proved to be a substantial challenge. The nature of the course is fundamentally different than traditional lecture courses. It requires that students work in teams, which introduces grading difficulties, and requires that faculty deal with interpersonal skill issues. New projects must be either created by the faculty or solicited from industry each year. In either case, the projects should require an integration of a broad range of the student's coursework, provide a significant technical challenge, and finally, be interesting so that the students are well motivated. Design courses also generally involve significant writing content, oral presentations, and substantial students and lecturers' time, all of which conspire to make such courses very demanding on faculty time.

Students' fieldwork at industry through design projects can expose them to authentic project works or other interactive sessions as suggested by Kartam (1994). In this research, the researcher uses the Field project-based learning (FPjBL) approach that offers students a wide range of skills and design abilities to civil engineering students at the diploma level. The FPjBL approach can equip graduates with the knowledge, skills, and attitudes at the workplace and to prepare students to succeed in today's dynamic workplaces (Gonzales and Nelson, 2005).

1.4 Objective of the study

This research attempts to investigate the implementation of field project-based learning (FPjBL) in Structural Reinforced Concrete Design course at a local institution. The intended learning objectives and outcomes of the project will be examined. Accordingly, this research will explore the students' design abilities related to design work. The findings of the research will guide the development and implementation of field project-based learning (FPjBL) instruction.

This study is aimed to achieve the following objectives:

1. To investigate the design abilities demonstrated by students engaged in project.

2. To investigate how the field project-based learning (FPjBL) approach is able to enhance the design abilities of students in a structural reinforced concrete design course.

3. To design and develop the FPjBL instruction guide for Structural Reinforced Concrete Design course.

1.5 Research Questions

In order to achieve the above research objectives, the following research questions (RQ) are used.

Objective 1: To investigate the design abilities demonstrated by students engaged in project.

RQ1. What is the design abilities expected of civil engineering students?

RQ2. What are the design abilities of students engaged in the FPjBL?

Objective 2: To investigate how the FPjBL component is able to enhance the design abilities of a structural design project.

RQ3. How does the FPjBL develop design abilities among students?

Objective 3: To design and develop the FPjBL instruction guide for Structural Reinforced Concrete Design course.

RQ4. What are the improvements that can be made to the Structural Reinforced Concrete Design course?

1.6 Conceptual Framework

The conceptual framework in this study is governed by theories and studies in preparing future engineers as reported by the National Academy of Engineering (NAE, 2005). The challenges and attributes of future engineers involved surviving in the ever fast-paced global knowledge economy as well as possessing excellent design abilities and skills. The conceptual framework is represented in a graphical form to show the concepts that encapsulate the core of this study. According to Miles and Huberman (1994), conceptual framework is used to assist the researcher to decide the types of data collection and variables. It also guides the researcher during the data interpretation (Svinicki, 2011) by allowing the researcher to make choices about the relationships between the data.

Engineers of tomorrow will face great challenges. Technological and social challenges such as information explosion, communication technology, globalization, environmental contamination, infrastructural damage are some examples that engineers need to deal with. They will need to solve these problems where they have to perform and innovate at an ever-accelerating rate. According to Engineers 2020 (NAE, 2005), the key attributes that will support the students' success are strong analytical skills, good communication skills, understand the principles and having high ethical standards, professional, dynamic, agility, resilience and flexible as well as lifelong learners. Thus, it is imperative to realize that students in the 21st century are interested, committed and ambitious about what they have learnt and at which situations they are exposed to.

Field project-based learning (FPjBL) characterizes a constructivist teaching and learning approach. It is a comprehensive instructional approach to engage learners in a sustained, cooperative investigation as reported by Bransford and Stein, (1993). The learning theory encompassed the FPjBL activities is known as constructivism in which students reflect on their experiences and construct their own understanding of the learning (McHenry *et al.,* 2005). It is also a search for meaning in the issues and tasks around the students are actively trying to construct the meaning through the design project. This meaning requires understanding parts of the design tasks as well as the context of wholes of the project. Constructivism guides a set of instructional principles for the teaching of design in project work. It underlies the beliefs about knowledge and learning in which students "learn by doing".

According to Thomas (2000) project-based learning such as FPjBL promotes constructivism as its underlying principles. It enhances the student-centred learning using authentic projects and real life experiences. Real problems in project tend to engage learners more because of the large context of familiarity of the problems in project (Gao, Demian and Willmot, 2008). For example, this allows the learners to become active builders of their own knowledge through real design projects (McHenry *et al.,* 2005).

McHenry *et al*. (2005) elaborated that student's work collaboratively to plan for projects within the curricular content using authentic tasks that emphasize on time management and innovative assessment. In this context, students learning are enhanced by interaction with peers within the projects' activities because in constructivist learning, collaboration plays a vital role as knowledge is socially constructed when students work in a team (Hasna, 2008).

In FPjBL the learning strategy that engages the learners in complex activities usually requires multiple stages and an extended duration. The project learning May requires more than a few class periods or even a full semester. According to Thomas, Mergendoller and Michaelson (1999); Brown and Campione (1996), projects are challenging because each task is based on questions that may need further rectification. These challenging questions served to organize and drive students activities and engage them in a meaningful project. The problems in the project give learners the opportunity to work autonomously over extended periods of time. In addition, the problems in projects culminate realistic products or presentations such as artefacts, personal communication, or consequential tasks that meaningfully address the driving questions.

Blumenfeld *et al.* (1991) supported the issue of real problems in real environment from the perspective of knowledge construction, that learners construct knowledge by solving complex problems. These complex problems would indirectly get students to use their cognitive tools, finding sources of information and other individuals as resources. Helle, Tynjala-Olkinuora and Lonka (2007) agreed that real life problems in project promote the important of knowledge restructuring for the development of expertise. Other study by Prince and Felder (2006) highlighted the benefits of authentic or real project on the perspective of knowledge and skill transfer.

Student-centred learning is another key feature of the constructivist learning that encompasses activities in projects (Gao, Demian and Willmot, 2008; Helle, Tynjala-Olkinuora and Lonka, 2007). Brown and Campione (1996) listed three features of student-centred learning. These are the freedom of choice, students' responsibility for their own learning and the creation of a supportive learning environment. Students have more control of their learning and the role of the lecturer is to facilitate and guide the learning. In FPjBL, students have the oppurtunity to exercise their choices and control what to work on, how to work, and what is required to generate the final product. According to Blumenfeld *et al.* (1991) choices and controls are critical to enhance students' motivation in their learning. Learner control also encourage students to utilise their prior knowledge and experience (Puteh, Ismail and Mohammad, 2010; Prince and Felder, 2006).

The conceptual framework of the study shown in Figure 1.1 attempts to integrate the related theories and beliefs about knowledge and learning, which underlie FPjBL (Mills, 2002). With the adopted orientation of design process from Khandani (2005) in FPjBL, the development of the design abilities and skills in students is expected to be enhanced.

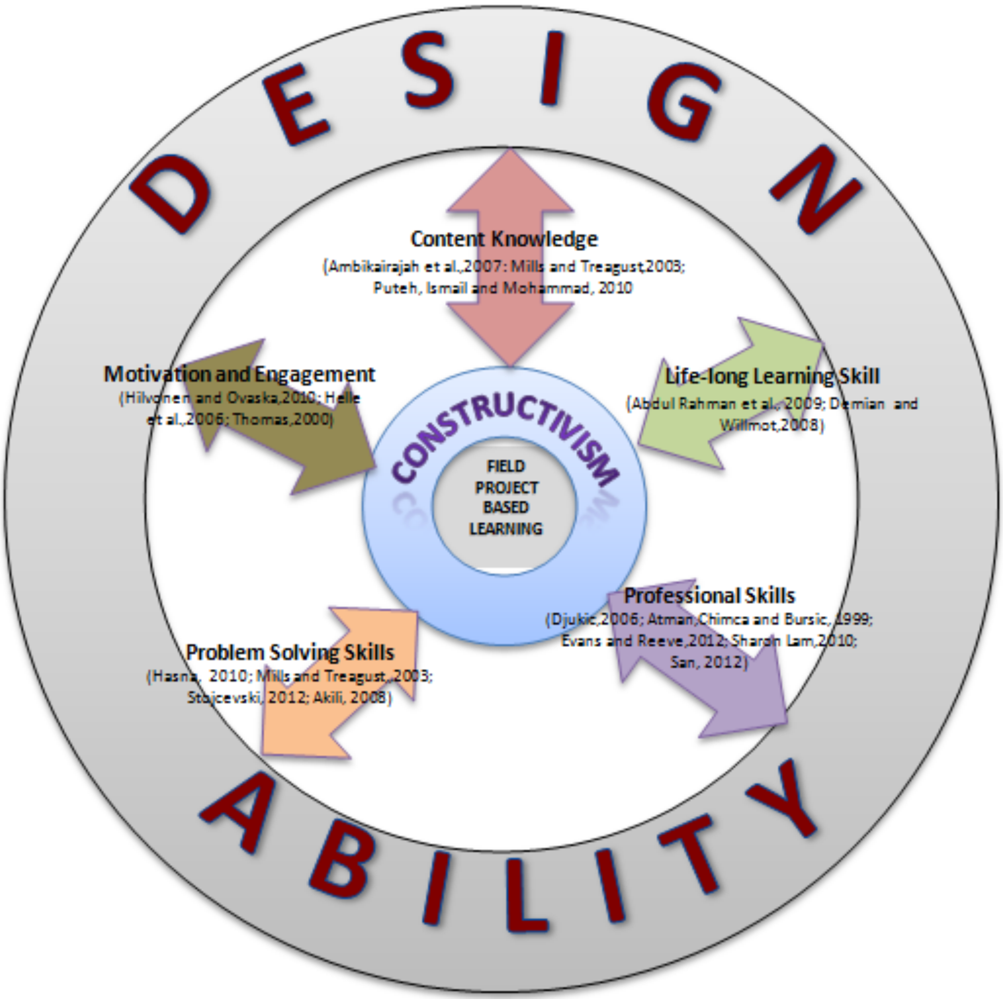


Figure 1.1: Conceptual Framework of the research

The implementation of FPjBL in structural reinforced concrete design course, students are exposed to the technical and non-technical aspects of design, which is associated with the cognitive, psychomotor and affective domains of knowledge. Content knowledge is the most obvious skill required by students because students should possess good knowledge of fundamental engineering science and maths in order to successfully achieve the outcome of the design course (Penuel and Means, 2000; Thomas, 2000; Boaler, 1997).

In completing a project, students use problems to construct meaning as recommended by Ambikairajah *et al.* (2007). The most important ability of students in FPjBL is to solve ill-structured problems in which the problems drive the learning of the learners. This is because the solution of a problem or a completion of a task requires students to complete a number of educational activities that drive the learning (Palmer and Hall, 2011). Problem solving in engineering design requires students' ability to reach a solution, therefore, students understanding of the problems is essential when they know how to the problem should be solved. According to Thomas (2000) it is crucial that students are allowed the freedom to ask different questions and approach the problem differently in PjBL. This freedom of choice can generate multiple solutions (Blumfeld *et al.,* 1991) which students are exposed in FPjBL.

Other aspect of design ability identified in Figure 1.1 is professional skills. Students are expected to work in a team, while maintaining the professional and ethical responsibility. In addition, professional skill such as communication and understanding the impact of engineering solution in a global, economic, environmental and societal contexts are needed for students to acquire during FPjBL. ABET 2000 stated that students must be prepared for engineering practice through the curriculum. Students are also expected to engage in design experience based on the knowledge and skills acquired in their coursework which incorporated the engineering standards and realistic constraints.

Another design ability available in Figure 1.1 is lifelong learning. Lifelong learning is learning to know, learning to do, learning to live together and with others and learning to be (Ambikairajah *et al.* 2007). Helle, Tynjala-Olkinuora and Lonka (2007) reported similar findings on lifelong and self-regulation learning of students engaged in design projects. FPjBL emphasizes the use of problems to trigger students' self-directed and collaborative learning as well as their lifelong learning skill development.

The ability to sustain, become more engaged and interested in design contributes to the motivation and self-worth of students (Hilvonen and Ovaska, 2010). PjBL increases motivation of students participating in the project design course. According to Thomas (2000) students are more motivated to bring out and test their ideas and increase their level of understanding when they are confronted with authentic projects. Motivation and engagement are required in PjBL because they support students' learning and practicing skills (Baillie and Fitzgerald,2000; Helle, Tynjala-Olkinuora and Lonka, 2007; Lutz and Schachterle, 1996; Ambikairajah *et al.,* 2007). They involve interest and value due to the novelty of tasks in the projects and the authenticity of the problem. In addition, Blumenfeld *et al.* (1991) discovered that students felt the 'ownership' towards the project when they are given the opportunity to question and to solve the project on their own.

The focus of this research is the implementation of project-based learning in structural reinforced concrete design course. Students were attached at a local design firm. Themes are presented with quotes arising from the study and that includes: the content knowledge (Penuel and Means, 2000, Thomas, 2000, Boaler, 1997), life-long learning (Ambikairajah *et al.,* 2007), professional capacities (Ngai, 2011; San, 2012, Gavin, 2011), problem solving skills (Barron, *et al.,* 1998; Gavin, 2011), motivation and engagement (Baillie and Fitzgerald, 2000; Helle, Tynjala-Olkinuora and Lonka, 2007; Lutz and Schachterle,1996; Ambikairajah *et al.,* 2007).

1.7 Significance of the Research

This research offers an innovative method of project-based learning for enhancing design abilities and skills of structural reinforced concrete design course in civil engineering students. The contributions of this research are:

1. To provide an innovative method of project-based learning to enhance students' design abilities and skills. The courses employed project-based learning activities as an important focus of the course to transfer the gap of theory into practice. The skills developed by learning through field projects will indirectly help students, ready and confident to begin their careers (Akili, 2007).

2. The findings of the study are expected to inform relevant authorities such as faculty administrators to provide guidance and insights into curricular changes, teaching methods, and exposure to civil engineering practice in

Malaysia and helps in establishing enduring connections with the industrial sector.

3. This study is also significant in assisting design lecturers to manage the contextualization of engineering design theory and practice. It can provide guidance and insights that would contribute to the understanding of the type of teaching approaches adapted by higher learning institutions.

4. Besides that, this study is also expected to guide the current assessment method on assessing students' skills in design projects and provide an input for the instructional process in project works including learning outcomes, teaching and assessment method.

1.8 Scope and Limitation of the Research

This research investigates the current project-based learning practice in Structural Reinforced Concrete Design course of a three-year diploma program at a local higher learning institution in Malaysia. This research only examines the current learning objectives or outcomes as stated in the course outline. It did not investigate the formulation of the learning objectives or outcomes prepared by the lecturers.

The research is limited to third-year students who took this course prior to their diploma graduation. Due to the shortage of resources, only two groups of students were exposed with the field project-based learning carried out at a consulting firm. The students did not have any training or experience prior to this field project-based learning.

This study is a qualitative research, which was conducted to gain deep understanding of the situation, event or people. According to Merriam (2009), the information obtained may not be generalized in other setting. Creswell (2003) added that generalization and reliability are insignificant factors in a qualitative research. Furthermore, the project-based learning in this study could help students enhance their design abilities so that they are able to transfer their design knowledge into real practice.

1.9 Definition of Terms

This research uses some common terms from civil engineering and the education discipline. Few terminologies used throughout the thesis are clarified for better comprehension below.

1.9.1 Project

A project is an activity where the participants have some degree of choice in the outcome (Hiscocks, 2012). It is a complex effort that requires an analysis and must be planned and managed, because of the desired changes (The Aalborg PBL Model, 2010). It involves a problem or task and the result is completed and functional (Hiscocks, 2012).

1.9.2 Project work

Project work integrates the investigations of a given topic. It is presented in a form of written report with detailed illustrations such as, the calculations, sketches and drawings (Blumenfeld *et al.,* 1991). The project (for students) must "*be crafted in order to make a connection between activities and the underlying conceptual knowledge that one might hope to foster* "(Barron *et al.,* 1998).

1.9.3 Project-based learning

Project-based learning (PjBL) is a model that organizes learning around projects (Thomas, 2000). Project work follows traditional instruction in such a way that the project serves to provide illustrations, examples, additional practice, or practical applications for material taught initially by lecture-based. Students learn the central concepts of the discipline via the project thus it is a student-centred approach to learning (Chandrasekaran *et al.,* 2012; Prince and Felder, 2006).

PjBL encompasses a diversity of approaches, the researcher adopted the defination by Prince and Felder (2006) for the study:

> *Project-based learning begins with an assignment to carry out one or more tasks that lead to the production of a final product – a design, a model, a device or a computer simulation. The culmination of the project is normally a written and/or oral report summarizing the procedure used to produce the product and presenting the outcome.*

This definition encompasses a project that are central, not peripheral to the curriculum, a range of educational activities are imposed on students such as active and collaborative learning; the problem-based learning in PjBL drives students to encounter the central concepts and principles of the discipline; the projects involve students in a constructive investigation of 'real' design problems and student-driven to some significant degree to projects.

1.9.4 Engineering Design

Design is widely considered to be the central and most distinguishing activity of civil engineering (Akili, 2007). Design has been employed as a vehicle for project-based learning and exposes on how theory is brought into practice. In this research, the design as in structural reinforced concrete design course, DDA3164 using the engineering design process described by Khandani (2005).

1.9.5 Field Project-based Learning

Field project-based learning is learning incorporating "hands-on" activities through projects by developing interdisciplinary themes as well as conducting field trips. Thus it is project-focused based on experiential education or active learning (Thomas, 2000).

1.9.6 Design Abilities

Design courses emerged in education as a means for students to be exposed to theory and practice where they could learn the basic elements of the design process by doing real design projects. Design abilities encompass the Outcomes 3a–3k of ABET 2000 in which graduates should have the knowledge, skills, and attitudes of learning. These skills and attitudes are both technical and non-technical and come from cognitive and affective domains (Mourtos, 2011). These skills include analytical skills, open-ended problem solving skills, a view of total engineering, ability to use design tools as well as interpersonal, communication and team skills.

1.9.7 Life-long Learning

Life-long learning is a continuous learning process that stimulates and empowers individuals to acquire all the knowledge, values, skills and understanding they will require throughout their lifetimes (Savage, Chen, and Vanasupa, 2006).

1.9.8 Student-Directed Learning-(SDL)

SDL is a continuous engagement in acquiring, applying and creating knowledge and skills in the context of an individual learner’s unique problems (Steward, 2007). It places the responsibility on the individual to initiate and direct the learning process and can enable an individual to adapt to change (Savage, Chen, and Vanasupa, 2006).

1.9.9 Problem Solving Skills

According to Stojcevski, (2012) problems are often complex, ill defined and with no singular process model. There are different kinds of problems which exist in design. It requires system, procedural and strategic knowledge that students need to develop for contextual thinking and decision-making.

1.9.10 Collaborative Skills

Collaborative skills are the ability to work effectively and respectfully with team members (Göl and Nafalski, 2007). Students should also able to exercise the flexibility and willingness to be helpful in their respective teams and in making necessary compromise to accomplish a common goal among their teams. In addition, students should be able to share responsibility for collaborative work, and value the individual contributions made by each team member.

1.9.11 Assessment Method

Methods or procedures used to evaluate students achievements based on performance or student learning (Aziz, 2009). The evidence is based on what students can do and what they know (Biggs and Tang, 2007).

1.10 Organization of the Thesis

Chapter 1 provides the introduction and background of the research. The conceptual framework of the research, the research problems and research objectives, which guide the study are also presented in this chapter.

Chapter 2 reviews the literature related to the research. The project-based learning in design is highlighted in relation to the attributes and abilities, as well as, the models in PjBL. The relevant educational theories, skills required for project-based learning and the assessments of project are also provided.

Chapter 3 describes the research methodology of PjBL approach. The details of the study such as the choice of case study institution, data collection methods, data analysis and issues related to the reliability and validity of the data is also presented in this chapter.

The result, analysis and discussions of the research are provided in Chapter 4. The discussions are presented in relation to learning attributes and abilities demonstrated by the students engaged in field project-based learning.

Chapter 5 presents the conclusion of the research findings. The field project-based instruction to enhance the students' design ability is presented together with some recommendations for project-based learning practice. This research also offers an improved assessment method to focus on student design effort on communication and teamwork. Lastly, recommendations for further research are also offered.

1.11 Conclusion

This chapter discusses the current project-based learning in structural design course that includes the learning objectives and outcomes, teaching and learning activities in the course and the assessment method. The current and most common project-based learning is classroom-based and does not address and correspond the learning outcomes and objectives. Moreover, the design processes of students learning and reasoning within a task-based context need to balance the theory learnt and practice in design as expected by the industry. Thus, the focus of the research is the field project-based learning (FPjBL) in a structural design course where students are partially engaged at the industry. The challenge is to produce the field project-based learning instruction guide that could inculcate the knowledge, practical and attitudes acquired by students. The literature review related to this research is discussed further in Chapter 2.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents related literature focusing on project-based learning (PjBL) in line with engineering design education. In order to understand the context of this study, it is necessary to develop the understanding of the background of engineering education in general, and the structural design education in particular. The nature of engineering design and its process, teaching and learning activities in the engineering design courses, the need and expectation of industries with regard to skills and abilities in design are examined. Models and approaches of PjBL as practiced by several institutions in relation to learning outcomes, attributes and abilities are presented. Relevant educational theories related to PjBL in design assessment and evaluation in PjBL are also discussed.

2.2 Engineering Design

Design is a subject that is constantly being studied and analyzed as the most distinguishing activity of the engineering profession (Akili, 2007; Simon, 1996; Dym and Little, 2000). According to Mourtos, Okamoto and Rhee (2004), design is the heart of engineering practice and a complex process (Mourtos, 2011; Grigg *et al.,* 2004). It is central to the learning of engineering design education and it has captured the interest of many stakeholders and researchers.

Design is an essential part of engineering activity because it requires both technical and non-technical competencies. Such competencies relate to one's cognitive and affective domains (Mourtos, 2011). In fact, design courses have emerged as an intermediary for students to be exposed to the skills of engineers. The key to any engineering discipline is design because design abilities and skills in engineering is the application of scientific principles to design. By designing, one could learn the basic elements of the design process through involvement in real design projects (Akili, 2007).

Design has traditionally been an important part of an engineer's training (Hasna, 2008), either as whole subject or integrated as a project in civil engineering courses (Sobek and Jain, 2005). The Accreditation Board stated the importance of design for Engineering and Technology (ABET, 2000) through its statement:

> *Engineering programs should not only teach design courses but also integrate design concepts into their engineering curriculum.*

ABET (2000) also specifies that engineering graduates must demonstrate the following skills and competencies; a) the ability to design a system, component, or process, b) the ability to function on multidisciplinary teams, c) the ability to identify, formulate, and solve engineering problems; d) the ability to communicate effectively. Likewise, the engineering emphasizes undergraduate engineering graduates should develop an understanding of the design process as well as the ability to work in teams, communicate effectively, think critically, and solve problems (Coleman, 1996; Rhoads *et al.,* 1995).

According to Felder and Brent (2003), the ability to design is one of the most important attributes of the twenty first century engineering education. This is because it is dealt with the creation of new and improved systems, processes, and products to any engineering activity (Mourtos 2011). ABET's (2000) definition of design is;

> *the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective.*

Dym, *et al.* (2005) promotes engineering design as a thoughtful process because design is complex and hard to teach. The authors defined 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 specified set of constraints.*

The thoughtful process in engineering design depends on the systematic, intelligent generation of design concepts and the specifications. These processes encompass skills related to design engineers (Dym and Little, 2003; Dym, 1994). The skills as characterize by Dym *et al.* (2005) of design engineers, he/she should be able to; a) tolerate ambiguity that shows up in viewing design as inquiry or as an iterative loop of divergent-convergent thinking, b) maintain sight of the big picture by including systems thinking and systems design, c) handle uncertainty and able to make decisions, d) think as part of a team in a social process; and think and communicate in the several languages of design.

On the other hand, the majority of the educational content in engineering design is taught in an epistemological approach, systematic questioning, where known, proven principles are applied to analyze a problem to reach answers or solutions (Dym *et al.,* 2005). For this study, the definition of engineering design by Dym *et al.* (2005) is being used to reflect the design skills and abilities expected in the FPjBL designed by the researcher. The problems related to the engineering design will be further discussed in this chapter.

2.3 Engineering Design Process

Published models of engineering design process are widely available and often illustrated with a block or cyclical diagrams. The diagrams encloses each stage of the process and identify the stages using arrows, typically double-ended to signify iteration (repetition) between phases. The number of stages depends on the detail and complexity with which the design process is rendered. However, whether block or cyclical diagrams are used, it does not fundamentally alter the step's content but underscores the central role of iteration in design (Mosborg *et al.,* 2005).

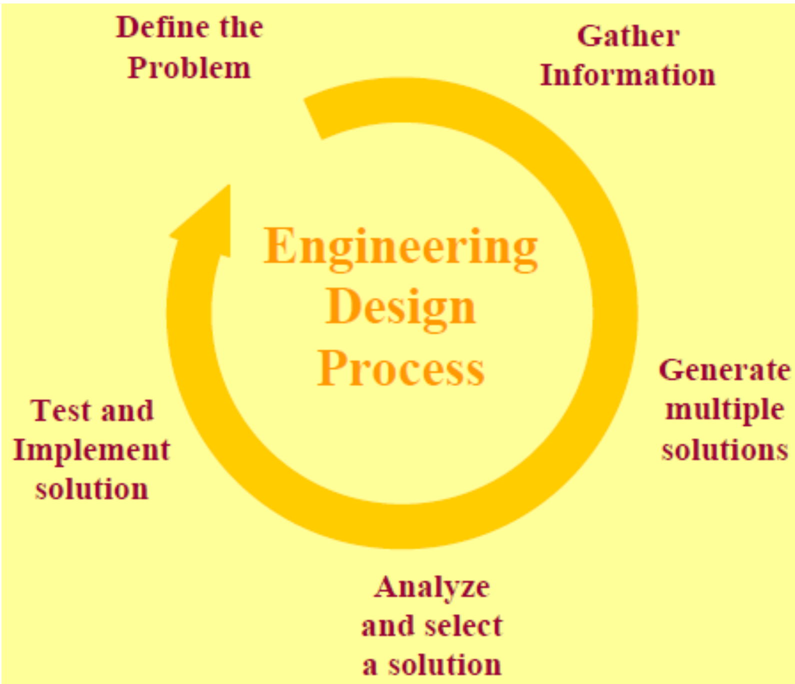


Figure 2.1: Design Process by Khandani, (2005)

Khandani (2005) introduced 5 stages of engineering design process (refer to Figure 2.1). He considers design problem as highly iterative (repetition) process. Since design problems are vague and have multitude of correct answers, Khandani (2005) believed that design process may require backtracking and iteration. Unlike Khandani (2005) and Oakes (2004) employ the eight phases of design process (refer to Figure 2.2) which he called the 'design cycle'. Each phase of his design cycle may be repeated many times before the production of the design. In addition, iteration is part of his design cycle whereby brainstorming in any step would be carried out to generate the solution of a design problem.

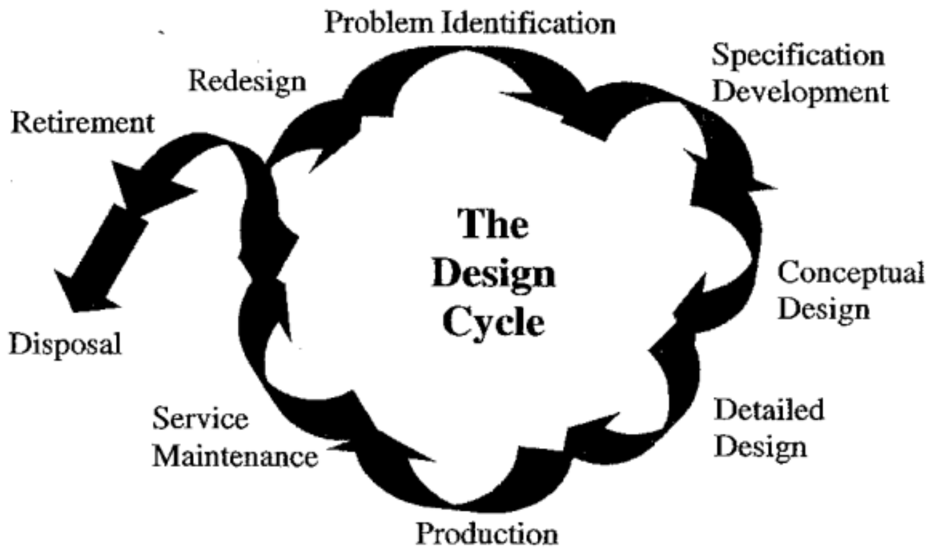


Figure 2.2 : The Design Cycle by Oakes, (2004)

Voland (2004) attempts to quantify the design process and its accompanying tools and techniques into a more technical practice. He used a 5-step cycle to describe the design process, and strongly emphasized the theme of ‘iteration’ and the ‘needs’,analysis. He highlighted the need for iteration and how it can begin at any point within the design process. His design process is strived for technical definitions of the design process, but in some instances fails to relate the goals of the design process in relation to the learning outcome of the students.

Nicolai (1998) used open-ended problems in his design process shown in Figure 2.4, since these are the only type of problems that occur in industry. He suggested that student must be exposed of an experience being an engineer by introducing problem situations, which force them to link engineering theory to real-world problems. This can be done by doing some original thinking, evaluating alternate solutions, making a decision and defending it.

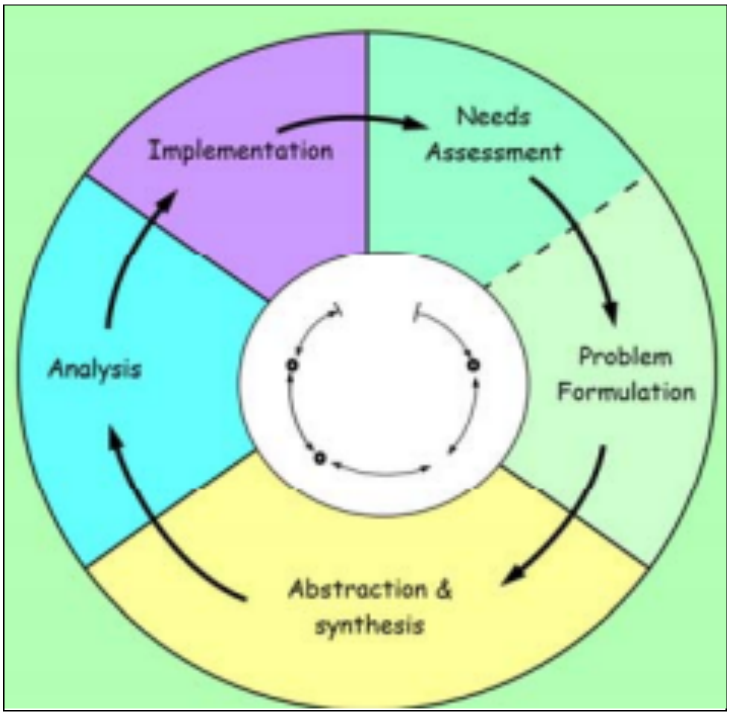


Figure 2.3 : The Design Cycle by Volan (2004)

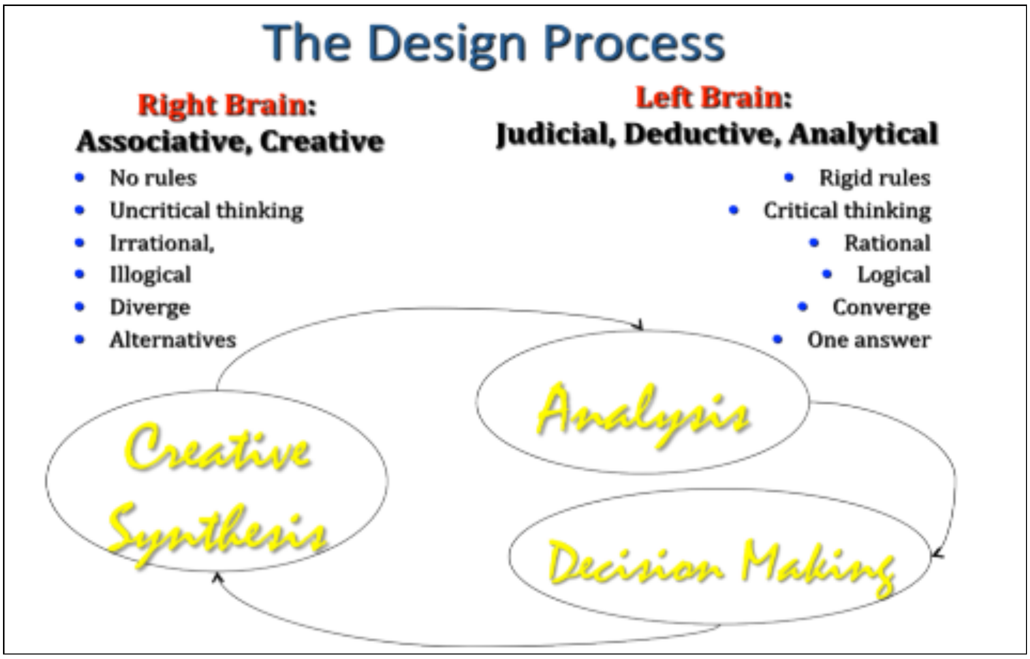


Figure 2.4 : Open Ended Design Process by Nicolai, (1998)

On the contrary, Mourtos's (2011) design process involves an iterative cycling through a sequence as shown in Figure 2.5 . He referred the process as a sequence of convergent-divergent thinking (Nicolai, 1998). This is because iterative engineering design process requires experience that students need to undergo in the form of open-ended problem by exploring, analyzing, evaluation and making decisions. This convergent-divergent component occurred in every phase in Oakes' (2004) design process as well.

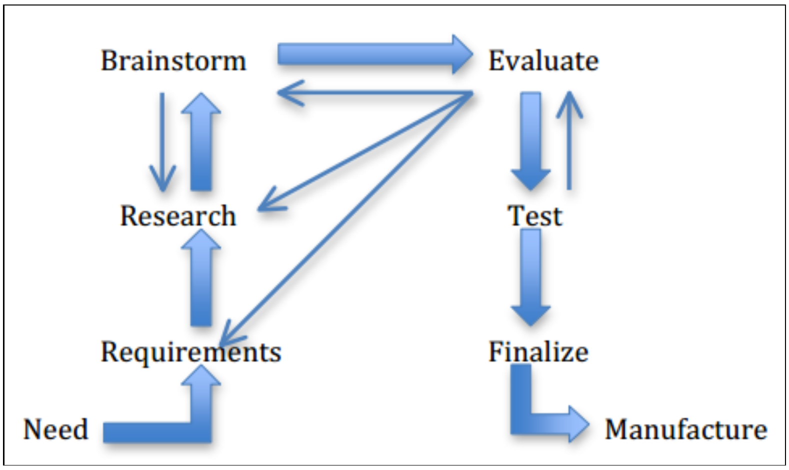


Figure 2.5 : The Engineering Design Process (Mourtos, 2011)

Dominick, *et al.* (2001) discusses four critical skills in design process. He established these skills from his own professional experience of decision making, project management, communication, and collaboration. These skills are generally demonstrated by the students through active and experiential work with design projects.

With regards to project based learning, Teck (2009) elaborated that engineering design process applied in project-based learning typically consists of activities such as project definition, investigation, processing of data, realization and evaluation. In his design process, the first step is the clarification and understanding of the project requirement. Next is the investigation phase where the activities include finding resources, collecting data, interviewing, observing and selecting the appropriate data. During the processing activities phase, the students will attempt to make sense of the data collected through analysis, classification and synthesis of the product. Finally, the realization phase will require the students to conceptualize possible solutions, learn how to prioritize and manage their time in order to produce a prototype.

Despite various representations of the engineering design process shown in Figure 2.1 to 2.5, the design process are consistent with respect to its process. It is important to recognize that any model is a simplified description of a more complicated reality. Not every step will be used to the same extent in every design, and some steps may be performed out of order. The design process continues as long as the need continues, and it ends only when the cost of continuing process exceeds the value of an improved design.The design process is repeated again and again as new and better solutions are developed.

This section has discussed several learning design process in established models proposed by several researchers such as Khandani (2005), Oakes (2004), Voland (2004), Nicolai (1998) and Mourtos (2011). Although these design models highlight the students' ability to design and solve problems, they do not encompass students' generic competencies such as their ability to function in multidisciplinary teams and engage in effective communication. Such are ABET's requirements on engineering programs and should be addressed and embedded in the design learning process. This is the inadequacies of the prescribed models and will be addressed in this thesis.

2.4 Teaching and Learning Issues in Design

Engineers face significant challenges in the 21stcentury as there is a growing demand for engineers who are knowledgeable, having technical competence as well as skills in human relations (Mills and Treagust, 2003; Arciszewski and Lakmazaheri, 2001). Today's engineers must also cope with continual technological revolution and organisational change in the workplace, commercial realities of industrial practice as well as the legal consequences of every professional decision they make (Arciszewski and Lakmazaheri, 2001; Mills and Treagust, 2003).

Moreover, the concerns of administrators to reduce cost and to improve the quality of education mostly focus on the student's course evaluation. They prefer to focus on immediate measures rather the long-term efforts to improve the structural design education (Arciszewski and Lakmazaheri, 2001). The quality of future engineers depends very much on the quality of engineering education, which in turn is highly dependent upon the developments in the engineering curricula (Nguyen, 1998).

Despite these challenges, the predominant model of engineering design education remains similar to that practiced in the 1950's; academics lecturing large classes with single-discipline, normally lecture-based delivery delivered in the early years of study (Mills and Treagust, 2003; Dym, 2004). The literature that follow will highlight some critical issues pertaining to engineering design teaching and learning activities in engineering education.

2.4.1 Content Versus Process Driven

Historically, engineering curricula have been based largely on an engineering science model called the Grinter report (Mills and Treagust, 2003; Akili, 2007). Universities have engaged in rigorous theoretical and technical courses on basic sciences and fundamental engineering in training the engineering students. For example, the research by Petroski (2000) and Seely (1999) have reported that engineering programs have overemphasized analytical approach and engineering science at the expense of "hands on" design skills. In another instance, research by Mills and Treagust (2003) reported that many engineering programs are content driven rather than process driven. Wallace (1996) and Dym (2004) reported that content areas of engineering program are separated from engineering application and agreed that most engineering courses are currently based on the development of fundamental scientific principles.

Analysis on the program guide books of many universities, it is evident that most engineering programs spend the first few years of the curriculum focussing on basic siences, mathematics and engineering science. This finding reflect that engineering curricula are focussing more on engineering science and technical courses but not providing enough integration of topics relating to industrial practice. Therefore, engineering design courses need to include and improve on the current trend of design education by integrating the theory and practice via implementation of projects within the curriculum.

Another parameter to justify that many engineering programs are content driven is by analysing the assessment of engineering courses. The assessments are mostly related to the demonstration of the technical concepts and principles. These concepts and principles are generally closed-ended problems based on tests and examinations and cover the technical aspect of the course.

Felder and Brent (2003) studied the learning and teaching of engineering courses and they concluded thatengineering projects are able to assist students to achieve the desired learning outcomes. This is because the teaching and learning activities in the courses demand students' knowledge, skills and attitudes (Hiscocks, 2005), consequently, these activities support the students achievement and performance in the course. Thus, universities must make provision for engineering courses to include teaching and learning activities with materials that are updated and capable of enhancing the skills and attributes of future engineers (Nguyen, 1998). For the purpose of this study, the teaching and learning activities based on the recommendation made by Felder and Brent (2003) was selected (Please refer to Section 3.7 for detailed discussions on the teaching and learning activities in design)

2.4.2 Old Versus New Instructional Strategies

In order to prepare students with future workplace environment, changes have to be made to the current delivery of engineering education. Felder *et al.,* (2000) revealed, "…many engineering classes in 1999 are taught in exactly the same way that engineering classes in 1959 were taught”. This is a shocking revelation because for the past 40 years, there is not much improvement in the way engineers have been taught (Puteh, Ismail and Mohammad, 2010). Harris and Cullen (2009) agreed with Felder *et al.*’s (2000) assertion that engineering curricula is still employing the traditional practice of adding content to address the Engineering Criteria 2000. These old-fashioned instructional strategies have prompted Mills and Treagust (2003) to argue for more student-centered activities in engineering programs such as PjBL.

Many engineering programs are involved with project work and practicals. These activities could allow students to gain “hands” on skills and experience through student-centred approach. This student-centred approach can facilitate the students’ learning and provide oppurtunities for them to be creative, engage in critical thinking and become problem solvers. Design projects is also used as a vehicle to motivate and integrate learning to students in engineering courses (Dym *et.,al* 2005). Teaching students in project and asking them to work on the project tasks on real work can expose them to “learn-by-doing” (Akili, 2007).

Several researchers have carried out the PjBL approach of design at course level and curriculum level. Many engineering programs have offered capstone design courses (final year project), and more are beginning to offer a cornerstone (first year of study) as an introductory project-based course. Little and King (2001) reported that PjBL is performed at Harvey Mudd College as cornerstone projects to support fundamental design education, whereas the capstones in PjBL is focus on conceptual design methods (Dym *et al.*, 2005). The cornerstone project-based courses are also seen to enhance students’ motivation and their retention in engineering, partly because they introduce engineering content and experience early in the curriculum. In addition, first-year students are also in direct contact with the engineering faculty (Dym, *et al.,* 2005). In this projects students are encouraged to explore solutions utilising design tools that would be used by a practising engineer. By doing so students would be able to relate to the theory. According to Anderson (2007), PjBL can foster an atmosphere of self-directed, self-paced and flexible learning within the framework desired outcomes for the students (Andesrson, 2007).

2.4.3 Theory Versus Practical Experience

The current program does not provide sufficient design experience for students as claimed by Mills and Treagust, 2003. A decade ago, Dym (1994) warned that design is complex problem solving that involves generating and evaluating specifications to achieve objectives and constraints. He associated design skills as the skills of *"good designers"* who can tolerate ambiguity while maintaining the big picture, able to handle uncertainty when making decisions, thinking as part of the team, and communicating with several languages of design. This issue was agreed by Niccolai (1998) that the engineering curriculum must let the student experience the learning by introducing problem that force students to link theory into practice by doing original thinking, evaluating alternative solutions, making a decision and defending it. The open-ended problem at industry is an example whereby students are exposed to the problems that occur at the industry.

In contrast to the lecture method, the teaching approach such as PjBL emphasizes faculty and students' interactions. For instance, Dym (1994) encourages "interactive dialog" between the lecturers and students in projects so that students learn to interact with individuals who hold various viewpoints, and developing design specifications and calculations. Similarly, Dally and Zhang (1993) emphasize that the teaching and learning process involves two-way communication between the students and the faculty members; the faculty member as a consultant and a coach, by providing assistance and encouragement. All these senarios reflects that design education can be carried out in the teaching and learning activities such as PjBL. The lecturers can also act as supervisors and customers for the design as described by Harris and Jacobs (1995) by giving advice on specific design concerns.

Other approach to student-centred learning is the use of industry sponsored design projects. It has become more widespread and is frequently perceived as an improvement on traditional instruction methods as reported by Ivins, (1997); Keefe, Glancey and Cloud (2007). The industry sponsored approach is gaining momentum as it gives exposures to the student. Other approaches in the teaching of design as suggested by Paulik and Krishnan (2001) and Benjamin and Keenan (2006) is by introducing elements of competition or placing emphasis on problem-based learning on students (Benjamin and Keenan, 2006).

Engineers must constantly improve their methodologies in design especially familiarising the knowledge of codes and standards awareness of the changing needs of society. However, the demands of engineering practice has far exceeded, the pace and scope of engineering education (Eggert, 2002). Therefore, students should be prepared and equipped with knowledge, skills and attitudes as required by the National Academy of Engineering (2005) that is by providing students with more design experience. Thus, project-based learning (PjBL) in design courses has been given considerable attention in engineering education locally and abroad to develop the design skills and abilities that students are lacking from the traditional lecture-centred approach.

Currently, many engineering curricula comprise of theory and practical classes but according to Harris (2001) the theoretical lecture courses covers the largest volume of the material. This could hinder students' attention on the material delivered and this kind of teaching are often criticized for not engaging the students' attention. Therefore, the integration of theory with hands-on design projects in PjBL implemented at Harvey Mudd's Computer Engineering class has proven to be effectively engaged students in their learning.

Not only that, it is also discovered that lecturers lack practical experience in teaching design courses and only a handfull of lecturers possess industry experience on design (Mills, 2002). Lacking such experience, lecturers may not adequately relate the design theory into practice. Therefore, in order to provide students with good design education, lecturers must carefully be equipped with the design learning experience. A practical training program at the industry for lecturers can help overcome this problem.

Currently, the higher learning institutions regard research activities as a primary criterion for academic staff promotion. Thus, the training of lecturers at industry appear to be a significant issue. Firstly, the lecturers are reluctant to move outside their research zone where they are confident and focus. Secondly, the lack of support from management on practical training limits the PjBL working group on design. Finally, the support group from industry to facilitate design projects is limited due to the minimum relationship between the industry and university.

2.4.4 Enhancing Communication and Teamwork Skills

Several researchers have identified that graduates still lack communication sklls and teamwork experience (Kashefia, Ismail and Yusof, 2012; Felder *et al*., 2000). Moreover, universities and industries agree that many engineering students upon graduation lack generic skills such as communication and teamwork (Nguyen, 1998; Felder *et al*., 2000). Thus, more oppurtunities for students need to be offered for them to develop these skills and abilities. As suggested by Felder *et al*. (2000), engineering programs should provide some guidance on how to instill these communication and teamwork skills to students.

Working in the design office is project-based therefore teamwork is necessary. Teamwork can give students an appreciation of the complete design cycle through the real design project as each student will work as part of the team to produce a design for the project. According to Mills and Treagust (2003), critical issues in the current delivery of engineering education can be overcome if the engineering science are integrated with the technical courses and relate to industrial practice. This will provide sufficient design experiences and exposure to students while engaging them with communication skills and teamwork experience (Mills and Treagust, 2003). Therefore, faculty can expose students to modern engineering practice and developing more awareness amongst them, the impacts of social, environmental, economic and legal through the involvement of the industry. Moreover, there are demands from the accreditation boards such as MQA and ABET for engineering programs to improve students' abilities in oral and written communication and teamwork.

The above discussion has focused on the pedagogical issues in the teaching of design. It can be summarized that the problems include the following:

a) Engineering programs have overemphasized content rather than the learning process.

b) Many engineering design courses are still delivered using the traditional teaching approach.

c) Theoretical lecture-based classes are still practised in project-based learning.

d) Students' communication and teamwork still are not given due recognition in project-based learning.

2.5 Industry Expectations On Engineering Graduates

Industries generally seek graduates who have expertise in technical skills. The findings of the " *Educating Engineers for the 21st Century*" by Spinks, Silburn and Birchall (2006) reported the requirement of industry on engineering graduates as;

> ' *Industry wants engineering graduates who have "practical experience of real industrial environments". Specifically, "industry ... regards the ability to apply theoretical knowledge to real industrial problems as the single most desirable attribute in new recruits.*'

Surveys conducted mainly in USA and Australia of industry perceptions of engineering graduates (for example, Evans et al. 1993, Katz 1993, Lang et al. 1999, Meier et al. 2000, Sageev and Romanowski 2001, Scott and Yates 2002, Holcombe 2003) have consistently identified communication and teamwork as important attributes where "competency gaps" are frequently found. The importance of these non-technical skills in promotion and career success is discussed by Sageev and Romanowski (2001), Bhavnani and Aldridge (2000) and Scott andYates (2003).

The need for the change of engineering education in Malaysia has been reported by Hassan *et al*. (2007) and Zaharim *et al*. (2007). Economic challenges and globalization forced employers to seek for competent graduate engineers. Consequently, graduates have to prepare themselves not only with excellent academic qualifications but also with relevant capabilities, skills, abilities and personal qualities. Furthermore, several researchers in engineering education found that the current educational system and practices does not provide enough emphasis on teamwork, communication, knowledge retention and ability to synthesize and make connections between courses and fields (Zaharim *et al.,* 2009. Similarly, Hassan *et al.,* (2007) and Juhdi, Jauhariah and Shahruddin (2007) claimed that Malaysian graduates lack in generic skills such as communication and leadership.

The last decade has seen an increasing debate on the quality of engineering education (Graham and Crawley, 2010; Strobel and Barneveld, 2009). Moreover, the Vision of Civil Engineer 2025 requires the body of knowledge necessary to effectively practice civil engineering at the professional level in order to blend technical excellence with the ability to lead influence and integrate all skills to optimise approaches to planning, design, and construction. At the Summit, participants created a profile of the civil engineer in 2025, that the attributes possessed by the individual must be consistent with the profession's aspirational vision. The desired attributes are knowledge, skills, and attitudes. The knowledge is largely cognitive and consists of theories, principles, and fundamentals and skill refers to the ability to do tasks such as problem solving and think critically.

Employers have high expectation on fresh engineering graduates to perform as soon as they are hired (Zaharim *et., al* 2009). Industries want students who can work in team-based projects. This is because almost every task undertaken in professional practice by an engineer will be in relation to a project with varying times scales. Projects have varying complexity and its completion requires the integration of all areas of an engineer's undergraduate training (Mills, 2002). In addition, projects helps students to develop skills and gain the experience necessary to carry out projects successfully in the real world (Tedford, Seidel and Islam, 2006). Montufar-Chaveznava, Yousuf and Caldelas (2008) claimed that not only project generates good results but it also manages to bring about the agreement between the demands of the industries and university instructions in regards to the skills and abilities of engineering students.

Many studies have been carried out to determine the skills and abilities required of engineers by today's industries (Nguyen, 1998; Shafie and Nayan, 2010). These include the need to improve especially in non-technical aspects of engineering education. Industries are seeking graduates who are technically skilled as well as possess non-technical skills (Mourtos, 2011; Noordin, Md Nasir, Ali and Nordin, 2011) in order to survive in the work force. The most dominant attribute and skill required of industry apart from communication skills, problem solving, ability to work in a team, interpersonal skills and self-motivation is analytical skill (Anderson, 2007). International survey on chemical engineers from 63 countries showed that effective communication and leadership indicated high deficiencies in Australia (WCEC, 2004). Accreditation bodies such as ABET and MQA (refer to Figure 2.7) require non-technical component, including ethics, lifelong learning, team work and communication skills as part of the engineering curricula.

Design is the fundamental core of structural engineering design of Civil Engineering (Academic Guidelines, 2010/2011) (the others are geotechnical, water and transportation engineering). To structural engineers, design is what they do when they develop the schemes for construction of a building (Mills and Treagust, 2003). According to Dickens (1998), it is necessary to expose students in context with industries to enrich student learning in design. For example, the industrial attachment to students can benefit not only the students but also the academics and industry.

The engineering environment at industries has changed dramatically. International competition, the shift from defense toward commercial enterprise, and new technologies have restructured the industry and altered how engineers practice engineering. William A. Wulf, the President of the National Academy of

Engineering, defines engineering as "design under constraint."[2] Increasingly, engineers must supplement technical mastery with business and communication skills, and an understanding of the ethical and societal impact of engineering solutions. Traditional engineering undergraduate programs, at over 130 credit hours for a BS degree, are not set up to handle an increased liberal education component or radically different modes of curriculum delivery such as team-based or affective domain modalities. A previous study by Graham and Crawley (2010), solicited feedback from the industry that calls for change from industries to ensure that engineering graduates are equipped with a broader and greater experience of addressing real engineering projects.

2.6 International Practice of Project-based Learning (PjBL) in Engineering Design

Project is an activity used in engineering as a unit of work (Mills and Treagust, 2003). Projects or project work may refer to an exercise, a task or an activity. Project method is called as project-based learning by some authors such as Adderley (1975), Kilpatrick (1921) and Kuethe (1968). According to Kolmos (1996) project work is:

> *a way of organizing the learning process that characterized by an active discussion and writing process carried out in group-based course. Project work stresses the process as well as the product in project report. Teamwork is an integrated concept of project work.*

This definition is made on the context of engineering education. It places the importance of organizing the learning process and end product of the project as defined by Thomas (2000) as;

> *a model that organizes learning around projects.*

From the two definitions above, it is deduced that there are three basic types of projects depending on the extent of lecturer control or student control as described by Kolmos (1996) as well as different objectives, knowledge and skills. According to Kolmos (1999), the distinction between the three are as below;

1. Assignment projects that involve planning and control by the lecturers. The problem, the subject and the methods are choosen in advance. These project are implemented traditionally in the engineering program.

2. Subject projects are student control whereby students make the choice of the problems.

3. Problem projects that are based on the problem whereby students start with the problem, analyze it, find and select the solution and implement.

Projects in practice requires the integration of all areas of engineer's training, therefore it should be a major component of student learning. Moreover, task undertaken by professional practice will always be in relation to project. PjBL may also be applied in individual course or throughtout a curriculum (Mills and Treagust, 2003; Heitmann, 1996).

According to Heitmann (1996), there are two types of project depending on its application; project-oriented study and project-organised curriculum. Project-oriented study involves small projects within individual courses. The project is integrated in the traditional teaching of the same course. Normally the project will focus on application and integration of previously acquired knowledge. Normally the projects can be carried out individually and in small groups.

In project-organised curricula, the projects are used to structure the principles of the entire curriculum (Hietmann, 1996). This type of project would focus on related subject-oriented required for a certain project. Students work in small group and lecturers as advisors and consultant. Project undertaken throughout the course and vary from one semester to a year. This kind of PjBL has been practiced at

Aallbory University in Denmark. The PjBL of this study belongs to the first type that encompases assignment project by a lecturer, facilitation is done by lecturer and an engineer from industry to assist students' learning in project.

The term project-based learning (PjBL) was used from 1980's as reported by Morgan (1983) where students are given some degree of choice in the outcomes. Students develop an understanding of a topic or issue through some kind of involvement in an actual real life problem or issue in which they have some degree of responsibility for designing their own activities (Goa, Demian and Willmot, 2008).

PjBL has been defined in various ways by different educational disciplines and levels (Mills and Treagust, 2003). However, according to Chandrasekaran, *et al.,* (2012) generally the principles of project-based learning in common are as follows:

1. Student's work in groups and collaborate on the project activities.

2. The problem ia a real world problem that affects the life of the student's is presented for investigation.

3. Student's discuss findings and consult the lecturer for guidance, input, and feedback.

4. The level of student's skills determines the degree of guidance provided by the lecturer.

5. The final products resulting from project-based learning can be shared with the community-at-large, thus fostering ownership and responsible citizenship in addressing real world problems.

There are other definitions of PjBL as stated by other researchers. As an example, according to Kraft (2005) and Moylan (2008), PjBL may be described from two different perspectives. One perspective emphasizes the students performing a lecturer-facilitated project, with the transformation from 'lecturer telling' to 'students doing'. The second perspective uses lecturer-guided project and involves students' self-directed learning while using a standard curriculum approach. In both perspectives, the lecturer is the enabler of learning, utilizing a hands-on approach to engage the student learning.

Engineering education is expected to put theory into practice (Lee and Lai, 2007). Thus, PjBL is the best strategy when teaching basic and advanced engineering subjects in engineering design because students are able to link both theory and practice (Montufar-Chaveznava, Yousuf and Caldelas, 2008). Some generic skills such as management and communication are also reinforced on the students during project realization, providing better engineering education (Montufar-Chaveznava, Yousuf and Caldelas, 2008).

In conclusion, PjBL is an effective method of learning in the engineering curriculum (PBLE, 2003; Hiscocks, 2012). Project encourages the involvement of the students in their learning processes in engineering. Thus PjBL is a student centred approach to learning (Chandrasekaran *et al.,* 2012). Usually it is task oriented in which the project is often set by the lecturer and the students are expected to produce solutions to solve the design problem. The design problem is open ended and focus on the application and assimilation of previously acquired knowledge.

However, there are choices in the implementation of project in engineering design. As projects is a central role to any engineering, lecturers can use PjBL as an educational tool in design (Hiscocks, 2005). PjBL is an effective method of learning in engineering courses and curriculum because it encourages the involvement of the students in their learning process (Guerra and Kolmos, 2011).

Table 2.1 shows the PjBL practices in some country in the world. As can be seen from the table, the PjBL outcomes are being used extensively in courses in engineering programs, covering a range of disciplines as well as at program and curriculum level (Mills and Treagust, 2003). Some examples of PjBL in engineering programs reported in the literature included the program at Aalborg in Denmark, CDIO which is the collaborative efforts of the Royal Institute of Technology (Sweden), Linkoping University (Sweden) and the Massachusetts of Technology (USA) and Monash University in Australia, are described in detail below (refer to Chapter 3 for the discussion on the PjBL currently at CST, UTM).

Table 2.1: PjBL Practices and Learning Outcomes

University	Type of PjBL	Year	PjBL Outcomes
Aalborg University, Aalborg, Denmark	Problem based Project Organized 50% Course and 50% Project work.)	1974- University level Curriculum. Undergraduate and post-graduate	1) Increased motivation towards learning and students engagement in project work 2) Development of process competencies
University of south Australia, Australia.	Project based learning Capstone Project14 week module	1995 - undergraduate	1) Students work as a company. Simulation of real work environment. 2) Project and finance management, information managements. 3) Group learning.
University of Oklahoma	Sooner City Project developing a city's infrastructure	1996 - Civil Engineering and Environmental Science. Integrated design project throughout the curriculum.	Real engineering design problem to address graduates' problems in technical literacy; oral and written communication skills; and design experience
Four British Universities	PjBL/PBL	Curriculum-undergraduate	1) This study shows project work can improve student's transferrable skills, and their perception of subject content. 2) This should also shows that information learned by project work has over 80% more retention after one year compared to lecture based learning.

University	Type of PjBL	Year	PjBL Outcomes
Stanford University, California	(P5bl) lab model Problem, projects, process, products and people	1993- Civil and Environmental Engineering	Famous for its' ground breaking work on Global Project Based Learning (PBL), development of the pedagogical principles, the ICT environment. The purpose is to engage graduate and undergraduate students, faculty, and industry practitioners in multi-disciplinary, collaborative, geographically distributed PBL activities.
Indian Institute of Technology Delhi, India	Project based learning Robotic competition.	2008- Final year undergraduate	Understanding of the engineering product development, project management skills. (Manvendra, 2008)
Univ. of Queensland Australia	Project Based Learning attributes based curriculum design	2009. Undergraduate chemical engineering CAPE activities	The curriculum is designed in a way that graduates obtain professional skills and process skills. The model is designed based on graduate competency profile and accreditation norms
Roskilde University	Problem-oriented project work50% courses and 50% project work.	1972-University level Curriculum: Undergraduate and post-graduate	RU promotes elements such as interdisciplinary, problem situation and group project work. The starting point is a real life technical problem. The courses at RUC give students an extensive technical and procedural knowledge, and expose theories and methods. Students learn to organize and execute projects with other teams

1. The Aalborg University PBL Model

One well-known example of PjBL implementation is practiced at Aalborg University, Denmark. It is a predominantly project-organized curriculum in engineering program that has been described and summarized by several authors (Fink, 1999; Luxhoj and Hansen, 1996; Kjersdam, 1994; Mills and Treagust, 2003) since its establishment in 1974. The project work requires 500 hours of workload per semester. This co-operation between the university and industry is closely realized to allocate real-life engineering problems to solve.

PjBL at Aalborg is strongly problem-oriented with the project work as the key element. The project comprises three main principles as shown in Figure 2.6. Each project work comprises problem analysis, problem solving, and report. However, the first year at the university, students are required to complete basic studies based on traditional format. This basic study includes fundamental studies such as mathematics and physics as well as the introduction of project work and teamwork. The curriculum comprises of 50% project work, which is 25% on course work and another 25% on coursework fundamental studies such as mathematics and physics. The projects are gathered from industry problems and assigned every year to students. Students work in group of five to seven for the project and they are assigned office space to work on their projects. Students are given the freedom to choose the projects as approved by the faculty as well as to select their own group members every semester.

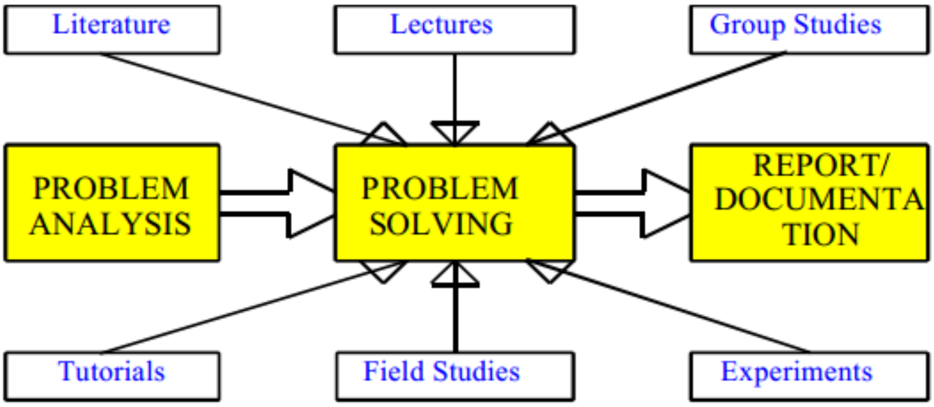


Figure 2.6 : Principles of project organized problem solving (Kjersdam, 1994)

2. Conceiving-Designing-Implementing-Operating (CDIO)

The Conceiving, Designing, Implementing and Operating or the CDIO model originated at MIT in the late 1990s and later was developed by the collaborative efforts of the Royal Institute of Technology (Sweden), Linkoping University (Sweden) and the Massachusetts of Technology (USA). It aims at preparing engineering students for the future, by systematically reforming engineering education (Crawley *et.,al* 2007). The CDIO approach has become popular and is adopted by a number of universities worldwide including Arizona State University, Beijing Jiaotong University, Purdue University, Lancaster University, Taylor's University Malaysia and Singapore Polytechnics, to name a few.

A CDIO undergraduate engineering education entails a unique features as described by Berggren, Brodeur and Crawley (2003). It is a curriculum designed with myriad of CDIO activities. The combination of student projects, the internship opportunities and the instructions promote the multidisciplinary approach of CDIO. Moreover, an active and experiential group learning are in place because students acess networked classrooms and laboratory hands on activities. The CDIO model has designed a well and robust continuous assessment and evaluation process for the module.

The CDIO approach consists of twelve standards that facilitate the implementation of the CDIO approach at a new institution interested in adopting the CDIO initiative. The standards address an integrated curriculum development, program philosophy, syllabus outcomes, design-build experiences and workspaces, integrated learning experiences, active learning, faculty and academic development, skills assessment and program evaluation (Crawley, 2007).

The CDIO aimed to improve teaching and learning via the following approaches; increasing active and practical learning, emphasizing problem formulation and solutions, exploring the theories of engineering tools and procedures and engaging in innovative methods of collecting feedback *(www.cdio.org).* Lynch, Seery and Gordon (2007) claimed that CDIO supports PjBL whereby students are informed of the desired learning outcomes prior to starting any project. Likewise, CDIO also promotes curriculum restructuring to include design and build b and integration of other subjects in interdisciplinary engineering course.

The CDIO's Conceive stage deals with the conceptual, technical, and business plans. It identifies the needs and problems to be solved as well as the technology required. The Design stage focuses on creating the actual design – such as preparing the plans, working drawings andalgorithms that are required to implement/complete the project. The Implement stage applies the design into the product solution by a combination of manufacturing, coding, testing and validating and lastly the Operate stage is to operate the implemented product to be delivered as intended.

Both PjBL models at the Aallborg University and CDIO are valuable initiatives of a larger effort in transformingthe engineering curriculum. However, it is subjected to *"…top-down,bottom-up and push-pull forces"* (Eijkman, Kayali and Yeomans, 2009). The authors warned that there are a range of issues surrounding curriculum innovation including that of financial assistance, resistance to change, engineering content and educational structure. For this study, the researcher adopted the field project-based learning (FPjBL) to enhance the structural design ability of civil engineering students.

2.7 The Importance Of PjBL In Design Projects

Earlier discussion in Section 2.3 has identified the gaps related to the established models pertaining to the learning process in engineering design. This section will discuss the importance of PjBL in design projects, and why it is crucial to integrate the students' ability in design when working in project-based learning.

Projects in design courses offer an opportunity to fulfill a variety of learning outcomes including the students' preparation to practice in their disciplines (Mills and Treagust, 2003). The learning outcomes address the content knowledge, generic skills such as problem solving skills, lifelong learning, professional skills, collaborative learning and motivation and engagement. Moreover engineering graduates require a broader range of skills and attributes other than the technical capability that was formerly demanded.

PjBL atrributes in design as published by the University of Nottingham require higher order cognitive skills such as critical analysis, synthesis, evaluation; the application of theoretical knowledge to practical situations. Other attributes include problem solving skills, professional development and advancement through self-directed and lifelong learning. teamwork and interpersonal skills, management skills as well decision making skills.

PjBL has many variables and many layers throughout the educational system (Kolmos, Graaff and Du, 2009) learning principles. However, it is beneficial to develop diverse PjBL practices to conceptualise dimensions for variation as mentioned by Kolmos, Graaff and Du (2009). For example, students are encouraged to integrate knowledge from related courses which accompany the students' project work in order to analyze and solve the problem.This is because problem and project support each other (Kolmos, 1996).

For this study, the researcher utilizes PjBL model that cover over one single course as refered by Heitmann (1996) as project-oriented study where project is within the individual design course. The project is integrated in the traditional teaching of the same course. Normally the project focuses on application and integration of previously acquired knowledge and is carried out in small groups. The learning outcome for structural design at the case study institution is shown in the CLO (refer to Appendix A).

Understanding the engineering design thoughts processes is important in measuring the design outcomes as suggested by Dym *et al.,* (2005). The design skills taught should relate to the skills and abilities expected in completing design projects. To achieve these attributes, Graham and Crawley (2010) suggested the PjBL approach because it increases students' engagement in design concepts and improves their skill development in engineering practice.

PjBL is an effective approach to enhance student knowledge and skills in engineering design (Graham and Crawley, 2010) and helps students to develop skills and gain the experience necessary to carry out projects successfully in the real world (Tedford, Seidel and Islam, 2006). According to Chandrasekaran *et al.* (2012), the key elements of competency and integrative learning principle for projects relate to the fundamental knowledge base, engineering ability, and professional attributes such as communication and teamwork.

This study proposes that FPjBL is an innovative strategy because its implementation fulfills the initial objective of engaging students with real-world projects. Project-based learning is considered as an innovative approach to pedagogy of engineering education based on the following reasons as described by Puteh and Ismail (2011). Firstly, the concept of "project" is common to students (Mills & Treagust, 2003). Secondly, the task and role differentiation expected of students highlights individual uptake (Mills & Treagust, 2003). Thirdly, the institutions with funding difficulties might be able to adopt this approach as it can be applied to individual courses, if not throughout the curriculum. Fourthly, it can be implemented as small projects by the "Lone Rangers" (Bates, 2000) or interested and enthusiastic lecturers, not necessarily the whole faculty and finally, it tallies Felder *et al.,* (2000) recommendation that to ensure the success of an instructional method, the method must be pertinent to engineering education, falls within the context of typical engineering classrooms, requires a small amount of practice of the lecturer and coherent with current theories of learning.

Many lecture use perceived problems with possible solutions in a project. True problems in projects are always disguised and it takes a skillful individual to analyze a situation and extract the real problem. However, projects involved open-ended problems that resemble the work of professional engineers (Harris and Jacobs, 1995). Open-ended problems in design, is useful because students can learn and make their own judgment on the problem. Harris and Jacobs (1995) believed that project approach simulates professional engineering practice because projects generate students' enthusiasm. Others think that it reinforces the idea that design is open-ended or that multiple approaches to the client's objectives can be achieved (Dym, 1994).

Project learning is synonymous with learning in depth, motivate students to encounter and struggle with the central concepts and principles of a discipline (Mills, 2002). Project-based learning teaches students skills as well as the content. These skills include communication and presentation skills, organization and time management skills, research and inquiry, self-assessment and reflection skills, as well as group participation and leadership skills (Anderson, 2007).

PjBL provides a format for implementing several powerful instructional principle, including differentiating instruction, scaffolding instruction, and facilitating socially constructed knowledge (Dym and Little, 2003). This approach fosters the development in students understanding of the content-area as well as the development of effective and efficient strategies. For example, this instructional principles can be used for information gathering and processing, communicating, collaborating, goal setting and self-evaluating.

Several literature described the advantages of PjBL (Andreas, 2003; Thomas, 2000; Boaler, 1997; Penuel and Means, 2000). The first common advantage is that it allows teachers and students to focus on compelling ideas. PjBL allows contents knowledge to be investigated realistically and holistically.

The second advantage is that PjBL is an effective and engaging strategy where students search for answers and solve problems (Sovoie and Huges, 1994)). The investigations provided opportunities for students to learn complex ideas and skills and later apply them in a variety of contexts.

The third advantage is that PjBL prompts students to collaborate while at the same time supporting self-directed learning (Abdul Rahman *et al*., 2009; Demian, and Willmot, 2008). It offers the students the learning experiences that draw on the thinking and shared efforts of many individuals in the group. It also allows students to develop a variety of social and negotiation skills.

Finally, PjBL enables students to develop productive work skills that can be integrated in their lifelong learning endeavour (Ambikairajah *et al.,* 2007). In PjBL, the role of lecturers and students, the nature of curriculum, the teaching and learning strategies, and assessment are all different from the traditional method of factual information. In project-based learning the teacher acts as a facilitator and mentor, providing resources and advice to students as they pursue their investigation. The students are actively engaged in conducting complex multi-faceted and authentic investigation often in small groups, extending over a period of time. The curriculum planned is student-centered, and the outcomes of the student's learning process are neither predetermined nor fully predictable.

PjBL is a student-centered learning approach that engages students both cognitively and socially in their pursuit of knowledge. PjBL encourages students to be involved cooperatively in challenging learning situations that focuses on higher order thinking and problem solving skills (Mills and Treagust, 2003) and has positive effects on students' content knowledge (Thomas, 2000). PjBL has proven students performed better on assessment of content knowledge (Boaler, 1997; Penuel and Means, 2000; Thomas, 2000). It is also reported that PjBL had positive effect on groupwork of students as reported by Mergendoller, *et al*. (2006) and Graham and Crawley (2010) on their content knowledge learned more in PjBL.

PjBL has been identified for closing the gap between current student learning and developing necessary 21^{st} century knowledge and skills (Andreas, 2003). Moreover, several researches reported that PjBL has improved students' performance especially in science, engineering, technology and mathematics use PjBL as a construct for student engagement (Le *et al.,* 2006). Moylan, (2008) agrees that PjBL engages students' learning, allowing them to learn in all six levels of "Blooms Taxonomy" (refer Appendix S) with real world orientation (application) beyond the basic facts (comprehension); encourages higher order thinking (analysis) and promotes meanings from the projects that connect the students' new learning to their past performances (synthesis).

There are several reasons that rationalize the application of project-based approach in engineering programs. Firstly, project tasks are closer to professional reality (Mills and Treagust, 2003) and relate to the fundamental theories and skills of an engineer. Secondly, almost every task in an engineering profession involves the development of projects bearing the differences in time scales and levels of complexity (Savery, 2006). Not only that, project component also address critical issues of engineering education as it fosters student-centered learning, promote team working, communication and problem solving skills (Gao, Demian and Willmot, 2008; Prince and Felder, 2006; Sheppard and Jenison, 1997). Therefore, successful completion of projects requires the integration of all areas of undergraduate training which an engineer has been exposed to.

Finally, in its attempt to produce human resource for the innovation-led economy, higher learning institutions are challenged to promote innovative thinking and creative experimentation of future engineers. Engineering projects can provide this expertise as activities that engage scientific development generally originate from the engineering field (Ashford, 2004).

Many existing programs already make use of projects effectively to demonstrate learning outcomes through students achivement (PBLE, 2003). The learning outcome takes into consideration the expectations set by the professional bodies as well as other relevant sources such as Engineering Acceditation Council and Malaysian Qualification Accreditation. Approaches of project in design teach an additional set of skills, not only the technical know how but also non-technical skills as mentioned by Mourtos (2011).

Project-based learning enhances the students' learning outcomes during the project realization and provides better engineering education experience for the engineering students (Puteh and Ismail, 2011). They gain knowledge and skills as well as develop attitudes and behaviors relevant to their future work scenario. Project-based strategies promote active learning and engage students in higher-order thinking as claimed by Savery (2006). Some elements of creativity and innovations are also fostered in the students.

Project-based-learning is an effective method of learning in the engineering curriculum (Mills, 2002). It encourages involvement of the students in the learning process and conveys important information on project management. Projects can have a variety of forms and structures. In the process of organizing an engineering project, some explicit consideration should assist students learnt the design materials naturally and progressively.

Project-based learning enhances the students' learning outcomes during the project realization and provides better engineering education experience for the students (Mills and Treagust, 2003). Students gain knowledge and skills required of their future work scenario as the students developed strong technical skills as well as generic skills such as communication, teamwork and managerial skills through project work (Palmer and Hall, 2011).

The project-based learning promotes active learning and engage students in higher-order thinking as claimed by Savery (2006). Some elements of creativity and innovations are also fostered in the students. These studies discovered that project-based learning help learners to understand the important elements of the course that promotes teamwork, communication, knowledge, ability to synthesize and make connections so that they are better prepared for formal education to practice that guides them in their future undertaking.

This research investigated the design abilities of students engaged in FPjBL in structural reinforced concrete design course. The FPjBL implementation has considered several learning outcomes considered by several researchers (Ambikairajah et al., 2007; Hasna, 2010; Mills and Treagust, 2003; Djukic, 2006; Atman, Chimca and Bursic 1999) to provide better engineering education experience for the students in design education specifically in structural reinforced concrete design course. The findings are used to propose the module to rationalize the application of field project-based learning (FPjBL) approach in this course which include the knowledge, project/practical skill and generic skills such as communication and teamwork. It is important that all these abilities and skills be measured to encourage other generic skills that are usefull for students' lifelong learning such as time management, written and oral communication skills that comply with the accreditation requirement such as Malaysian Qualification Agency (MQA, 2007) (refer to Figure 2.7).

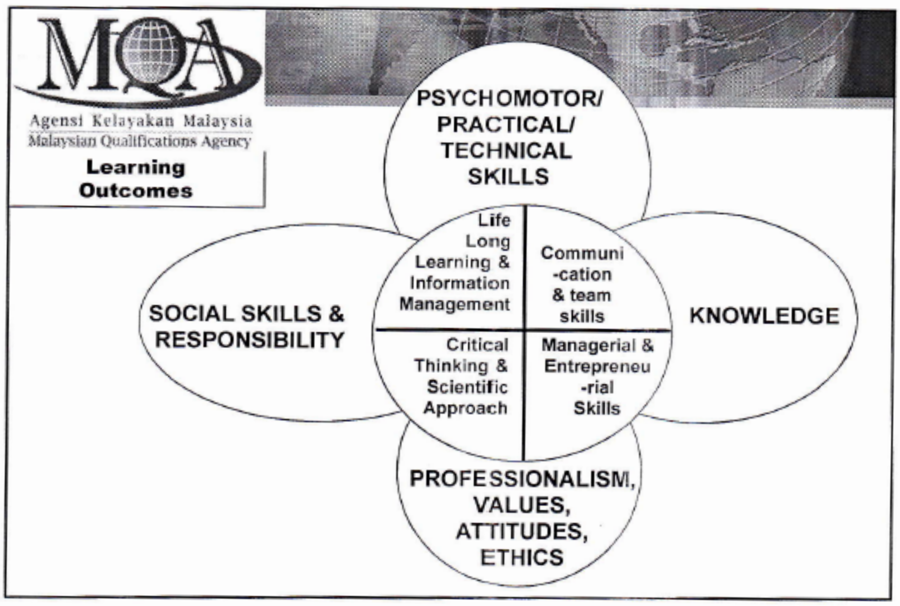


Figure 2.7 : MQA Learning Outcomes

Contrary to the ABET (2007) requirements (refer to section 2.2), the MQA (2007) has detailed the components that need to be covered in the learning outcomes. Knowledge, professional values, social skills and technical skills are the components deemed important in the learning outcomes of engineering program and the subject of this study.

2.7.1 The Importance Of Content Knowledge

Learning outcomes describe the knowledge, the skills and attitudes that graduates are expected to have demonstrated in the course of completing the program of study (Engineering Accreditation Council, 2007; ABET, 2007). PjBL is a pedagogical strategy widely applied in many universities worldwide with the purpose of improving the learning outcome of the students. PjBL is a comprehensive approach that is designed to engage students in the investigation of authentic problems (Goa, Demian and Willmot, 2008) and has proven to be a successful educational strategy in higher education as mentioned by Kolmos, Graaff, and Du (2009) to address the learning outcomes of engineering program.

The strategy for teaching and learning of design integrated with project has been practiced in the engineering programs for many years (Mills and Treagust, 2003; Graham, 2010). However, such strategy is limited to a certain extent (Mills and Treagust, 2003) and there is no concrete model for PjBL as there is no logical deduction from the theories to the model level (Kolmos, Graaff and Du, 2009). For example, there are a large number of phases that the students need to progress in order to complete the projects. This is very much dependent on the nature and intensity of the project, and the level of the project; course or curriculum level. The curriculum level requires high level of students' initiative and motivation, organization and other skills (Williams and Williams, 1994).

Graff and Kolmos (2003, 2007) identified three common principles in most PjBL models. These main principles include cognitive learning, contents and collaborative learning approach and are further described by Kolmos, Graff, and Du (2009) in Figure 2.8. The first principle is the cognitive learning approach where problem is assigned as a starting point in the learning process of a project. This is carried out to provide the learning context which forms the bases of the learner's experience. The second principle refer to the contents in which interdisciplinary learning underpins the curriculum's overall objectives in relation to theory and practice. Finally, the third principle is the collaborative learning in which a team-based learning approach is practised. The team-learning is expected to be demonstrated through communications and interactions of the students. In this way, the students are able to share their knowledge and able to organize themselves in the collaborative learning environment.

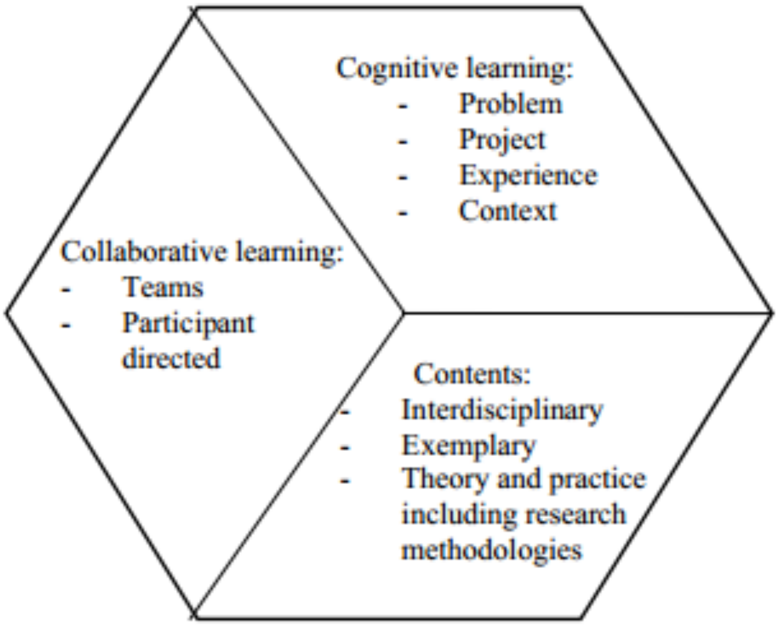


Figure 2.8 : Engineering Content As Part of PjBL Learning Experiences (Kolmos, Graaf and Du, 2009)

Projects are suitable for developing many of the specific skills and more generic attributes required of the graduate engineers (Mourtos, 2011; Akili, 2007). For example, projects help students to develop problem solving and professional skills as well having deep understanding of content knowledge, which enable them to undertake their self-directed learning. PjBL fulfills distinct educational objectives by not only developing content-oriented, subject specific on what students should know, but also process-oriented skills on what the students should be able to do (Groh and Duch, 2003).

The use of field project learning experience in undergraduate programs offers students the opportunity to apply their knowledge and receive feedback in a supportive environment before entering the workplace or undertake further study. The following sub-sections will discuss some of the skills enhanced through PjBL in a design course as students' progress through their design process. This is because students generally feel more motivated if they are able to solve design problems and fullfill a quality of lifelong learning (Krajcik & Blumenfeld, 2012), while at the same time gather the professional skills they require before entering the work force.

Based on the discussion of learning outcome of PjBL in design courses, several researchers reported that the content knowledge of engineering science and fundamental courses posed fewer problems to the students (Akili, 2007; (Chandrasekaran *et al.,* 2012). The researcher has highlighted positive effect on the content knowledge of design course such as solving technical problems in civil engineering and ability to apply knowledge of mathematics, science and engineering fundamentals to well-defined engineering procedures and practices.

2.7.2 The Importance Of Problem Solving Skills In Design

One of the most valued skills in design is the ability to solve problems (Cordon *et al.,* 2007). Problem definition, brainstorming, data gathering, picking the best solution, implementation of the solution, and anticipating possible outcomes of implementing the solution are cited as critical steps in design (Oakes, Leone and Gunn, 2006). Wankat and Oreovicz (1993) identified analysis, synthesis, generalization, simplification, creativity, and decision making as central elements of problem solving.

Design problems are commonly open-ended in nature (Dym and Little, 2000; Mourtos, 2011; Khandani, 2005). They deal with gathering and interpreting information and determining constraints. Normally, there are more than one solution to the problems (Dym and Little, 2000; Khandani, 2005). It involved generating, analyzing and evaluating alternatives and making decision (Dym and Little, 2000;

Gao, Demian and Willmot, 2008). Solving a design problem is a contingent process and the solution is subject to unforeseen complications and changes as it develops (Khandani, 2005). This design problem category falls under cognitive learning as mentioned by Kolmos, Graaff and Du (2009).

Problem solving skills have always been important in engineering design. ABET (2000) has put a new focus onthese skills in engineering education that tallies with outcome No. 3e, which states that engineering graduates must;

'*have an ability to identify, formulate and solve engineering problems'.*

Several studies have discovered that engineering graduates lack essential problem solving skills in tackling real world problems (Woods, *et al.* 1997*;* Oakes, Leone and Gunn, 2006). This statement is supported by Anderson (2007) who claimed that traditional project-based instruction allowed students this opportunity; however, it tends to provide limited opportunity for students to explore creative solutions to problem solving. In addition, Woods *et al.* (1997) highlighted that design students need to become good problem solvers and they should undertake the following steps and attributes (Bloom, Karthwohl and Massia, 1984).

1. read, gather information and define the problem.
2. use a process in design, as well as a variety of tactics and heuristics to tackle problems.
3. monitor their problem-solving process and reflect upon its effectiveness.
4. emphasize accuracy rather than speed.
5. write down ideas and create charts/figures, while solving aproblem.
6. organized and systematic.
7. flexible (keep options open, can view a situation fromdifferent perspectives / points of view).
8. draw on the pertinent subject knowledge and objectively and critically assess the quality, accuracy, and pertinence of that knowledge/data.
9. willing to risk and cope with ambiguity, welcoming change and managing stress.

10. use an overall approach that emphasizes fundamentals rather than trying to combine various memorized sample solutions.

There are variations between problem solving and exercise solving (Cordon *et al*., 2007). Table 2.3 defines and differentiates the necessary conditions for problem solving. Problem solving is often situational and interpersonal and the solutions may come from students' perception (Cordon *et al*., 2007) whereas exercise solving involves only one correct solution which the students are expected to discover in order to complete the exercise.

Table 2.2 : Differeces between problem solving and exercise solving

(Mourtos, Okamoto and Rhee, 2004)

No	Problem Solving	Exercise Solving
1	Involves a process in obtaining the best solution.	Involves a process in obtaining the exact solution.
2	The situation is ill defined and involves ambiguity Assumptions must be made in solving the problem.	The situation is well defined. (known and unknown).
3	The context of the problem is brand new.	Students have encountered similar problems.
4	No explicit statement on the skills or techniques applied for solving the problem.	Often prescribe assumptions to be made, principles to be used and hints.
5	Requires strong oral and written communication skills.	Communication skills are not essential.

In order to instill the problem solving skills to the students, lecturers are encouraged to engage in problem-based learning so that students develop the skills such as critical thinking skills. According to Hasna (2008), problem-based learning in design begins with the presentation of real life problems that supports the application of the skills required in practice. When engaging in problems, students are responsible for their own learning, and lecturers act as facilitator to students. Following the completion of problem work, students can reinforce their learning through groups discussion.

It is also important to note that when solving problems in projects, students need to possess the critical thinking ability (Ceylan and Lee, 2003). Critical thinking is the capasity to analyse and criticise which falls outside the limits of principles in design (Ralston and Bays, 2010). Engineering graduates need strong critical thinking to design in order to survive in the world of rapid growth change and complexity (Ceylon and Lee, 2003). Critical thinking is essential in project's design. This is to allow students to get to the root of a design problem before arriving at the final design product. Problems in design may fall outside the limits of the principles of design, thus if students possess the critical thinking ability, it would enable them to solve the design problems. According to Ceylon and Lee (2003), critical thinking is the careful, deliberate determination of whether we should accept, reject, or suspend judgement about a claim – and of the degree of confidence with which we accept or reject it. The use of cognitive skills or strategies increase students' ability to critically think to arrive at clear, accurate, precise and relevant judgements to the purpose at hand.

Not only that content knowledge and problem solving abilities are important in design, lifelong learning skill (LLL) is another skill promoted in PjBL.

2.7.3 Lifelong Learning (LLL)

Lifelong learning (LLL) may be broadly defined as learning that is pursued throughout life: learning that is flexible, diverse and available at different times and in different places. Perez *et al.* (2010) highlighted the importance of lifelong learning. Siaw (2002) is also in favour of PjBLbecause it encourages self-directed and lifelong learning.

Delors (1996) defined LLL based on his four 'pillars' of education for the future; learning to know, learning to do, learning to live together, and with others and learning to be. According to him, learning can instil creativity, initiative and responsibility in people and enables them to show adaptability through the ability to manage uncertainty, conflicts and communication. The emphasis on learning to learn and ability to keep the learning for a lifetime.

The European Commission (2001) listed LLL as having four broad and mutually supporting objectives which include: personal fulfilment, active citizenship, social inclusion and employability or adaptability. In this regard, LLL has wide dimensions that transcend from narrow economic and vocational aspects. The European Lifelong Learning Initiative defines LLL as,

> *a continuously supportive process which stimulates and empowers individuals to acquire all the knowledge, values, skills and understanding they will require throughout their lifetimes and to apply them with confidence, creativity and enjoyment, in all roles circumstances, and environments* (Watson 2003).

This definition relates very strongly to the focal duty of the lecturers whose tasks are to encourage and spur the students into believing that he or she can solve difficult learning tasks (Abdul Rahman *et al.,* 2009). In PjBL, students find solutions to the design problems. They need to anticipate what is expected that are related to their learning works. A positive and fearless attitude of student leads to the courage to accept more and more challenging tasks. Students find new ways to steer and control their learning. Furthermore, the attributes of Engineers in 2020 are the imperative for engineers to be lifelong learners. Therefore, the primary objectives of undergraduate educators are to equip engineering students with the skills and knowledge required to be successful global engineers in the 21st century.

Lifelong learning is related to the students self-directed learning (SDL); a continuous engagement in acquiring, applying and creating knowledge in the context of an individual learner's unique problems (Nepal and Steward, 2010). Students are required to follow SDL guided tasks whilst simultaneously achieving desired learning outcomes (Nepal and Steward, 2010). However, many students struggle to adjust to such learning activities (Nepal and Steward, 2010) because they do not have experience to self-manage themselves. Nepal and Steward (2010) found that PjBL provides the SDL for students and encourage them to tackle the problems confidently, thus boost their motivation and capacity for active learning.

In relation to teaching and learning, SDL emphasized the priority of students' thinking and learning by themselves. The main role of the lecturer is to guide students' learning instead of controlling their learning. Students self-reflect, self-monitor and eventually self-regulate their learning (Pang, 2004). Dewey (1938) emphasized on the provision to students with oppurtunities to explore knowledge by themselves.

According to Knowles (1975), the definition of SDL in its broadest meaning is a process in which individuals take the initiative, with or without the help of others, in dianosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. His definition emphasizes the process of SDL. Whereas, Candy (1991) emphasized on the learning goal in which he described SDL as having personal autonomy, the ability to manage one's own learning, independent learning outside formal institution and lifelong learning.

Boud and Feletti (1991) defined SDL as an approach to learning in which the behaviour of the student is characterised by the following:

1. Responsibility and awareness of the learning process and outcome

2. High level of self-direction in performing the activities and problem solving tasks.

3. Active input to decision making in relation to the tasks given

4. The use of lecturers/professionals as a resource persons.

These definitions of SDL reflect the goal of the education and the lifelong learning pursuit of the students. It is the approach of the educational practice as well as an integrated part of learning of any kind (Boud and Feletti, 1991).

2.7.4 Professional Abilities Required In Design

Professional abilities in this study covers the discussions on communication and teamwork skills. Presently, many employers are not satisfied with the level of engineering graduates in the work place in terms of teamwork and communication (Zaharim *et al.,* 2009; Koehn and Koehn, 2008). They expected new engineers to be equipped with relevant skills such as professional skills. As reported by Mills and Treagust (2003), it is critical that the engineering graduates of today possess strong professional skills especially in communication and teamwork.

Traditionally PjBL provide team experiences in utilizing engineering concepts learned in the previous courses to provide solution to real design problems (Brackin & Gibson, 2007). According to Brackin and Gibson (2007), the general philosophy of PjBL requires:

1. The project's problems to be provided by the external industrial clients.

2. The utilization of formal methodology.

3. Emphasis of teamwork skills.

4. Reports to be communicated orally and written reports.

Engineering design projects mostly involve individuals working in a team where students are required to share ideas and respond to others. This helps in improving their thinking and deepens their understanding. Hence, there is an urgent need for students to be exposed to team working and group dynamics during their course of their engineering program. Teamwork highlights the fact that individuals approach learning from multiple perspectives and differing viewpoints that students have much to learn from their peers (Dally and Zhang, 1993; Byrd and Hudgins, 1995).

Collaborative learning is a philosophy that improves working together, building together, learning together, changing together, improving together, in order to learn skills and build knowledge (Göl and Nafalski, 2007). Projects in engineering design is rarely done by an individual working alone (Campdell and Colbeck, 2011; Eder, 1991). Therefore, faculty must include instruction on teamwork and group dynamics in engineering design.

Lingard (2007) divides team assessment into two different perspectives; teamwork functions and individuals' performance. He listed the following abilities, which each team member is expected to perform:

- Attend meetings and arrives promptly
- Complete individual tasks promptly
- Gather appropriate information
- Perform research when necessary
- Complete tasks with high quality
- Accomplish a fair share of the work
- Express himself or herself clearly
- Openly express opinions
- Share opinions and knowledge
- Listen to views and opinions of others
- Consider the suggestions of others
- Adopt suggestions of others when appropriate
- Provide help to others
- Solicit help from others
- Seems committed to team goals

- Show respect for other team members
- Distinguish between the important and the trivial.

Design projects also requires clear and effective communications in various levels. Communication is expected not only between team members, but also between the team and the third party such as the lecturer or the supervisor. Design projects typically involve written and oral reporting on project (Harris and Jacobs, 1995). These report writing not only contributes to the development of communication skills, but also simulates industry practice (Mills, 2002). Needless to say, good verbal communication requires not only the ability to express one's ideas clearly but also the ability to listen carefully and understand ideas and concerns expressed by others (Hattum-Janssen and Lourenco, 2005; Hermon and McCartan, 2010; Koehn and Koehn, 2008). ABET (2000) stresses that engineering graduates should demonstrate an ability to communicate effectively. Team members normally help improve students' communications skills (Koehn and Koehn, 2008).

In projects, students are required to submit written report. This report required students to communicate effectively as outlined in outcome 3(g) of ABET EC 2000 as follows:

a) Produce well organized reports following guidelines

b) Use clear, correct language and terminology while describing projects and solutions to design problems

c) Describe problems accurately and specifications used and get important results.

The Engineers 2020 states that a student must learn not only technical knowledge, but also the skills of communicating (Engineering, 2005). Engineering has always engaged multiple stakeholders that include government agencies, private sector industries and the public. In the new century, the parties that engineering ties together will increasingly involve interdisciplinary teams, globally diverse team members, public officials, and a global customer base (Educating Engineers in 2020, 2005). Good engineering will require good communication and is enabled by an ability to listen effectively as well as to communicate through oral, visual, and written mechanisms (Djukic, 2006). Modern advances in technology will necessitate the effective use of virtual communication tools (Thomas, 2000).

2.7.5 Motivation And Engagement In Design

Other components which are not regarded in the models of engineering design process are the students' motivation and engagement in the design projects. This is because PjBL is a comprehensive approach to classroom teaching that is designed to engage students in the investigation of authentic topic and issues (Gao, Demian, and Willmot, 2008; Hellström, Nilsson and Olsson, 2009). Students are more engaged with and get greater satisfaction from the activities which involved authencitichty in PjBL (Helle *et al.,* 2007; Blumenfeld, *et al.,* 1991; Hermon and McCartan, 2010) in which the outcome of the project would actually be used by the client (industry) where the problem is authentic and has value (Blumenfeld, *et al.,* 1991; Barron *et al.,* 1998). In this instance, students are more engage in deep learning rather than surface learning (Hermon and McCartan, 2010) because the problem in projects are challenging and individual accountablity in group working is stressed.

The importance of students motivation in relation to engagement in the teaching and learning process of projects has been recognized by several authors (Gao, Demian and Willmot, 2008; Helle *et al.,* 2007; Blumenfeld *et al.,* 1991; Hermon and McCartan, 2010). Nevertheless, there is little concensus as to how to define motivation and engagement. Generally, there include a psychological and behavioural component in the definition. According to Chapman (2003), the definition on engagement is based on three criterias as follows:

1. Cognitive criteria in which students are attending to and expending mental efforts in the learning tasks encountered. For example, students make an effort to learn and integrate new materials with previous knowledge.

2. Behavioral criteria in which students make the effort to be active participants and reponse to the learning tasks. For example, students ask relevant questions, solve related problems and participate in relevant discussions with lecturers/engineers and peers.

3. Affective criteria in which students level of investments in relation to their emotional and learning tasks. For example, high levels of interest would pose positive attitudes towrds students learning tasks.

According to Gao, Demian and Willmot (2008) learner motivation thus, engagement is increasingly seen as an indicator of instruction. Interaction among students, the lecturers and students and students and professionals were most predicative of positive change in students' academic development, personal development and satisfaction (Smith et al., 2005). In fact the degree to which the students actively engaged in their leaning experience is one of the crucial factors in the educational development of undergraduates (Goa, Demian and Willmot, 2008).

One of the advantages of engagement in PjBL is the increase in students' motivation (Perez *et al.,* 2010; Welch, 2005). Several studies have been conducted on the effect of PjBL on student motivation. Welch (2005) claimed that PjBL motivates the students during the learning process as they discovered that PjBL is demanding, enjoyable and worthwhile. It forces students to push the boundaries of their knowledge through initiative, self-study, perseverance, and creativity. Moreover, PjBL allows students to have control over their own learning (Perry, Philips, and Dowler, 2004) that would increase their level of engagement, self-confidence and intrinsic motivation to learn (Howard, 2002; Nolen, 2003).

The last decade has seen increasing debate on the quality of engineering education (Graham and Crawley, 2010; Strobel and Barneveld, 2009). Students should be prepared with suitable knowledge, skills and attitudes. This call seems to be coming central to the re-engineering engineering education. One approach for addressing this issue is to provide students with more design experience at industry. Thus, project-based learning in design courses can been as the focus of considerable attention in engineering education locally and abroad. According to Graham and Crawley (2010), this approach increases student engagement and improves skill development and it is recognized as an effective approach to enhance student knowledge and skills in engineering design.

Experiencing learning with flexible environment within the projects is another factor that contributes to the students' self image and their motivation to succeed in their studies (Barak and Maymon, 1998). Evaluations of courses designed around PjBL at Purdue University in the United States indicated that students were positively motivated by projects, thus encourage them to apply the real perspective on the course content (Stouffer, Russel and Oliva 2004). In addition, many faculty members would be pleased to learn that students spend more time on these projects and they did not complain. According to Goa, Demian and Willmot (2008), the more students engage in PjBL, the better the PjBL will be.

This section has explored the generic skill abilities that are crucial in the implementation of PjBL in design. The relationship of these abilities and PjBL has captured in the conceptual framework of this study as depicted in Figure 1.1 (please refer to Figure 1.1 on page 17).

Figure 1.1 highlights the elements of generic skills including lifelong learning skill, professional skill and problem solving skill. Motivation and engagement are also highlighted in project-based learning as these important components are missing from Khandani (2005), Mourtos (2011) and other design process models of learning. Motivation and engagement also serves as the contribution of this study to the body of knowledge in project-based learning in design.

2.8 Constructivism PjBL

PjBL employs the fundamental theory of education in its implementation. The following section will discuss the theory of constructivism and its association with PjBL.

Constructivism has gained attention because it fosters learner-centered approach and students' active participation (Frank, Lavy and Elata, 2003; Richardson, 2003). Constructivist approaches are implemented in PjBL where students have a chance of learning by doing simultaneously, they can enhance their critical skills, and shape their learning process by being active participants (Gulbahar and Tinmaz, 2006). PjBL is one of the methods which originates from the theory of constructivism by supporting students' engagement in problem-solving situations (Doppelt, 2003). Students in a PjBL environment deal with real-life problems, which may contribute to permanent knowledge (Gulbahar and Tinmaz, 2006). PjBL promotes new ideas, discovery of new issues and knowledge integration from different sources (Droppelt, 2003). This can be linked to the constructivist theory introduced by Jean Piaget (1972). According to Piaget, learning originates from an active process of knowledge construction. This knowledge can be gained through real life experiences and linked to the learners' previous knowledge.

The theory of constructivism states that that learners construct knowledge for themselves and they seek meaning as they learn (Lynch, Seery and Gordon, 2007). PjBL promotes the theory of constructivism because students focus on the understanding of the information during the project implementation. Not only that, they are expected to work together to acquire new information in their project. Learning takes place during the construction of knowledge collaboratively through students' investigations and problem solving.

In constructivist learning, PjBL requires students to retrieve prior knowledge and collaborate among them to acquire new knowledge. By working in groups, students discuss and arrive at possible solutions to a particular design task. The lecturer/engineer serves as a facilitator to enable the students to take charge of their own learning.

The constructivist theory also emphasizes on the importance of students' learning gathered through own experiences. In the case of PjBL, industry exposure can enhance the students' knowledge and enable them to utilize what they have previously learned and adapt the situation to PjBL in design (Lynch, Seery and. Gordon, 2007).

The problem solving in design education involved the active learning approach puts students central to their learning process (Dewey 1916; Gardner 1993, Sternberg and Grigorenco 1995). The emphasis is placed on the activities or processes of the students that motivates the learning processes that occur in the minds for which the students are responsible for (Droppelt, 2003; Gulbahar and Tinmaz, 2006). Active learning in PjBL transfers the responsibility of the learning from the lecturer to the students (Droppelt, 2003).

The knowledge gained through active learning is constructive in nature because knowledge is gained from active thinking and problem solving (Gardner, 1991). Piaget and Inhelder (1969) described that an activity can be applied in making the students engage in meaningful learning. The construction of new knowledge becomes more effective when learners are engaged in constructing products that are of interest to them. Papert (1991) believed that the creation of an engineering prototype such as projects supports the constructivist theory.

PjBL exposed students to constructivist learning where learning is determined by the complex interplay among learners' existing knowledge, the social context, and the problem to be solved (Tam, 2000). PjBL approach is directly related to the application of knowledge as part of an effort to prepare graduates for their professional practice (Puteh, Ismail, and Mohammad, 2010). PjBL is a comprehensive instructional approach to engage learners in sustained, cooperative investigation (Bransford and Stein, 1993) built upon authentic learning activities. Constructivism is reflected in PjBL through the creation of a student-centered learning environment and emphasis on artifact creation as part of the learning outcome based on authentic and real life experiences with multiple perspectives. Thus, learners are allowed to become active builders of knowledge while confronting misconceptions and internalizing content and associated conceptions (Doppelt, 2003). In this study, the researcher select the field project-based learning (FPjBL) as it is directly related to the application of theory into practice.

2.9 Assessment of PjBL

Assessment is used to provide feedback to students on their learning. It is an important aspect of project-based learning as it demonstrates the learning outcomes as stated in the course outline.

According to Oehlers (2006), the assessment process provides several aims. First, it drives the student's learning method . Hence, it is crucial that the assessment is refined in order to help create a long-term and deep appreciation of the material. Second, it helps an environment in which the relationships between the lecturer and the students, the material they learn in the course and their peers ensure a deep-understanding and appreciation of the subject matter. Bailey (2006) agree that assessing students' design process knowledge is essential for understanding how to best create learning environmentsto facilitate the development of such knowledge.

There are two types of assessment used in design project.

1. Formative assessment is described as an assessment that occurs during the course of instruction to provide feedback to students (McMillan, 2007). Formative assessment is used to prompt students to articulate and self-assess effectiveness of their problem scoping, concept generation, and solution realization design activities toward producing a design solution meeting varied stakeholder needs. Feedback from lecturers guides students' process improvements. For example, an instruction such as processes, tools, and techniques and information can be transferred from teacher to student in the assessment processes used by the teacher to evaluate the students' performance (McMillan, 2007). These efforts can provide a comprehensive engineering design assessment which is important in undergraduate engineering program. Formative assessment is used by lecturers and students (Brookhart, 2003). Lecturer use formative assessment for instructional decision, whereas students use it for improving their own performance. This relationship is important as both the lecturer and the student should be striving towards the same goals and objectives.

2. Summative assessment is defined as an assessment that occurs at the end of an instructional unit to document student learning (McMillan, 2007). Summative assessment is used to evaluate quality of the defined problem, selected concept and proposed solution with regard to solution requirements in design course. It is common that students focus their efforts on what is graded, they focus to achieve deliverable requirements presented by lecturers. Most traditional course assessments often focus upon the success of a design product for students to achieve a good design. A summative assessment is used to document learning accomplishments of students over a period of time, from one learning activity to the next. Brookhart (2003) descibes that summative assessment methods are often easier for the lecturers to manage.

Awarding individual grades to the students and it is one of the challenges in assessing project-based learning. In contrast to professional practice, the management of the company assesses the result of the project. Hence, a realistic evaluation for a project undertaken must contains full range of skills being developed during the project implementation such as teamwork, communication, life-long learning, understanding of social, environmental and economic contexts and so on as well as technical skills (Mills, 2007).

Gibson (2005) described that the assessment criteria for undergraduate projects in engineering design places a strong emphasis on oral and visual communication skills as well as the usual technical aspects of design project. In addition, the team skills assessment is important for engineering students to allow students to practice and use later in the workplace (Aman *et al.,*2007).

The accurate varIation in the make-up of assessment components depends on learning objectives of the engineering project courses (Srisiriwat, 2010). Without a clear understanding of the teaching and learning goals, students have a risk of becoming confused and they waste time trying to discover the objectives of the lesson. As emphasized by PBLE (2003), the learning outcome of project describes the essential learning that students must acquire. This learning outcomes involve a combination of the knowledge and understanding, intellectual abilities, practical, subject-specific skills and generic or transferable skills.

According to Graham and Crawley (2010), very few PjBL activities employ formal formative assessment such as feedback mechanism to students on project. This is because there is skepticism among academic staff on the positive impact of PjBL; it may simply be a result of the more favorable lecturer. Paterson, Bielefeldt and Swan (2009) questioned the effectiveness of the assessment as "anecdotal and qualitative" as it is unreliable and it is an approximate measurement of learning. Unlike students, they often support PjBL as it is a mechanism for improving their learning.

Table 2.3 and Table 2.4 show assessment of project in design courses and example of project an assessment scheme for project report. As can be seen from the tables, there are variations on the assessment of project-based learning in engineering design courses as practiced in some universities. This may be due to the fact that markings are normally left to the discretion of the lecturers and also the nature of project. In conclusion, although some programs assessment is being revised nevertheless, a comprehensive and rigorous outcomes assessments have not yet emerged (Graham and Crawley, 2010).

Table 2.3 : Assessment of project in design courses

	University	Assessment
1.	Universiti Teknologi Malaysia	Analysis and Design – 40% Drawing and Creativity – 30% Organization – 30%
2.	University of Loughborough	1. Define the problem – 10% 2. Design options: Creative formulation of solutions – 30% 3. Detailed calculations: Applying broad range of existing and new knowledge – 35% 4. Tender documents – 15%

	University	Assessment
3.	Brackin, Rose-Hulman and Gibson (Project Report)	1. Understand the problem 2. Design specifications that addresses the needs 3. Multiple solutions

Table 2.4 : Example of an assessment scheme for project report (Gibson, 2005)

	Poor	Fair	Good	V. Good	Excellent
Presentation skills					
Layout, references, language, etc.	2	4	6	8	10
Methodology and understanding					
Comprehension, analysis	4	8	12	16	20
Synthesis, organisation of ideas	4	8	12	16	20
Evaluation, objectivity	4	8	12	16	20
Content					
Information evaluation, fieldwork	2	4	6	8	10
Laboratory work, modelling, creativity	2	4	6	8	10
Software design, mathematical skills	2	4	6	8	10

This section has discussed various types of issues in assessing project work in design. Detail assessment should also include the elements of communication and teamwork. This is because when the course learning outcomes highlights the importance of these two generic skills, they should also be assessed and measured.

Effectiveness of teamwork is a new tribute desired of graduates from engineering schools (Sheridan, Evans and Reeve 2012). In traditional engineering classrooms, the team effectiveness is promoted through projects and problems. However, the method does not fully allow students to work towards their full potential because collaboration among students is often not taught (Sheridan, Evans and Reeve 2012). Students can gain conceptual knowledge relating to team development and function through lectures, however feedback are also needed for them to learn from their actual teamwork experiences. In class, students receive limited and less personalized feedback from the lecturer due to limited interaction time. Assessment on teamwork is important in PjBL to measure the extent to which students are able to achieve the necessary skills. Formative and summative assessments show deep reflection of the teamwork process and individuals' contributions (Lingard, 2010).

Several researchers investigate that the communication instruction in PjBL of a design course focused on technical writing and oral presentation (Riddle, Simone, Farrel, and Jansson, 2008; Srisiriwat A, 2010; (Mills, 2007). However, in PjBL it is important to assess communication because it is the abilities required when students are required to incorporate the presentation of technical, graphical and concepts as well as communication techniques for project.

There is lack of focus on related project assessment according to Graham (2010). In engineering projects assessment is a crucial task as it is an integral component of the engineering course (Srisiriwat, 2010). A fair assessment is difficult and the survey conducted by Srisiriwat (2010) found that most educators used their own assessment criteria. Mills (2007), in this regard, developed clear and equitable assessment for group and individual project members. However, it is very hard to ensure fairness between the students. Willmot and Crawford (2007) highlighted that academics who feel comfortable setting examinations and individual coursework assignments are deterred from devising team assessments. This is because they fear that lazy students may benefit from the efforts of their teammates and diligent students may have their efforts diluted by weaker team members. Therefore, a fair assessment practice for engineering project should be able to support individuals and groups work. Evaluation of the project could be done individually or in groups through presentations, reports, self-reflection, peer and self-assessment (Teck, 2009).

Several authors such as Dym and Little (1994), Cross,(2000), and Ullman (2003), helped shape the design literacy landscape through their publications on design. However, they failed to analyse the alternative assessment method specific to the teaching and learning of design.

Dominick, *et al.* (2001) created a rubric-based assessment system that students and lecturers could easily use. The usage of his assessment led to the adoption of some of their definitions and terms related to the design process. Nevetheless, the discussion on the assessment or feedback that could be provided to students is lacking. One might assume that the authors have chosen to leave this to the lecturers, but another interpretation may simply be that that assessment is not typically seen to be sufficiently important to justify its inclusion. However, despite the lack of attention on assessment in design textbooks, the body of literature in engineering journals, as well as research books and regards assessment a priority in design pedagogy.

In helping to reach course objectives and learning goals, a rubric on design is used. The rubric provided the details in achieving course objectives where the students could link to the learning goals and apply it to evaluate their communication and peers.

2.10 Conclusion

The needs of the engineering industry design sector and the issues and challenges pertaining to the teaching and learning activities in engineering program have been reviewed in this chapter. PjBL approach is an appropriate approach to address those issues. PjBL fosters student-centred, collaborative, integrated, interdisciplinary process with students working in a small group on authentic problems. In addition, the integration of PjBL in engineering design involves the three important elements of knowledge, skills and attitudes. Engineering educators and higher learning institutions need to employ innovative teaching strategies to overcome the demanding issue of developing realistic students' projects. They also emphasize on hands on, practical skills with real projects that can enhance engineering students' learning and expose them with the creative process of teaching and learning. Similarly, the design and implementation of assessment for project should be able to assess students' achievement and performance in terms of abilities, skills and attitudes necessary in completing the project.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research methodologies on enhancing the students' design ability on project based learning of a structural design course. An overview of the research design on qualitative approach is highlighted, followed by the description of the operational framework, the selection of the research setting, the discussion of the instruments used, data analysis method and the steps taken to ensure credibility and the transferability of the findings.

3.2 Research Design

Qualitative research approach has been gaining popularity in social studies especially in education (Robson, 2002; Payne and Payne, 2004). This is the most appropriate and practical approach for in-depth understanding of an event or activities that occur in a natural setting (Hancock and Algozzine, 2006; Stake, 2005; Yin, 2003). In addition, its realistic solution is based on issues that deal with people based on the context of location and time (Mc Millan and Schumacher, 2006; Yusoff, 2001). Qualitative research is also suitable when the researcher is studying multiple factors such as investigating people's behaviour in certain learning environment (Yin, 2003; Stake, 2005; Hancock and Algozzine, 2006).

According to Denzin and Lincoln (1984), qualitative research focuses on the interpretation of phenomena in their natural settings, resulting in a rich format and set within a context (Creswell, 2003). Qualitative research is also carried out in investigating how people react and behave in these settings. In addition, qualitative research involves collecting information about personal experiences, life story, interviews, observations, historical, interactions and visual text which are significant moments and meaningful in peoples' lives (Merriam, 1998).

This research is designed to employ a qualitative approach in order to explore the multiple variables and data collected, hence, facilitate the development of new ideas about the phenomena under study (Johnson & Christensen, 2008). The research problem, the personal experience of the researcher and the audiences for whom the report to be written (Creswell, 2003) were considered. It is also carried out to satisfy the curiosity and desire for better understanding of the researcher, to test the feasibility of a more extensive study and to develop any subsequent study if required (Babbie, 2002). The insight gained through this qualitative exploration will allow the researcher the flexibility to probe into initial participant responses (Merriam, 2009). It is also useful in generating the hypothesis that would guide the research (Merriam, 2009).

The researcher is aware of the drawbacks of sole application of qualitative research. However, her experience as a lecturer in the course under study assist her in conducting the in depth analysis of the case. The problem under study is new and the existing theories do not apply with the particular group under study (Creswell, 2003). Therefore, documents such as course learning outcome and objective, interview transcripts, journal entries and observation field notes were analysed to investigate the following:

1. The relation between learning objectives and outcomes stated in course outline and the intended design abilities demonstrated by students in the project.

2. The design abilities demonstrated by students engaged in FPjBL.

3. Students' design skills and difficulties in FPjBL.

Table 3.1 summarises the research questions, data collection methods and data analysis techniques employed in this study.

Table 3.1 : Research questions, data collection and data analysis

Research Question	Intruments	Data Analysis
RQ1. What are the design abilities expected of students engaged in project-based task?	Course Learning Outcomes, MQA and ABET. Assessment and evaluation. Project report. Literature.	Content Analysis: Interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns
RQ2. What are the design abilities of students engaged in field project-based task?	Interviews Field Observations Journal Entries Project reports	
RQ3. How does the field project enhance students' design abilities?	Interviews Field Observations Journal Entries Project reports	Analyzed, compared, contrast and triangulated the identified theme and categories.
RQ4. What are the improvements that can be made to the Structural Reinforced Concrete Design?		FPjBL Instruction Guide

The above research questions, the instruments used and the data analysis techniques are used to develop the operational framework for conducting the research.

3.3 Operational Framework

The operational framework of this research is shown in Figure 3.1. It describes the sequence of work in accomplishing the research objectives and questions.

The research work involved the final year students in Structural Reinforced Concrete Design class. Preliminary study was conducted in order to confirm the gap in the project practice of structural design course. The researcher carried out an extensive literature reviews, applied her 20-year experience as a design lecturer and engaged in informal interviews with several students, lecturers and design consultants to determine the gap between the design theory and practice. The researcher published a paper on the preliminary investigation of the project component in the course during the course of her PhD undertaking (Please refer to Appendix V for the full paper). Documents on graduate attributes, the learning outcome of structural design course, and the breakdown of assessments on project as well as documents from Engineering Accreditation Council and Malaysian Qualification Accreditation were also analysed to study the present project-based implementation during the problem identification stage.

The results of the preliminary work have indicated some deficiencies and discrepancies in the current practice of project-based learning in design. According to Ismail and Mohamed (2009) and Puteh and Ismail (2011), it is critical to address the issues of curriculum structure and course innovation in order to meet the expectation of the design stakeholders. They further reported that it is also timely to change the delivery of the current engineering design education to prepare the engineering students with future workplace environment. These findings have led the researcher to explore and confirm the gap between the design theory and practice and have guided the researcher to develop and formulate the research objectives and research questions of this study.

Once the research objectives and research questions were formulated, the case study setting was identified. College of Science and Technology (CST), Universiti Teknologi Malaysia International Campus, Kuala Lumpur was selected in this study. In June 2010, CST was renamed the Centre of Diploma Studies. However, as this research began in 2008, it will maintain the name CST throughout the thesis. CST was selected because it offers a three-year Diploma of Civil Engineering program, which employs the design projects for the final year students. Graduating students from this program are expected to work as technical assistants or assistant engineers in the industry. The design consultant, Azman Lim and Associates Sdn Bhd was identified and requested formally by the researcher to conduct the research. Once the permission was granted, the lesson plan was designed and prepared for students to do their practical training at the company.

The data were collected after the students have undergone their practical learning and experiences in the design project prescribed by the design consultant. Prior to the data collection stage, as suggested by Merriam (1998) protocols must be observed. An observation guide (refer Appendix H and J) was developed to assist the researcher in the observation phase as suggested by Merriam (1998). For this study the observation involved an analysis of the setting as well as the learning activities in the field. Interviews with the students were also carried out during the course of data collection. Hence, the interview protocols were prepared to assist the researcher in extracting information from the interviewees on the design projects which they were involved in. This was granted by the Head of Department (HOD) of the Civil Engineering program at CST and was obtained prior to the interviews. Students' consents were also granted (refer to Appendix D) in order to approve their participation in the research. The data collected includes also documents including project reports and journal entries where students are required to self reflect on their learning activities during the implementation of the fieldwork (refer to Appendix L for self-reflection of journal entry).

The data analysis began with analysing; comparing and triangulating the data collected which include the documents, interview transcripts, observation field notes, and journal entries. By comparing and contrasting the results from various qualitative data, the accuracy and validity of the findings could be achieved as suggested by

Maykut and Morehouse (1994); Merriam (1998); Yin (2003) and Hancock and Algozzine (2006).

The findings were then compared with literature to develop codes on the design abilities expected of students. The selection of the codes and themes were then derived and the detailed description of the coding and themes is discussed in Section 3.8.

The field project-based learning (FPjBL) activities was developed by the researcher to take into consideration of students teamwork so that they realise their roles as a team member in the project team. The activities in project was also prepared to guide students on the tasks to be carried out during the field work. Details of the activities is dicussed in Section 3.7 and refer to Table 3.5. The concepts of FPjBL is based upon a constructivist model of human cognition (Savery, 2006), which contended that true knowledge lies in the interactions with the environments. For example, the FPjBL is designed to be facilitated by industry where students are given the real design project to work on and 'learn by doing'. In addition, the FPjBL can be further motivated by tasks in projects with activities assigned to students (Jonassen and Rohrer-Murphy, 1999). These real activities help students appreciate the learning and as such consciuosness learning emerged from them.

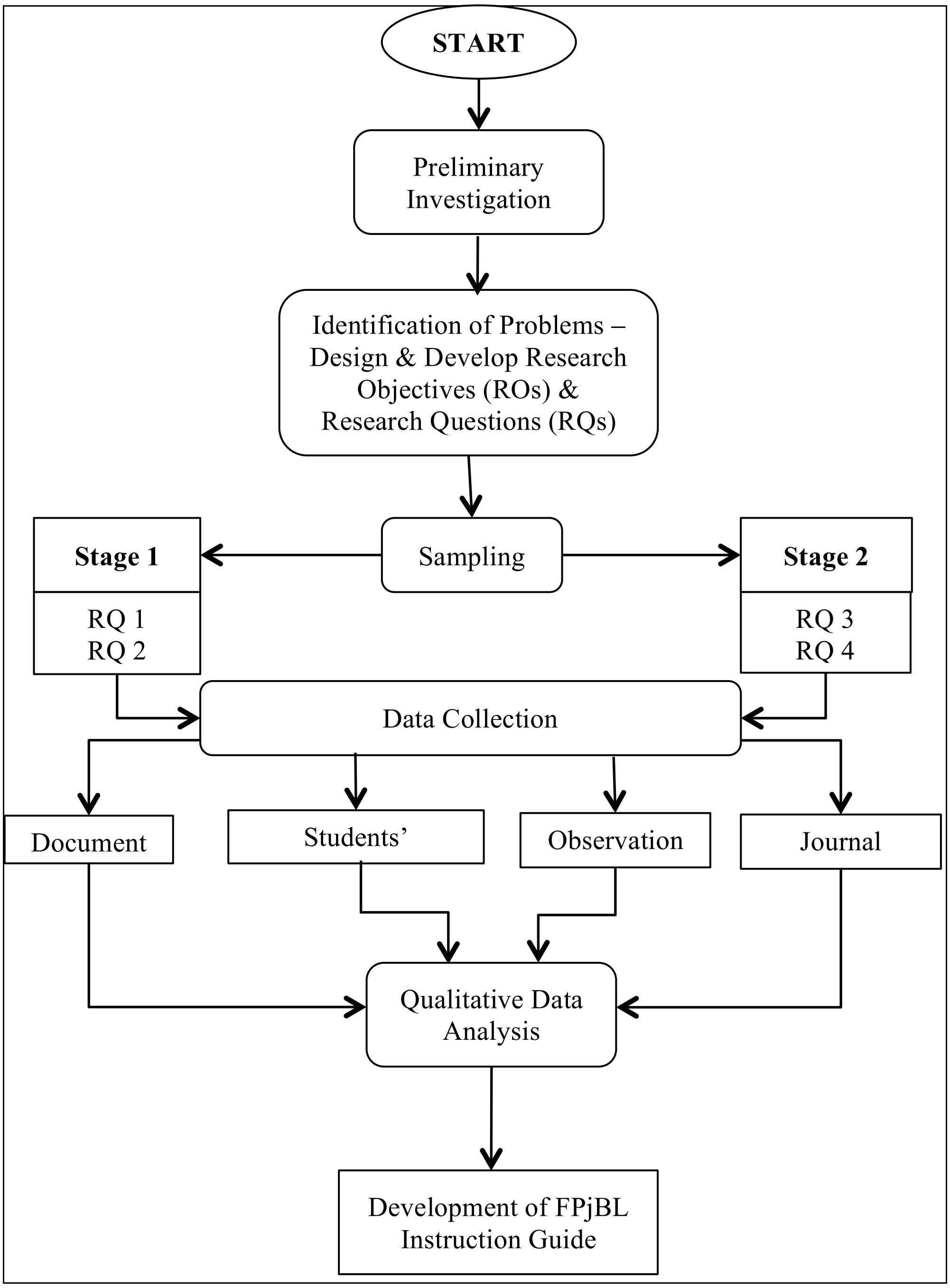


Figure 3.1: Operational Framework

3.4 Selection of the research setting

This section will describe a detailed description of the case study setting; College of Science and Technology (CST), Universiti Teknologi Malaysia (UTM)

International Campus, Kuala Lumpur and a design consultant firm, Azman Lim and Associates Sdn Bhd.

3.4.1 College Science and Technology (CST)

CST was selected as a case study for this research because of its long history in producing diploma graduates for the nation. UTM is the pioneer and the oldest higher institution in the country that offering engineering-based diploma programs with the aim of increasing the number of semi-professionals in the country. There were sixteen diploma programs offered in CST and among the programs is the Diploma in Civil Engineering.

The diploma of civil engineering (DDA) was initially offered under the auspices of CST. Currently, it is under the Diploma of Programmes Studies, School of Professional and Continuing Studies, Universiti Teknologi Malaysia (UTMSPACE). A six-semester curriculum was offered for a full-time DDA program, with a final semester of industrial training with selected industrial partners. The industrial training was integrated in the curriculum in order to better prepare graduates for engineering practice at their future workplace. In 2000, the DDA curriculum was reviewed and the industrial training element was removed due to several issues such as difficulties in allocating industrial attachments and some financial constraints faced by CST. Until today, the DDA program is implemented without the industrial training component.

According to Nguyen (1998), industrial attachment can expose students to design practices and can also engage them in other learning such as communication and management. Bearing in mind, this research aims at incorporating the industrial attachment via the students' design project component in design courses. The following section presents the company, which has been selected for such a purpose

3.4.2 Azman Lim and Associates Sdn Bhd

Azman Lim and Associates Sdn Bhd is a well-established structural engineering consultant situated at Taman Danau Kota, Off Jalan Genting Kelang, Setapak, Kuala Lumpur. This consultant was selected for the students' industrial attachment for their project work because of its close vicinity to CST. It was anticipated that the students could go to the consulting firm at a minimum cost and time. It was also noted that firms such as Azman Lim and Associates has to fulfil its social obligation or corporate social responsibility (CSR) to the society by providing industrial training for the graduating students. Based on this mutual understanding, the students were granted easy access to the company for their field-project work. For the purpose of this research, the industrial project work is integrated in the design course via the design project. Throughout the semester, five field visits were conducted and eight students were involved during each visit. The field visits aims to expose the students to the industrial experience with regards to design projects. The firm was also considerate enough to allocate a professional engineer as a facilitator and field supervisor to all the students for this research.

3.5 Sampling

Purposive sampling is the selection of participants who have knowledge of the area being investigated to get a deeper understanding of some phenomena (Maykut& Morehouse, 1994). The purposive sampling method could be used in qualitative research where the participants could give the most information about the phenomena being studied (Maykut and Morehouse, 1994; Punch, 2009). It is the most common sampling strategies where participants are selected in groups based on the criteria relevant to the research objectives of the study. For this research, purposive sampling was employed in selecting the participants. Sample size was selected on the resources and time available, as well as the study's objectives. The researcher decided to select the participants from CST so that she could gain a deeper understanding of the phenomena experienced by the participants. The researcher seek to accomplish this goal by selecting the case study which involves individuals and the organizations that provide the greatest insight into the research questions (Miles and Huberman, 1994). For this research, the sampling is differentiated in two stages.

3.5.1 Sampling Stage 1

For the purpose of this research, second-year students of session 2010/2011 were selected as the research participants. The students were coded as SP1 through SP12. These students were selected based on their performance in projects and their overall performance in their Test 1, Test 2 and final examination of Structural Design I. Only a small number of students were involved in this stage because they were the researcher's own students who were personally taught by the lecturer for the duration of one semester for that session (Semester I of the session 2010/2011).

3.5.2 Sampling Stage 2

The sampling for Stage 2 involved eight final year students of semester II of 2010/2011 session of diploma in civil engineering at CST. The number shrunk from twelve to eight because four of the participants in stage 1 were transferred to another class which was taught by a different lecturer. The remaining eight participants are those who were involved in Stage 1 and remained in the researcher's class on design project only for semester II, session 2010/2011 academic year. Boreggo, Douglas and Amelink (2009) endorsed that small number of participants in a qualitative study allows in-depth exploration of the issue. The sample size in the study requires detailed information where the goal is to describe a phenomenon in enough depth that the full meaning of what occurs is understood.

The eight students represent a diversity of students in the group. To illustrate, two students were high achievers, two students were above average, two students were average and two students were repeaters of the course.

The participants would underwent the FPjBL approach that provide the most information and important insights about the case being studied. Consent to participate in the research were obtained from the students before implementing the FPjBL module to them (refer Appendix D). Most of the interviews lasted for 20-30 minutes.

It is always important to maintain the confidentiality of the information collected from respondents (Fisher and Foreit, 2002). Thus for this research, codes were applied to protect the respondents' identity. Table 3.2 illustrates the coding assigned to the respondents.

3.6 Instruments

Several instruments were employed for the purpose of this research and a considerable time was spent in the natural setting gathering of information as suggested by Creswell (2003). The instruments used involved collecting documents such as CLO, students' assessment performance, and project reports. Other instruments include interviews, journal entries and observations of students in the FPjBL context.

3.6.1 Collection of Documents

Documents provide a source of information that can be used to support the data collected through interviews, journals and observations (Bogdan and Biklen, 2007; Hancock and Algozzine, 2006; Merriam, 1998; Punch, 2009). Examples of general documents include public documents such as policy documents, minutes of meeting and private documents such as journals, diaries and letters.

The documents collected in this research were:

i. The course outline for DDA3164 that provides the learning objectives and learning outcomes of DDA3164 (Appendix A).

ii. The lesson plan that provides the syllabus and topics covered for DDA3164 as tabulated in Table 3.3

iii. The project reports that provides the end product of the project component for DDA3164.

iv. The Student Performance on Tests, Project and Finals

By examining these documents, the researcher was able to analyse the learning objectives of the project stated in the learning outcomes and compared them with the lecturer and students' perspectives during the interviews. Similarly, the lesson plan with topics and syllabus were analysed to ensure that the project component is covered in the CLO. The assessment of written project reports were analysed to see how it was assessed and compared to other institutions. The students' achievement on each project component and the summative assessment were also analysed.

3.6.2 Interviews

The function of the interviews is to explain the observation whereas the observation helps verify the interviews (Creswell, 2003). Structured, semi-structured and unstructured are the common types of interviews (Merriam, 1998; Olds, Moskal and Miller, 2005; Gillham, 2005). Structured interview consists of specific close-ended questions (Merriam, 1998; Olds, Moskal & Miller, 2005; Gillham, 2008), whereas semi-structured interview is guided by a list of questions. On the contrary, unstructured or open-ended interview is like a conversation (Olds, Moskal & Miller, 2005; Gillham, 2008). The objective of the interview is to gain understanding on the insights about things that could not be observed (Merriam, 1998). In addition, respondents' thought and perspectives in their own words could be acquired through the interviews (Bogdan and Biklen, 2007).

The semi-structured in-depth interviews was adopted as the main data collection method used in this research. Instead of reading formal questions from a structured interview schedule, the researcher has a set of general questions to serve as a guide in order to seek detailed, open-ended responses to the questions. This is because according to Gillham (2005), semi-structured interview is the most common form of interviewing in the research. Moreover, the researcher hoped to explore and gain deep understanding of the students' project by conducting 'face-to-face' interviews with them. These interviews involved semi-structured questions and intended to elicit views and opinions from the participants (Creswell, 2003; Merriam, 1998). It probed issues in detail so as to encourage participants to express their views at length. The students were questioned on the activities which they have experienced while undergoing the field-project design because according to Creswell (2003), participants could be asked to comment on real events rather than giving generalisations so that they can reveal more about their beliefs, attitudes and behaviour.

This research has conducted face-to-face interviews because of several reasons. Firstly, the interviewer can clarify unclear or ambiguous questions which the respondents might misunderstand if they were to answer on their own (Rubin and Rubin, 2005). Secondly, the interviewer can gain better insight and ideas from the respondents through spontaneous and unexpected responses (Rubin and Rubin, 2005; Creswell, 2003). In addition, the interviewer can observe the non-verbal clues such as the body language in order to capture the respondent's feelings and attitude toward the questions posed. Not only that, the interviewer can change the tone and style of the interview questions to match the mood or the respondents' conversation styles as suggested by Rubin and Rubin (2005). Through her interviewing skills, the researcher would gain better understanding of the Structural Reinforced Concrete Design course in relation to the implementation of FPjBL.

According to Merriam (1998) and Miles and Huberman (1994), interviews can be used to provide information to develop the questions for a written survey questionnaire; as a stand-alone method for producing information for subsequent analysis; or in conjunction with other data-gathering methods in order to correlate and validate information obtained through multiple data gathering methods. As suggested by Hancock and Algozzine (2006) and Merriam (1998), the reseacher identifed the participants, developed the interview guide as well as identify the location to conduct the interview. The reseacher also identified the method of recording the interview data while following the ethical requirements pertaining to the interview.

The interviews were carried out to all the eight students as per the interview schedule in Table 3.2.

Table 3.2 : Interview Schedule and Participant Coding for Stage 2

Student	Date of Interview
S1-A	14 Feb 2011
S2-A	17 Feb 2011
S3-A	22 Feb 2011
S4-A	24 Feb 2011
S5-A	1 March 2011
S6-A	22 March 2011
S7-A	25 March 2011
S8-A	5 April 2011

* A = interview

3.6.2.1 The interview guide

In order to compile information about the students' experience during the application of FPjBL and their views, an interview guide was deeveloped. The Interview Guide (refer to Appendix E) is a list of designed questions that guided the researcher during the interview session (Meriam,1998; Creswell, 2003). The questions helped the reseacher to gain better understanding of the issues being investigated (Hancock and Algozzine, 2006). These interview questions were conducted with reference to the research questions and objectives. The interview questions were developed through the literature search and also after several discusions with the researcher's supervisors who are experts in the engineering design education. The Interview Guide consists of questions that were posed to determine the strongest and weakest points of FPjBL and its impact on the students.

The Interview Guide were also validated by consulting experts in qualitative research (refer to Appendix F) to ensure that the main themes in the research were covered during the interview. The interview questions were also translated from English to Bahasa Malaysia to cater for students who are not proficient in the English language. The translation of the interview was also validated by a language expert as shown in Appendix G. The reseacher also conducted a pilot interview to a civil engineering students before interviewing the real participants in the research as suggested by Merriam (1998). This study is carried out to gather information prior to the actual study, in order to improve the quality and efficiency of the research.

The interview questions were designed to focus on the participants' perspectives on the design projects, their expected design abilities and the skills addressed. Their views on the process of implementation of PjBL and their suggestions on the improvement of the project were also obtained. In addition, the difficulties encountered by the participants were also identified. Follow-up questions were raised in order to elicit their in-depth views on certain issues deemed important by the researcher.

All the interviews were conducted in the researcher's room because it was convenient and conducive. Moreover, the room is isolated from the noisy surroundings and allows the interviewing session to take place in a quiet manner.

3.6.2.2 Recording the interview

The researcher used audio recording in the interviews with the consent of the participants for the research. All interviews were electronically recorded using mp3 audio format. During the interview, the researcher took some notes for the follow-up questions and discussions. The audio recording was used so that the researcher can concentrate and listen and respond better to questions and answers. Moreover, the discussions flowed better as there were no distractions and the students could gather more information.

The recorded interviews were transferred to the researcher's personal computer and transcribed immediately after the interview ended. The researcher transcribed all the interviews herself because the transcribing process allows the researcher to recall and familiarize with the data as suggested by Maykut and Morehouse (1994).

The interviews were mostly conducted in Bahasa Melayu because most of the respondents were more confident to reply to the questions in their mother tongue. However, some of them code-switched their statements whenever they felt more comfortable to use some English phrases or words. Hence, the transcripts produced were of a mixture of English and Bahasa Melayu. It should be noted that the quotations, which appear in Chapter 4 of this thesis have been extracted from the translated version of the interview transcripts. Transcribing the interview involved taking notes of the interviews. It is the full scripts of the interview and the aim is to take the full written version of the interview. The translations of the transcripts have also been verified by a senior lecturer from a language department in CST (refer to Appendix G). However for the purpose of authenticity, the grammatical structures of the responses are retained to avoid misinterpretation of the comments as well as to maintain the originality of the sentences.

3.6.2.3 Ethical requirements during interview

Most authors who discussed qualitative research design, addressed the importance of ethical considerations in their research (Creswell, 2003: Meriam, 2009; Miles and Huberman, 1994; Silverman, 2005). Conducting interviews involve engagement with several ethical issues that arise from the reseacher's direct contact with the participants. Therefore, the researcher conformed to the ethical requirements for the research by obtaining the participants consent and keeping their identity as confidential as possible (Hancock and Algozzine, 2006). In this case, a reference code is assigned to each participant in order to safeguard their identity and to protect confidentiality of their comments (Refer Table 3.2).

3.6.3 Journal Entries

The students' journal entries were collected to enable the researcher to obtain the language and words of the participants on certain themes, in which the participants have given attention to compilling (Creswell, 2003). Journal entries provide additional information on the process of learning of the participants as an integral part of the research to search for meaning (Maykut and Morehouse, 1994). The students' personal journal can yield the understanding of the phenomena under study. It is a source concerning person's attitudes, beliefs and view of the world (Merriam, 1994). Students write and select the facts, incidents and events, which are most important to them. This in return enables the researcher to obtain the language and words of the participants. Moreover the researcher can conveniently accessed the journal entries as an unobtrusive source of information.

For this research, the researcher collected all the journals and searched out for information relevant to the research questions. The research data from journal entries represents the thought (Merriam, 1994), therefore the researcher used these data as evident for students' experience and views on the project component of the design course.

The confidentiality of the information collected from journal entries of respondents was suggested by Fisher and Foreit (2002) by using code numbers to protect the respondents' identity. The coding of journal entries for the eight students were denoted with coded numbers from S1-B to S8-B.

3.6.4 Observation of FPjBL Activities

Apart from the interviews, observation is another method applied in this research. Chaedar (2011) defines observation as a systematic and organized examination, which is intended to gain valid and reliable data. In addition, the observational data could provide additional information to the study being research (Yin, 2003).

The observation guide gives the observer a structure and framework to carry out the observation (Savage, 2000). It also serves as a contract of understanding with the participants to create a more comfortable atmosphere, and get specific feedback on aspects of the learning (Chaedar, 2011). For such purpose, the researcher prepared an observation guide which serves as a checklist during the field-project (refer to Appendix H). This observation guide was prepared in advance to list behaviours and activities that the researcher might encounter during the students' field visit to the firm.

Prior to the observation activity at the firm, permission was granted from the firm's Chief Executive Officer (refer Appendix I). The researcher explained about the objectives of the study and asked for approval to conduct the observation of the PjBL process. This was agreed upon and the firm assigned one professional engineer to supervise the students.

The researcher became the participant observer, as her participations in the group are limited (Meriam, 2009). Prior to conducting the observations, the researcher also prepared an Observation Guide (refer Appendix H) as well as Observation Check List (Appendix J). The Observation Guide consists of specific activities related to the research questions that need to be observed (Hancock and Algozzine, 2006).

The data collection began with the first observation on the 13 January 2011 (refer Appendix B for Lesson Plan). During the observation, the researcher sat across the meeting table of the meeting room of the firm. The researcher observed the students during the scheduled visits to the firm by recording what the students did listening to what they say and sometimes asking them clarifying questions. By directly observing the field project operations and activities, the researcher hoped to develop a holistic perspective, an understanding of the context within which the project operates (Savage, 2000; Babbie, 2002). In addition, students were also observed on their behaviours, interactions and exploration within their group members as well as with the firm's engineer in relation to the project activities.

The field notes were immediately transferred into word processing after the observations were completed. The field notes contain the actual occurrence in the setting. This followed Maykut and Morehouse (1994) suggestion that field notes should not include researcher's interpretation of the event.

The researcher followed closely the ethical requirements as suggested by Babbie (2002) and Hancock and Algozzine (2006). For example, she avoided interfering with students' activities in the field. Sometimes, students asked the researcher for assistance in performing the design activities. The researcher politely reminded students of her role and asked them to refer to the engineer.

3.7 FPjBL in Structural Reinforced Concrete Design course

Structural Reinforced Concrete Design (or course coded as DDA3164) is a final year design course at the DDA program in CST. It is a one-semester course and only offered in the final year of the program. The course provides the basis for the graduating students to apply both the theory and practice in structural reinforced concrete design. The design project is integrated in the course and the students have to complete the project, as it is a coursework component in DDA3164.

DDA3164 is a four credit-hour course consisting of three-hour lectures and three-hour studio session. Table 3.3 is the lesson plan for DDa3164 that shows the sequence of lecture topics carried out during the two-hour lecture over 14 weeks.

Table 3.3 : Lesson Plan For DDA3164

Week	Lecture topics
1	**Introduction** - Design concrete concepts and principles - Concrete compressive strength - Reinforcement tensile strength
2	**Design of beam** - Flexural strength of section - Singly reinforced section
3	**Design of beam** - Doubly reinforced section
4	**Design of beam** - Shear strength of sections - Design of links.
5	**Design of beam** - Check for deflection - Detailing of sections
6	**Design of slab** - Solid slabs spanning in one direction
7	**Design of slab** - Solid slabs spanning in two direction
8	**SEMESTER BREAK**

Week	Lecture topics
9	**Design of slab** **Restraint slabs**
10	**Design of column** - Short and slender column - Reinforcement details
11	**Design of column** - Short and slender column - Reinforcement details
12	**Design of footing** - Pad footing - Reinforcement details
13	**Design of footing** - Double footing - Reinforcement details

It is found that there is no grade allocation for the students' assignments on this course. Therefore, the lecturer would normally utilize one out of the three-hour studio session for the tutorial of the course. The three-hour studio session is normally allocated for discussions on the design projects in which the students would have to produce at the end of the semester. The overall marks given for the project is twenty per cent of the total grade of the course. The breakdown of the overall assessment and evaluation for DDA3164 is shown in Table 3.4.

The overall assessments for DDA3164 comprises test 1, test 2 and final examination which were given to students to test their theoretical knowledge on concepts of structural reinforced concrete design. The final project written report of 20% of the overall assessment covers the theoretical and technical aspects of the design project.

Table 3.4 : Assessment and Evaluation in DDA3164

Item	Descriptions	% Marks
1	Test 1	15%
2	Test 2	15%
3	Final Examination	50%
4	Project	20%
TOTAL		100%

The design projects presented to the students were generally imaginary projects invented by the lecturers. In certain cases, real projects from the industries are adopted but later simplified by the lecturers. In this regard, collaboration between the lecturers and the industry was not evident. Not only that, sources related to the project such as building specifications and geotechnical requirements were furnished and dictated by the lecturer. Therefore, students were not allowed to explore other options rather than the solutions, which the lecturers themselves have anticipated. This hinders students to expand their knowledge and skills and prevent them from applying the theory into practice. The same scenario was also highlighted by Dym *et al.* (2005).

Practical experience in design is a desired trait in civil engineering graduates required by many employers (Hale, Freyne, and Durham, 2007). If the students are given the opportunity for the industrial training experience, they may gain the project design exposure during their industrial attachment. Moreover, many higher learning institutions have removed industrial training component for the students (as in the case of CST) and hence, they do not have industrial exposure. Therefore, it is timely that the students are exposed to real project works through project-based learning approach at the industry.

For the purpose of the research, the activities for project were carried out using the three-hour period allocated for the studio session. Due to the requirement of the design firm, Azman Lim and Associates, the students were allocated three hours per visit for a total of only five visits (equivalent to five weeks) throughout the semester. All students were required to attend this field project-based learning. If any student were unable to attend the visit, he or she would have to ask the team members for any updates on their project work. However, the students involved in this field project showed strong commitments and were present in all visits. On the other hand, the remaining nine weeks were utilized for project work in the studio and closely supervised by the lecturer. This tally with Krajcik *et al*., (1998) and Thomas (2000), who argued that the project activities for the students must be structured to facilitate meaningful learning and carefully monitored as they progress through project stages in order to control any unforeseen problems.

3.7.1 The Project in DDA3164 at CST

Project work is similar to that proposed by Dewey (1938) who viewed that knowledge construction is based on the conviction that learning by doing, discussing in a group, and experiences enhance one's understanding of the content. Project work is a very good example of learning by doing because it engages students in an in-depth investigation that allows them to construct their own knowledge (Thomas, 2000). How project is implemented on students depends on many variables such as instructor's knowledge and experience. Various interpretation of the design project may be the results of unclear instruction on how the learning is carried out (Yilmaz, 2008; Thomas, 2000). Gultekin (2007) defined project as a learning approach that necessitate students to work over a period of time in order to investigate the real world issues or problems. Krajcik *et al.*(1994) characterized project as allowing the flexibility and responsiveness to students' input, cultural environment, and experiences.

At CST, the structural reinforced concrete design bearing the course code, DDA3164 is divided into theory and practical classes. It consists of 3-hour lecture and 3-hour practical cum tutorial. The learning goal is to enable the students to describe, analyse, design and organize the project individually and in a team.

Students were given a project and design exercises. This means that the lecturer must deliver the theories before students applied them in their project. Thus, these courses are in the form of project-assisted learning, which have been practiced over many years. More often, one lecture single-handedly teaches the subject and it is very much dependent on the lecturer discretion to manage the course.

For this study, the researcher take the advantage of the combination of project-assisted learning by lecturer and the client-driven projects (as called by Ansell, 1998) where companies or industries assign real projects in the industrial situation. In this research, the lecturer gave valuable lectures in class pertaining to the content of the course and expected the students to integrate knowledge that they have learnt in several courses. While the client-driven projects involved realistic constraints and require work that cuts across subject boundaries (Heywood, 2005).

3.7.2 Project Activities in FPjBL

The project component in DDA3164 is normally integrated in the course so that each project activity is synchronized with the lecture topic. The project is structured and guided with the purpose of providing some solutions to the design of the project. Table 3.5 illustrates the activities was conducted by the students during the project-based learning activities using the adopted and adapted design process by Khandani (2005).

Table 3.5 : Learning Outcomes, Project Activities and Design Process in DDA3164

Item	Learning Objective	Project Activities	Design Process (Khandani, 2005)
1	To select the most appropriates structural system or forms to bring the architect's concept into being (frames and elements,	• Transform Architectural Drawing Details into Structural Plan Layout. Check Lists: 1. Footing Plan 2. Ground Beam Plan 3. Second Floor Beam Layout 4. Roof Beam Layout • Identify one-way and two-way slab. • Use AutoCAD to produce details of the above.	1. Define the problem 2. Identify and establish the need of the design problem 3. Develop possible solutions 4. Select and evaluate the best solution 5. Construct the layout 6. Present the layout 7. Redesign if necessary
2	Realize the structure into load bearing frames and elements for analysis and design. To perform an estimation of loads.	Specify materials for project. Lists all the Specifications required for your design project. Refer to your architectural details: eg.f_{yk}=500 N/mm^2, f_{ck} =30 N/mm^2, f_{yv} = 250 N/mm^2	1.Gather pertinent information on loads 2. Examine the functional requirements of loads 3. Brainstorm possible solutions 4. Select the most promising load.
3	Perform analysis to determine the maximum member forces i.e. moments and shear, torsion, etc. for design.	Previous knowledge in materials and construction, Strength of materials and structural analysis.	1 Examine the functional requirements of loads 2. Analyse and select the solution
4	Design the sections and reinforcement arrangements for all structural elements	Design elements: Beam Slab Column Footing Produce calculations and accompanying design sketches	1. Define the design criteria and requirement 2. Generate multiple solution 3. Analyse and select a solution 4. Test the solution
5	Produce the final product of design: arrangement and detail drawings and bar schedules.	Detailed drawings	1. Implement the solution by conducting the detailed design with drawings.
6	Write report	Project report	Communication - written

3.7.3 The Development of FPjBL

After considering the preliminary finding, the industry benchmarking and the current project implementation in structural engineering design course, the assessment, integration of soft skills and abilities, a detailed of the intended field project-based learning was developed in the this sub-section. Since the industrial training component had been eliminated from the engineering program as mentioned earlier in this chapter, it is sensible to include the partial industrial placement component as field-project work to students.

Students are expected to meet the following objectives of FPjBL in DDA3164 using the engineering process as described by Khandani (2003) such as the definition of the problem, identification of solutions, evaluation of alternatives to reach the preferred solution, the production of a detailed design and associated drawings and the writing of project report. In addition, students were expected to meet design abilities such as developing effective group working, effective communications, producing written and oral reports and working to deadlines.

3.7.4 FPjBL Implementation Prior To Field Visits

Project based learning is generally done by groups of students working together toward a common goal (Thomas, 2000). It allows students to reflect upon their own ideas and opinions and make decisions that affect project outcomes and improved their learning process either individually or in the group.

Tedford, Seidal and Islam (2006) reported that most lecturers are unaware on how to utilize the teamwork's project to ensure maximum impact in students' learning. In this regard, Oakley, Felder, Brent and Elhajj (2004) suggested that several alternatives to be considered to measure the effectiveness of team working among students in design projects. This includes preparation by the lecturer to form teams, instead of letting students to self-select as this would ensure the diversity of students in the group.

The reseacher also prepared the lesson plan for the execution of the field PjBL (see Appendix B). The lesson plan was designed to enable the students to accomodate their time for the studio work as well as field visit in the semester. Five field visits to the design firm were conducted throughout the semester in order to expose the students to real engineering design projects.

Another preparation includes the presentation of the project description to the students after the formation of the teams. The project involved designing a two-storey bungalow or equivalent as illustrated in Figure 3.2 below. The details of construction and specifications were abstracted from the architectural drawings available from the design firm. Once the students have selected the specifications for their design project, they were required to propose the structural layout and calculate loads on the building. The project outcomes include the project descriptions, sketches and calculations that must be compiled in the project report. Later, the students submitted the project report on the date as informed by the lecturer.

DDA3164 – REINFORCED CONCRETE DESIGN

PROJECT

Design a 2-storey bungalow. Details of the construction and the relevant specifications are to be prepared by your group. You are required to prepare a design report on the following all structural components such as beam, slab, column and footing . All the data required is based on your own design except otherwise stated.

The report should display the calculations with sketches where necessary. Detail construction drawings of the elements should be drawn in pencil or ink in A3 size paper. Drawings using AutoCAD should be attached with manuals sketches.

The project report should be submitted not be later than the final week before Final Examination. 1% of total marks will be reduced for each day late.

Figure 3.2 : Project description for DDA3164

The students were made aware of the design process that they will undergo during the project implementation. The design process as suggested by several authors (Khandani, 2005; Mourtos and Furman, 2002), began with the identification of structural system by generating the ideas from the architectural functional plan. Next the selection of the sections that best fit the solution and finally the final design and detailing stage.

3.7.5 FPjBL Implementation During Field Visits

The researcher was thankful enough that the firm agreed to participate in the research. The remaining nine weeks of the semester were utilized for project work in the studio and closely supervised by the lecturer in the normal classroom scenario. This tally with Krajcik, *et al.* (1998) and Thomas (2000) who argued that students activities must be structured to facilitate meaningful learning and carefully monitored as they progress through project stage in order to control any unforeseen problems such as wrong parameters in designing structural section. The detail description of the project activities according to the learning outcomes is provided in Table 3.5. These include the learning objectives, the learning activities and design process that the students would engage during the course of the design project.

3.8 Data analysis and Interpretation

The data in this study includes analysis of documents, interviews, journal entries and observation. All the interviews were fully transcribed by the researcher herself so that she could familiarize herself with the keywords used by the respondents as suggested by Merriam (1998).

3.8.1 Analysis of Documents

The documents analyses for this study were the course learning outcomes (CLO), the mark distribution of the design course as well as the project reports from the final year students of session 2009/2010. These documents provide a rich source of information that can be used to support the data collected through interviews, journal entries and observations (Merriam, 1998; Hancock and Algozzine, 2006; Bogdan and Biklen, 2007).

3.8.1.1 CLO of DDA3164

The document analysis in this research comprises the course learning outcomes (CLO) of the course DDA3164, project assessment and evaluation of students and project reports. Teaching and learning of this course can be divided into two categories: conceptual design and detailed design. The conceptual design deals with the understanding of the design process where eventually students arrived at the future and proposed structural system. The detailed design stage is the design process of the final detailed design. At present, very little is taught about the conceptual design and the majority of the teaching effort is concentrated in the teaching of the detailed design methods and concepts. This is not an optimal situation according to Arciszewski and Lakmazaheri (2001) because the initial task of structural design is decided during the conceptual design stage. More than half of the time are spent during this stage of design.

The project-based learning is integrated in the course of DDA3164 in the CLO as shown in Table 3.6. The CLOs addresses the cognitive, psychomotor and affective domain of learning (refer Appendix S for Bloom’s Taxonomy). For the project work, students are required to submit the full written report accompanied by calculations and drawings.

Table 3.6 : Course Learning Outcome of DDA3164

No.	Course Learning Outcome	Taxonomy and Generic Skills addressed	Assessment
1	Describe reinforced concrete design concept	Cognitive	Project, Tests and Examination
2	Identify and analyse the design loadings	Psychomotor	Project, Tests and Examination
3	Analyse the structural elements.	Cognitive	Project, Tests and Examination
4	Organise and transform architectural drawing into structural layout elements	Psychomotor	Project
5	Design and detailing structural concrete elements.	Psychomotor	Project, Tests and Examination
6	Respond and think logically to solve problems and make conclusions.	Psychomotor	Project, Tests and Examination
7	Communicate clearly and effectively in oral and/or written forms.	Psychomotor	Project, Tests and Examination
8	Work collaboratively as part of a team	Affective	Not assessed
9	Acquire and manage knowledge for further study	Affective	Not assessed
10	Demonstrate ethical standard in professional practice and social interactions	Affective	Not assessed

3.8.1.2 Project Assessment and Evaluations

For this study, the assessment of the written project report as well as communication and teamwork were proposed for the intended FPjBL. In this research, students produced written design project based on tasks and activities and the lecturer judged their work. The assessments on the students' communication and teamwork skills were not clearly assessed. These skills were assessed along with the technical contents and embedded within the whole evaluation of the project.

A written design report based on group work is to be submitted to the lecturer on the final week of the semester. Students were required to demonstrate their understanding and capability in design and to justify the design alternatives proposed during the design process. The elements considered are the rationale for the design and justification and quality of final product reported (Mills & Treagust, 2003).

3.8.2 Analysis of Interviews, Jounal Entries and Observations

The researcher analysed the data from the interviews, observations, journal entries and observation field notes through content analysis. The researcher followed the content analysis proposed by Creswell (2003), Gillham (2000) and Merriam, (1998) to examine meanings, themes and patterns that may manifest in the texts gathered from interviews, journal entries and observation field notes.

3.8.2.1 Content Analysis

Content analysis is a research method and has been used in a variety of research applications in recent years (Zhang and Wildermuth, 2009). According to Hsieh and Shanon, 2005, the content analysis method is a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns. However, Patton

(2002), describes content analysis as data reduction and sense-making effort that takes a volume of qualitative materials and attempts to identify core consistencies and meanings. Content analysis is a method of identifying and coding data that is developed through inductive analysis as suggested by Borrego, Douglas and Amelink (2006). Themes were developed through patterns and similarities emerging from the inductive analysis carried out.

Using the content analysis, categories were created with scrutiny to the dimensions of each category by examining the similarities and differences (Creswell, 2003; Gillham, 2000). For example, each piece of data was coded and classified to make sense of the data collected and to highlight the important findings. Collapsing then reduced into classifications and combined based on the meaning and relationships. The researcher also referred to the research questions in analysing the data and determining the categories as proposed by Merriam (1998).

In order to identify the data set during analysis and write up, the qualitative content analysis began with coding where codes were assigned to each data set (Maykut and Morehouse, 1994). They were labelled S1-A to S8-A for interview transcripts, S1-B to S8-B for journal entries text and observation field-notes as OFN.

Level 1: Preparing Transcripts and Classify Descriptions

The researcher organized and prepared the data for analysis. This involved interview transcripts, journal entries, observations and documents. The researcher read through all the data to obtain the general sense of information and grouped and distilled relevant descriptions from the text of each data set (transcripts, journals) to evidence-based interpretations. The analysis entailed classifying, comparing, weighing and combining material to extract the meaning and implications to reveal the pattern. Later, listing of the common themes emerged and the data were linked together according to its content (Creswell, 1998; Gillham, 2000; Merriam, 1998).

In Table 3.7, students' interview were analysed to identify and highlights the statements, sentences or words that contain information related to research questions.

The research also engaged reading, re-reading and comparing sentences and their meaning repeatedly to arrive at the descriptive codes from the interview transcriptions in order to complete the analysis.

Level 2. Classify The Meaning

Theme categorization and identification is crucial in this research following Ryan and Benard's (2003) statement, which stated that most fundamental tasks in qualitative research is theme identification. In level 2, the descriptive codes were further organized and analysed by categorically, reviewing repeatedly, and continually coded as suggested by several renowned authors in qualitative research (Creswell, 2003; Maykut & Morehouse, 1994; Meriam, 2009) to find pattern, themes and categories (Zhang and Wildermuth, 2009; Punch, 2009). Therefore, the descriptive codes obtained from the interviews were read and the theme categories were assigned.

The descriptive codes from the remaining interview transcripts were analysed, classify and compared with the theme categories identified from in the first interview transcript. The theme codes that have the same meaning with previously identified theme categories were assigned the same theme categories whereas the others were labelled with new theme categories. Reading, re-reading, and comparing the identified descriptive themes and grouping them to the similar categories completed the Level 2 analysis.

Level 3. Theme Categorization and Coding Ability

Data collection and data analysis must be a simultaneous process (Merriam, 2005; Creswell, 2003). An important part of the analysis is the development of relevant coding scheme. According to Richards (2005), codings are to reflect the researcher's selection of categories and their meanings to the project. Coding allows the researcher to inspect, interrogate and interpret the data in the form of interview transcripts, texts or journal entries (Benard, 1996). Coding also enables the researcher to locate interview excerpts that refer to the same concept, theme, event or topical marker and later examine these excerpts together (Rubin & Rubin, 2005). The coding scheme enables a meaningful interpretation of the data with respect to the research objectives (Chi, 1997; Meriam, 2009). Rubin and Rubin(2005) proposed that the coding scheme assist the researcher in comparing how ideas are expressed across interviews to refine the meanings, elaborate concepts and themes, and suggests what needs to be added. Coding seeks to identify and describe patterns and themes from the perspective of the participants, then, attempts to understand and explain these patterns and themes (Maykut and Morehouse, 1994).

According to Maykut and Morehouse (1994), and Ryan and Benard (2003) the rule for reviewing categories is that the descriptive codes in each category should be similar. Therefore, in this study the identified categorized themes and the corresponding descriptive codes were reviewed.

The journal entries were also analyzed using similar approach. Depending on the words or statements and their meaning, the entries from the journals were categorized using equivalent themes with the interview transcripts. Depending on the statements on their meaning, they were either categorized according to previous identified categories or assigned as new categories.

Table 3.7 : Examples of descriptive code, themes categories and coding

Instrument	Description	Student	Level 1-Classify (Descriptive)	Level2-Core Meaning (themes categories)	Coding Ability
Interview	ABET 2000	ABET	*"Students should be able to apply knowledge of mathematics, science and engineering and to identify and formulate engineering problems"*	**CK-Content knowledge** Use techniques, skills and tools necessary to engineering design practice.	CK1-Problem Formulation
	What is your goal in FPjBL? What skills (abilities) do you to learn from project? What kind of knowledge you need for design project? What knowledge you want to get from FPjBL in design? For example, when you analyse the tasks, what do you do?	S4-A	***Knowledge*** *and* ***experience*** *[practice] on how* ***to do proper design*** (building), ..*I want* ***to explore*** new software (tools) used in design in industry.... Knowledge to do design. *Analysis and designing [building] helped me to learn basic design process; learning about a real life problem with a bit of fun; practical use of theory to do real things; challenging and interesting.*	Able to use theory to analyse Able to use theory to design	CK1-Problem Formulation PS- Problem solving

Instrument	Description	Student	Level 1-Classify (Descriptive)	Level2-Core Meaning (themes categories)	Coding Ability
Journal	What did you learn and what is the evidence?	S5-B	Moreover *many tasks [complex] need to be done* and *I must* ***know the content*** taught by Pn.XX to proceed to design beam, slab, column and footing. But it's very ***interesting [to design]*** because I can ***relate the course content with practical and other subjects[use prior knowledge]***	Must know the content {knowledge] Interesting to design Relate [practice] to content knowledge Relate [prior knowledge] to design practice.	CK-Content Knowledge
Document Analysis	1. Describe reinforced concrete design concept 2. Identify and analyse the design loadings 3. Analyse the structural elements 4. Organise and transform architectural drawing into structural layout elements 5. Design structural concrete elements. 6. Respond and think logically to solve problems and make conclusions. 7. Communicate clearly and effectively in oral and/or written forms. 8. Work collaboratively as part of a team 9. Acquire and manage knowledge for further study. 10. Demonstrate and understanding of professional and practice ethical value.		Know design concept Problem solving Psychomotor, Affective Know design concepts. Relate to engineering practice. Problem solving skills Communication Team work Lifelong learning Ethics	Theory and practice Ethics Teamwork Communication Lifelong Learning Problem solving skills	CK-Content Knowledge PRS-Professional Skills LLL-Lifelong Learning PS-Problem solving skills

Notes:

CK	=	Content knowledge
LL	=	Lifelong learning
PS	=	Problem solving
PRS	=	Professional Skills
ME	=	Motivation and engagement

Table 3.7 illustrates the examples of the descriptive themes categories, core meaning (theme categories) and coding applied for the interview transcripts, journal entries, documents and field notes. The result of the analysis and discussion are presented in Chapter 4.

3.8.3 Validity and Reliability

The quality of the qualitative research is considered to demonstrate the trustworthy of the research findings. Merriam (1998) describes these as internal validity, reliability, external validity and ethics. Guba and Lincoln (1989) refer to these criteria as credibility, dependability, transferability and conformability.

Validity or credibility is to check how the research findings match '*reality*'. According to Merriam (1998) the '*reality*' is holistic, multidimensional and ever changing and it is not a single, fixed, objective phenomena waiting to be discovered, observed and measured as in quantitative research. In qualitative research, what is being observed is the "*people's construction of reality* and how they observe the world (Merriam, 1998: p.203). Since students are the primary instruments of data collection, their interpretations of reality are assessed directly by the researcher through observations and interviews. Thus, the validity of the qualitative research by the researcher is closer to *reality* since she was in personal contact with the students.

According to Merriam (1998), there are six basic strategies to enhance credibility; they are, triangulation, member checks, long-term observation, peer's examination, participation or collaborative modes of research and researcher's biases. For this study, three strategies have been employed. They are triangulation, member checking and long-term observation.

Triangulation has been applied in the data analysis stage. Data were collected through multiple sources, which include interviews, observations, journal entries and document analysis. The researchers used these multiple sources of data to gain a comprehensive understanding of the case being studied as suggested by several researchers (Creswell, 2003;Yin, 2003; Merriam, 2009; Bogdan and Biklen, 2007). Various data collection methods such as the interviews, observations, journal entries and documents have different strengths and biases so they can complement each other (Miles & Huberman, 1994). In addition, triangulation is important because findings were based on several data sources and it is applied to build a coherent justification for themes as well as comparing meanings within the study (Creswell, 2003).

Member checking is used to determine the accuracy of the qualitative findings through the descriptions or themes (Punch, 2009). Punch (2009) defines member checking as an act of asking the participants to review the transcripts, field notes or descriptions of the data. In this study, the researcher asked several participants to justify the researcher's interpretation of their views.

Long-term observation was undertaken since the study was a full duration of semester for five field visits. All field project sessions were observed and recorded and all students were observed over the length of the course.

Reliability or dependability in qualitative research is used to check for consistency of the results obtained from the data (Creswell, 2003). They can also generalize some facets of multiple case analyses as mentioned by Yin (2003). Merriam (1998) suggests several techniques that can be used to ensure that the results are dependable. In this study, triangulations were employed in order to enhance the reliability of the research work. The researcher's position and audit trail were taken into account to ensure that the data results are dependable. This chapter has detailed the methodology used for data collection and the chapters that follow further decisions made regarding data analysis and interpretation. Thus reliability of the study has been addressed through all these phases.

Merriam (1998) describes external validity or transferability as the applicability of the research findings of the study to *another situation*. '*Another situation'* is up to the people in those situations who reads and decides what aspects can be applied to his/her own situation. For example, another researcher may use other evaluation technique for project to study other engineering discipline. Merriam (1998) also suggests the possibility of transferability to enhance the study's findings. Rich, thick description requires enough description of the current study through details provided in this chapter.

3.8.4 Bias

Bias is questions that encourage respondents to answer in a particular research finding that deviates from a 'true' finding (Babbie, 2002). Bias in a qualitative research occurs naturally in the design of any research (Rubin and Rubin, 2005), but the impact can be minimized by recognizing and dealing with them. During the interview sessions, the researcher answered briefly as suggested by Rubin and Rubin (2005). Sometimes the researcher gave clues on some questions she posed to the interviewees.

Since the researcher was not involved in the lecturing of the course DDA3164, the biasness would be minimized. For example, students were willing to participate in the study because it would not impact on their grade. The researcher carefully examined the purpose of inquiry and construct items that reflect the objectives of the research. The respondents were also asked repeated questions which were rephrased in order to consider the doubts that arisen during the interview (Babbie 2002).

3.9 Conclusion

This chapter has highlighted the background and rationales for choosing the case study institution, the industry and the participants. The sampling, instruments and data collection methods were also discussed. The content analysis method, the descriptive codes, their meaning and thematic categories were also highlighted. Lastly, the validity, reliability and the biasness of the research has been taken into consideration and discussed.

CHAPTER 4

RESULTS, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of this research that focuses on the expected design abilities performed by students and the actual skills demonstrated by them in the field project-based approach (FPjBL) of structural reinforced concrete design DDA3164. The design abilities, students' performance, the teaching and learning activities of field project-based learning in relation to the course learning objectives and outcomes are discussed in this chapter.

Several methods of data collection were employed for the purpose of this research. These include document analysis, interviews, observation as well as the students' journal entries in order to evaluate and examine their abilities through field project-based learning. From the results obtained, the researcher will propose a more comprehensive project-based learning instruction for enhancing students' design abilities includes the cognitive, psychomotor and generic skills (Chapter 5).

4.2 Document Analysis

This section analyses and presents the learning objectives and outcomes for project-based learning in structural reinforced concrete design course. The abilities expected of students are outlined in the CLO of DDA3164 offered at the civil engineering students at the diploma level.

4.2.1 Course Learning Outcome (CLO) and Objectives of DD3164

This study analyses the field project-based learning (FPjBL) that is integrated in Structural Reinforced Concrete Design (DDA3164). The course aims at providing students with the understanding of the basic principles and concepts in structural design such as the understanding of the behaviour of structures under loads and developing the structural component detailing. Therefore, prior knowledge in structural analysis, building construction, concrete materials and properties are required in order for the students to be able to design in this course.

The project has been integrated in DDA3164 at College of Science and Technology (CST) since its formation in 1995. The project runs parallel to the theoretical concepts taught by the lecturer. The project is introduced in the normal class lectures and the emphasis is on the concepts of structural reinforced concrete design.

The intended learning outcomes and objectives of DDA3164 are shown in Table 4.1. The content of this table is constructed based on the accreditation requirements of ABET, Malaysian Qualification Accreditation, MQA, Board of Engineers Malaysia and as well as authors such as Mills, (2002), Mourtos and Furman (2002) and Nicolai (1998). The project plays a very important role in the course as reflected in the assessment methods in Table 4.1. The project in DDA3164 encompasses three general learning categories; the understanding of engineering design (the cognitive), the knowledge application (psychomotor) and the transferable (affective) skills.

Table 4.1 : Course Learning Outcome (CLO) of DDA3164

No	Course Learning Outcome	Taxonomy Level and Generic Skills	Assessment Methods	Expected skills in project's work
1	Describe reinforced concrete design concepts and principles	Cognitive	Test, Exam, Project	Ability to apply knowledge of basic science and engineering fundamentals. (Content Knowledge)
2	Identify and analyse the design loadings	Cognitive	Test, Exam, Project	In-depth technical competent in structural design such as how the load effects are modelled in structural system and analysis.
3	Design the structural elements.	Cognitive	Test, Exam, Project	Having good knowledge and ability to apply techniques of analysis, considerations on design, construction and materials.
4	Organise and transform architectural drawing into structural layout elements	Psychomotor	Project	Ability to Communicate through design solutions through sketches and engineering drawings
5	Design and draw structural concrete elements.	Psychomotor	Test, Exam, Project	1.Ability to communicate design solutions through sketches and engineering drawings 2. A broad knowledge of relevant design aids and manuals.
6	Respond and think logically to solve problems and make conclusions.	Psychomotor	Test, Exam, Project	1. Ability to undertake problem identification, formulation and solution 2. Ability to produce engineering solutions that are functional, economical and technically correct
7	Communicate clearly and effectively in oral and/or written forms.	Psychomotor	Project	Ability to communicate design solutions through sketches and engineering drawings

No	Course Learning Outcome	Taxonomy Level and Generic Skills	Assessment Methods	Expected skills in project's work
8	Work collaboratively as part of a team	Affective	Project	Ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member.
9	Acquire and manage knowledge for further study	Affective	Project	Expectation of the need to undertake lifelong learning and capacity to do so
10	Demonstrate theoretical standard in professional practice and social interactions	Affective	Project	1. Ability to understand the professional and ethical responsibilities and commitment to them. 2. Ability to communicate effectively with professionals and community.

The intended CLO in Table 4.1 incorporated both the technical and generic skills approved by CST and by the Academic Board of the University. The cognitive outcome in project is intended to enable students to achieve between levels one to four of the Bloom's Taxonomy for items 1 through 4 in the CLO (refer to Bloom's Taxonomy, Appendix S). This includes describing, identifying, designing and transforming the design concepts by analysing and applying the structural elements of DDA3164. In this instance, students would be able to apply the knowledge of basic sciences and engineering fundamentals in design. In addition, an in-depth technical competence in structural design to understand the need as to how the load effects are modeled in structural system and analysis are expected of students. They are also expected to have knowledge and ability to apply techniques of analysis, methods of construction and materials properties in design.

FPjBL involves ill-defined problems, therefore are expected to respond and think logically in solving the problems and make conclusions (item6). The expected skills of project include problem identification, formulation and solution and producing engineering solutions that are functional, economical and technically correct. Therefore, skills such as analysing, organizing and problem solving are expected of students to perform the design problems with confidence and proficient.

DDA3164 exposes the students with the fundamental generic skills in design such as communication and teamwork. For item 7, students are expected to communicate clearly and effectively both in oral and written format. They are also expected to communicate the design solutions through sketches and engineering drawings. For item 8, students are expected to work collaboratively and function effectively as an individual and in multi-disciplinary and multi-cultural teams, either as a leader or manager or an effective team member. In item 9, the expectation of the need to undertake lifelong learning and capacity to do is also considered in the CLO. Lastly, item 10, outline the students' ability to understand the professional and ethical responsibilities while engaging themselves in the engineering project.

The practice of projects in engineering design education has to reflect the outcomes and objectives of project-based learning approach. Students' expectation with regards to projects in design has been highlighted in Puteh, Ismail and Mohammad (2010). Students have high hopes that the projects would assist their understanding of the whole course in design. These students have high expectations that the projects would enhance better practice their design abilities. Some of the design abilities students expect to gain from the projects are: working in a team, solving design problems, organizing projects, using application software in designing, engaging in creative thinking and exposure with problem solving (Puteh, Ismail and Mohammad, 2010). Despite the details in the CLO, several skills and abilities were not implemented within the course such as teamwork. Therefore, it is important that the tasks implementation of project be carried out and addresses this skill.

Students' motivation and engagement in projects has not been taken into consideration in the CLO, even though several authors have recognized its importance (Gao, Demian and Willmot, 2008; Helle *et al.,* 2007; Blumenfeld, *et al.,* 1991; Hermon and McCartan, 2010). However, the concenses on motivation and engagement is increasingly seen an an indicator of instruction because it generally includes the psychological and behavioural aspect of individuals. The interaction among students, lecturers and professionals are predicative of positive change of students.

4.2.2 The Analysis of Assessment and Evaluation of projects

Project evaluation and assessments for DDA3164 were gathered and analysed. In this course, the project report is compulsory and need to be submitted and assessed by the lecturer. The current practice at CST revealed that a standard marking scheme for design project has not been formulated to assist in the evaluation of design projects. The grades that the students received for their design projects were very much dependent on individual lecturer's discretion. Despite the 20% weightage given to the projects (from the total grade of the whole course), each lecturer has the freedom to allocate the marks in evaluating the projects. Some lecturer placed the importance on the students' analysis ability of the design materials, while others may include creativity of the students as well as the team working effort. However, majority of the lecturers emphasize on the students' technical knowledge as evident through the design project. These variations in the components of the assessment of projects have raised the questions of inter-rater reliability in assessing the design projects and it may further developed unpleasant feelings among the students when they discovered that different lecturers graded their design projects on separate aspects. Consequently, students who were not properly assessed on their design abilities in their design projects would score highly in the design projects but failed to excel in their tests and examinations on the design course.

Table 4.2 shows the students' performance on tests, project and the final examination for DDA3164. The project marks are compared with tests and final examinations results of students. Test 1 and Test 2 were given to students to test their theoretical knowledge on concepts of structural design and is also the same for the final examination (refer sample test and final paper in Appendix N-R). The 20% weightage given to the projects (refer to Table 3.4 for marks distribution) depended on the lecturers' own understanding of the project and their discretions. For example, a lecturer may allocate the marks for the project to include the ability of the students to analyse design components, to demonstrate some elements of creativity and to manage working in a team, while others may assess and give more weightage on the technical knowledge only. This resulted in the students performing well in their design projects but failed to show equivalent accomplishment in their tests and examinations.

Table 4.2 : Student Performance on Tests, Project and Finals

Student's Code	Test 1 15%	Test 2 15%	Project 20%	Final 50%
SP1	6	5.6	17.1	16.5
SP2	6.2	4.5	17.2	19.5
SP3	7.2	4.4	16.7	22
SP4	7.1	4.8	17.2	15.5
SP5	5.4	7.5	17.4	29.5
SP6	7.1	8	15.2	19
SP7	6.5	9.2	16.8	34
SP8	5.3	3.3	16	18
SP9	8.4	3.8	17	11
SP10	6.6	3.5	16.5	20
SP11	7.1	3.8	15	13.5
SP12	3.6	1.7	17	27

It was also discovered that students' performed poorly in tests and examination, but showed excellent results in their projects. The question was raised regarding the correlation between the tests and the projects; if students have understood the concepts and principles well, these should be reflected on the project work produced. Table 4.2 demonstrates that on average, all the twelve participants in this study have obtained more than 15% for their project work. However, they scored badly in their test 1, test 2 and final exam, which quizzed their theoretical understanding on the design concepts. Student SP12, for example, obtained the lowest scores, 3.6% out of 15% for Test 1 and 1.7% out of 15% in Test 2. Surprisingly, he fared excellently in the design project by scoring 17% out of 20%. SP8 also showed the same trend. He scored 5.3% and 3.3% for Test 1 and 2 respectively but attained 16% for the design project. Even the final exam did not indicate that he is a good performer for the subject as he only managed to score 18% out of 50%. This is a very clear example of inconsistency in assessing the students' design abilities where students get high project marks but failed to show achievement in their learning of design. Design abilities not only look at the students' designing skills but also encompass other skills such as problem solving and team working as suggested by Abdul Rahman, Mat Daud, Jusoff and Abd Ghani, (2009); Aman *et al.*, (2007); and Andreas, (2003).

In assessing students' projects, it was discussed that the lecturer was more concerned with the final product, i.e the project report. Moreover, the expectations of lecturers on projects were more related to the contributions of project towards the whole course. They were more concerned with how the students regard the project, which they later associated with students' knowledge in preparing the project report.

The approach at CST requires further enhancement on the opportunity for the students to engage in self-directed learning and become independent learners without direct supervision from the lecturers. Puteh and Ismail (2011), Mills & Treagust (2003) and Mergendoller (2006) outlined several recommendations that could be useful to some faculty which plan to undertake project-based learning in their design classrooms.

1. Bring students to project sites to expose them to real life designs and site conditions.

2. Introduce to students on cases handled by the local consultants.

3. Presenting to students with more samples of real projects.

4. Introduce project-based approach earlier in the undergraduate course i.e. from first year onwards.

5. Assessment on projects should be further increased, as projects are time consuming to be completed. Perhaps, instructors should also reduce the number of tests and absorb the marks into the project.

6. There are opportunities for the students to engage in self-directed learning and become independent learners without direct supervision from lecturers.

7. Introduce more updated computer application software, which can be used in designing.

FPjBL approach is an excellent vehicle for teaching engineering subjects such as structural design course, DDA3164 because students can be taught in contextual situations. This knowledge and skills are not isolated from one another instead they complement each other. Therefore, FPjBL is an excellent approach if industry can be involved in the teaching of engineering design, as students will be able to link the theoretical frameworks to real world applications.

Although FPjBL has several advantages, it is also associated with difficulties as far as teamwork is concerned. Lingard (2010) claimed that engineering programs provide little or no specific instruction in the assessment of project. Moreover, project assessment is the most under-research topics in engineering education (Sobek II & Jain, 2004) because of the nature of project works that involve problem solving skills, self-directed learning skills and collaborative skills and abilities.

Typically, in CST and as reported by several authors (Djukic, 2006; Gibson, 2001; Cajander, Daniels, McDermott and Von Konsky, 2011), projects are designed primarily for the development of technical knowledge and skills with little focus on the collaborative skills such as interpersonal skills, organizational, team play, etc. At CST, all the lecturers assessed the students' project work based on the technical understanding and organization and some on creativity. Assessment were normally related to design process characteristics and very subjective according to Sobek II and Jain (2004). Thus, the challenges are in enhancing the design abilities among the team members toward a common goal in design so that fair individual and team assessment are achieved.

The researcher also observed that the learning outcomes of the projects in DDA3164 were not properly addressed. Based on the researcher's 20 years experience in teaching the design project, the students were graded by evaluating their written project report only. Generic skills such as teamwork and communication observed during the course of the project work were not considered. Students' journal entries gave specific illustrations of the development of these skills as well as technical skills. Sketches, drawings and calculations and numerous discussions among students and lecturer are examples of communication abilities developed by students. The communication development can be seen through the teamwork and negotiation abilities illustrated by students in their journals. For ease of understanding, the students are coded S1-S8.

> *We meet again to find that we are still in the midst of the beam's design. I asked (S2) and others for suggestions. We brought all the information together with the advice of (S3) this week.*
>
> (S4-B)

> *Worked with (S5) and (S7) today and threw ideas around. Overall a very productive day.*
>
> *(S8-B)*

These quotations indicated that students collaborated with their peers as well as sharing ideas and discussions across other groups. The methodology used by other group indicated that they had agreed to adopt the same process amongst them. As observed by the researcher, this was done after discussion and debate, not just copying for expediency without understanding.

The professional skills such as the ability to undertake problem identification, formulation and solution would allow opportunities for students to develop this ability. However, these skills are left for the students to undertake as long as the end products of the design are correct. An indication that the student has developed the problem formulation process is given in the following excerpt;

> *I believe that the process of design is nearly the same for beam as the other beam which I have already done but I'm having the problem of calculating the loads on it.*
>
> (S6-B)

The learning outcomes of DDA3164 would normally comes under headings such as knowledge skills, thinking skills, personal skills, personal attributes and practical skills (Gibson, 2002). As mentioned earlier in section 4.2.1, assessment in the project work is not well defined in the learning outcome of design course. Therefore, the learning outcomes would normally comes under headings such as knowledge skills, thinking skills, personal skills, personal attributes and practical skills (Gibson, 2002). Other skills such as personal skills, team working and communication are also generally documented in the learning outcome, but yet have proven difficult to assess with regard to the FPjBL implementation, which is similar to the findings by Hashim and Mohd Din (2009).

Students are expected to be able to perform tasks in projects work whereas the lecturers' task is to assess and evaluate the project work in a fair manner. In this context, it is of paramount importance to develop a fair and reliable method of evaluating systematically in order to identify the extent to which the students are applying their knowledge and abilities in design. This is to ensure that the students are not only gaining the basic knowledge but also their knowledge beyond the fundamentals. As students progress through their academic careers, their level of understanding is expected to increase.

One of the major challenges posed when implementing PjBL is that of awarding grades to students working in groups. This is because the nature of design courses often leads to subjective evaluations in which the balance between awarding individual grades to student as well as group work. This is a dilemma because the individual effort in a team is often difficult to identify and reward (Mills, 2007; Dutson, Todd, Magleby, & Sorensen, 1997). At CST, the students faced several issues with regard to assignment grading (Puteh, Ismail and Mohammad, 2010).

At CST, the assessments of project in DDA3164 are equally awarded to the group of students. The assessment on projects does not include the professional skills of item 7 to 10 of the CLO (refer to Table 4.1). All project work are assessed based on the written report submitted by the students at the end of the semester and evidently that there was no assessment being made on teamwork ability (Puteh, Ismail and Mohammad, 2010).

The assessment of a project should focus on a full range of skills such as technical abilities, communication and team skills as well as peer assessment being developed during the project as suggested by Mills (2007). Whilst there are several assessment tools and techniques used by several authors (Mills, 2007; Gibson 2002) for PjBL but for this research (FPjBL), the researcher will propose the assessment for written project that will be concluded in the following chapter.

The researcher has adopted and improvised the assessment on teamwork and communication in project work with reference to the CLO of DDA3164. The assessment is based on the ability to work in a team and team interaction. On the other hand, communication among team members can be assessed as suggested by Mills (2007); ability to communicate concepts and original ideas to fellow team members, ability to reports and explain technical findings, both written (including numerical and graphical presentation) and spoken, clearly and concisely and ability to participate and co-operate as a willing and responsible team member.

4.2.3 The Expected Design abilities Desired by industry

The literature review detailed in Chapter 2 helped to develop the intended project-based learning for the structural reinforced concrete design course, DDA3164. The needs of the engineering industry and the outcomes of several engineering education been conducted in various countries in recent years have highlighted that industry attachment is relevant to capture the students' skills and knowledge of structural engineering design through authentic projects (Zaharim, *et al.,* 2009; Nguyen, 1998; Mills and Treagust, 2003). In professional practice, the work in the design office is project-based and every task is undertaken by an engineer will be in relation to projects. For example, the design of high-rise buildings may take a few years, and engineers may be involved with numerous small projects for various clients at any given time.

The use of teamwork to in project-based learning enables collaboration, social interaction and negotiation of understanding. Students hoped to gain ownership of project and direction of learning as well as opportunities to reflect their own work if given the exposure to do so. For this study, the researcher adopted the field project-based learning to be integrated to structural design, DDA3164 based on the guidelines for generic skills and knowledge of structural engineering design in Table 4.1.

Table 4.3 summarizes the skills desired by the industry. It is divided into technical skills and generic skills. There are nine generic skills including the self-directed lifelong learning that is expected in the engineering industry. Other needed abilities of engineers are the abilities to solve open-ended problems and effective collaboration (Nicolai, 1998).

Table 4.3 : Technical and Generic Skills Desired by Industry

Technical Skills	Generic Skills
1.Understand the basic principles in structural design.	1. Ability to apply knowledge of basic science and engineering fundamentals.
2. Understand loads and how their effects are modelled in structural system and analysis.	2. Ability to communicate effectively with professionals and community.
3.Understand the need to produce engineering solutions that are functional, economical and technically correct.	3.In-depth technical competence in structural engineering.
4. Having good knowledge of the properties of materials such as steel and concrete.	4.Ability to undertake problem identification, formulation and solution.
5. Having good knowledge on of modern techniques of structural analysis, design and construction.	5. Ability to utilise a systems approach to design and operational performance.
6. Having a broad knowledge of relevant EUROCODE and Malaysian Standard (MS).	6.Ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member.
7. Having knowledge of available analysis and design aids including computer programs and design manuals.	7.Understanding the principles of sustainable design and development
8. Having the ability to communicate design solutions through sketches and engineering drawings.	8. Understanding of professional and ethical responsibilities and commitment to them
	9. Expectation of the need to undertake lifelong learning and capacity to do so.

As can be seen from the table, the engineering design abilities require both technical and non-technical that comes from cognitive as well as the affective domains (Mourtos, 2011; Nguyen, 1998). Thus, engineering graduates must posses, not only a breadth of discipline comprising the technical skills and knowledge, but also generic attributes and other skills in today's professional environment such as business deals.

Wellington *et al.* (2002) highlighted the importance of communication, decision-making, problem solving, leadership, emotional intelligence, social ethics and ability to work in a globalised work environment and different backgrounds. These are the most essential generic skills and attributes of a modern engineer. The emphasis given to personal and professional attributes by the industrial sector indicates that engineers are not only expected to be technically proficient in the field but also to behave and operate properly within an organisation. Other generic groups such as intellectual skills and standards of engineering practice were also highly regarded by the industry.

In the study carried out by Puteh, Ismail and Mohammad (2010), the authors found that the students prefer project-based learning to be carried out at the industry for design courses. This is because it is a good exposure and approach for them to apply other abilities such as self- assisted learning, assisting their professional skills as well as gaining other knowledge.

4.3 Expected Skills in Students' Field Project Based Learning (FPjBL)

Projects in DDA3164 expose the students to the theoretical concepts of structural reinforced concrete design course in order to enable them to design specific structures, for example beams, slab, column and footing of a building. Since the students were engaged with the engineer at the firm, they utilised the studio's period to better understand the project component. The projects were adopted from the firm's on-going project. Sources related to the project such as building specifications and geotechnical requirements, were furnished by the firm's design engineer to enable students to focus on structural elements of structures. In executing the project, the students visited the design office for five alternate weeks.

Consecutively, they consulted the lecturer when they faced problems with the project.

Transfer of knowledge and ideas from the field experience engineer allow students to develop the design process in training. Project work is the ideal way to link universities and industry so that specialist knowledge is strengthened along with the field knowledge during the course duration of the training. Thus, the following section will analyse the implementation of FPjBL in DDA3164. The outcomes of the research will be reported with reference to the conceptual framework presented in Chapter 1 through interviewing the students, analysis of the journal entries and observations of the researcher.

The analysis of the data collected through various data collection methods have enabled the researcher to identify the important components that build up the students' design abilities. These components are identified after careful analysis of the data. Appendix W provides the detailed analysis of the data with regards to the respective components. The abilities critical in design projects include:

a) Content knowledge

b) Lifelong learning skills

c) Problem solving skills

d) Professional skills

e) Motivation and engagement

For ease of understanding, the students are coded S1-A to S8-A for the interviews and S1-B to S8-B for their journal entries.

4.3.1 Content Knowledge

A project is normally applied as a medium to enhance the relevant concepts and theory in the design practice. Therefore, the content of the course and materials are crucial to the course. Furthermore, the design project must be selected in such a way that different structural elements are prescribed and evident within strict time completion when executing the project. According to Chowdhury, Guan, & Doh (2005) exposure to different designs content and environment enable students to compare their designs thus, help them better understand the content of different design projects.

Content knowledge is very much related to problem identification and mastery of structural reinforced concrete design course. These are the two components that are highlighted by the students during the interview and journal entries.

Problem formulation is the ability to use the knowledge expected from an engineer (Woods, 1996) and this was emphasized in ABET 2000 outcome 3a and 3e;

> *Students should be able to apply knowledge of mathematics, science and engineering and to identify and formulate engineering problems.*

For the students to be able to initiate the design in project DDA3164, they must have the fundamental concepts and theory with prior knowledge in structural analysis, materials behaviour and construction.

Feedback gathered from the students through the interviews and journal entries have raised the importance of problem formulation in the design projects. Several students identified the weight of formulating problems in their design projects, evident from the following excerpts:

Analysis and designing building helped me to learn basic design process; learning about a real life problem with a bit of fun; practical use of theory to do real things; challenging and interesting.

(S4-A)

I'm able to decide suitable formula for the problem and decide the technique to use in relation to the problem in project..... can help me to have a deeper understanding about the problem.

(S8-A)

For me, before I start any problem in design, I would diagnose the problems...need realistic value with the help of the engineer and friends.

(S5-A)

Projects encourage students to work on the problem in depth (Hasna, 2008). While doing the project's problem, students require the ability to self-direction in the learning. To achieve this, students take initiative to learn individually or with the help of others. Respondent S8-A claimed that he diagnosed his learning needs, formulated his learning goals, identified resources and sometimes asking friends and engineer to assist him solve his problem so that he was able to choose and implement appropriate strategies for his design problem.

Both students S3-B and S8-B were able to associate their knowledge with real world content knowledge crucial in completing their design project. The students used fundamental knowledge to identify engineering formula to formulate the engineering problems.

Another important component of content knowledge is the mastery of the core subjects. Without the mastery of the subject, students will have difficulties in designing. Gusky (2007) and Bloom (1985) highlighted the importance of providing the opportunity for the students in developing a mastery of the structural design fundamentals. The observation by the researcher found that students were able to overtly show evidence of understanding of the design tasks before moving to the next task. Student S-8A demonstrated the use of subject mastery in completing a design project.

> *I was able to identify the missing requirements [in beam design] through evaluating the best design solutions from the resources we discussed among ourselves in the group.*
>
> (S8-A)

Similarly S3-B explained the role of previous course in executing the project. He was able to complete the puzzle between the courses he undertook.

> *I think now it makes sense why I'm studying other courses because now I am able to relate materials from previous courses. For example, construction specification, I must have knowledge on construction materials. Their strength characteristics are important to structural design.*
>
> (S3-B)

In this scenario, engineers are always expected to select the solution that uses the available resources and best meets the project's requirements (Khandani, 2005). The students used to consider many factors such as aesthetic quality, reliability, environmental consideration, safety, functionality, ease of use, aesthetics, ethics, social and cultural impact before starting on a design project.

One of the characteristics of PjBL is the necessity for the students to solve prepared project tasks. These tasks were designed to help students to master each learning item before proceeding to a more advanced task (Bloom, 1985). Students would normally discuss on the tasks and make decisions within the time frame every week. According to Benjamin Bloom (1985), mastering learning is a particular learning objectives. In this study, the field task No. 2 in the CLO (refer to Table 4.1) is an example of the mastery of the subject. The students demonstrated and used the in-depth technical knowledge to model the project into structural system and analysis.

The quotations below demonstrated students' ability to relate the theory and practice while satisfying specified set of constraints in project's design. This has tested the students' basic understanding of engineering methods and design principles implemented through projects before they move onto the next difficult tasks as suggested by Mourtos and Furman (2002).

> *I discuss with team mate for possible layout (alternatives), then consult the engineer and sometimes ask lecturer to confirm the solution before proceeding to the next task advance task....I really understood the subject matter that allow me to do so.*
>
> (S3-A)

> *Now I understand the content and the practical aspect of how loads are transferred throughout the structure.....this task is important to be understood before proceeding into the next task*
>
> (S5-A)

Students views on projects indicated that the necessity of their mastery concepts in project more thoroughly. Students demonstrated willingness and strived hard to achieve good grade in helping other teammates.

4.3.2 Lifelong Learning Skills

Another ability crucial in design project is lifelong learning. Lifelong learning is learning to know, learning to do, learning to live together, and with others and learning to be (Jacques, 1998). It is the learning that is pursued throughout life that is flexible, diverse and available at different times and in different places (Ceylon and Lee, 2003). In relation to project-based learning, the students were keen to know the mastery learning tools they undergo, such as learning to do and learning to work with others in teams. They were also expected to be responsible for their own learning and developed their self-learning skills. As such, lifelong learning can instil initiative and responsibility in the students, assisting them to easily adapt in their career at the industry.

FPjBL is employed to provide a student-centred, active approach to learning (Greenberg, Delgutte and Gray, 2003). It encourages independent thinking as students seek to solve problems. In project students acquaint themselves with necessary theory and concepts and apply them in design. In this way, students enhanced their design abilities if they already develop the independent thinking.

Project can trigger students' self-direction in the learning as well as their lifelong learning skill development (Gao, Demian and Willmot, 2008). In order for students to embark on projects, they plan and initiate the learning process such as locating and evaluating relevant information in projects. This enables them to know and understand the real perspectives of the real projects' work at industry. They also appreciate the goal in projects' design and have greater control over their learning. Consequently, they gain a deeper understanding of the subject matter in design. The self-directed learning is characterizes as desire for learning, students' self-management and self-control as reflected from the following excerpts:

> *The project assigned by the design firm is very useful and worthwhile. Creating something real through the project is the most beneficial achievement. I think it will provide [me] an insight as to go about creating real life design later for work or further study.*

(S3-A)

Several students in FPjBL were observed and illustrated to have greater control over their learning process in that they could choose their learning environment and pace of study as well gather materials that help them design effectively as mentioned by Ambikairajah *et al.,* (2007). They appropriately locate, evaluate and use the relevant information, as it was required, critically determine what techniques were appropriate and they were independent and self-sufficient in their learning. The following students elaborated on their lifelong ability:

I searched through internet, read from text book and look for same (similar) problem… I ask the engineer also to give me the clear information about the design.

(S5-A)

Began the tracing of the structural layout and indicate the load distribution. I've a bit of trouble so ask the engineer and search in the textbooks....could help me out.

(S4-B)

FPjBL is shown to be effective in increasing students' motivation by engaging them in their own learning (Abdul Rahman *et al.,* 2009), thus promotes their self regulate learning. FPjBL builds the learning experiences to students, finding information and sources give students knowledge of how to go about acquiring the knowledge they may need. The following quotes highlighted students' encounter of self-strategies in executing the design projects:

Could use rule of thumb for the beam's section

(S3-A)

I read examples and lecture notes and applied it to the project

(S5-A)

I didn't really get much work done though....I spent a lot of time on looking at the code, going through the lecture notes and asking questions with (S3).

(S7-B)

Another skills the students experiencing during the course of the project are the multi-tasking skills expected in design activities carried out at the industry. These students pointed out that:

The experience in this project is important because next time when I start my carrier, I will have less problem of adjusting my working life and environment. I like challenging project because that drives me to learn something new....and upon finishing the project, I felt a sense of achievement in my study.

(S3-A)

I want knowledge and to experience on how to do proper design for building, ..I want to explore new software and new technology used in design and in industry....

(S4-A)

ABET (2000) outlines that engineering programs prepare students to engage in life-long learning. Through the students' group discussion and brainstorming as shown in Figure 4.1, they shared their thoughts and exchanged new information among them. This subsequently would train them to decide on what to learn, choose an approach to learning, and manage the learning process independently.

Figure 4.1 : Students during discussion at the firm

4.3.3 Problem Solving Skills

Another ability, which stood out from the interview and the journal entry, was the problem solving skills. This skill is addressed in the CLO in item No 6.

Problem-based learning is defined as any environment in which problems drive the learning (Woods, 1996; Hasna, 2008). In projects, problem solving in engineering requires the students to reach a solution. In order to reach the solution, students need to develop the inquiry skills, which include critical questioning, finding relevant evidence, examining the requirements and weighting alternatives. Thus, encourages students to develop critical thinking and problem solving skills that they carry for life (Hasna, 2008).

According to Mills and Treagust (2003), students are positive about the PjBL in design courses and they are sufficiently prepared for problem solving skills. If PjBL is implemented, problem solving will be indirectly implemented as well

(Noordin, MD. Nasir, Ali, & Nordin, 2011). There are three roles of problem solving according to (Conley, Livingstone and Meharg, 2006): the first is the acquisition of factual knowledge; the second is the mastery of general concepts and finally the use of prior problems that for solving future problems. This was evident in the study when one of the students communicated his experience when undergoing the design project.

> *Actually I want to know theory fully. At the moment we know the basic.....beam analysis, bending moment, etc. and than I think about it and then decide how I want to implement design...what I learn from project, I wanted to know what is[deep understanding] if I can use it further in other problems.*
>
> (S2A)

When engaging in problem solving in design projects, it is expected that the students engage in a type of thinking referred as ‘ design thinking’. Design thinking is another aspect in problem solving where asking questions is a beginning step in designing projects (Dym & Little, 2000). In solving design problems, students are expected to utilise the design thinking skills that acquire their critical design ability.

There are two types of design thinking skills used in projects; critical thinking and creative thinking as mentioned by Mills (2003). Critical and creative thinking help students to solve problems and make decisions. The more flexible and efficient the way they think, the more effective it will be in their life. For example, thinking of something from a scratch and putting things together in a new way is design in critical and creative way. Students become open-minded on new ideas and know how to go about to get more information. One of the students explained his engagement in design thinking f.om this excerpts:

> *When I do analysis in structural components, I break up them into various parts and think critically and creatively to understand them better.*

(S4-B)

Critical thinkers base their judgments on evidence. They look for connections between subjects and know the difference between a conclusion that might be true and one that must be true. Students analysed and understood design concepts and information required by questioning everything and avoided common mistakes in reasoning as elaborated by this student:

Now I can make justification based on the connection between analysis and design…..but to confirm I ask the engineer…..so that I am more confident because I got first hand knowledge how engineers work in their daily life

(S2-A)

Despite having knowledge of appropriate theoretical concepts, the importance of developing inquiry skills is also important to trigger critical thinking skills in design project. Thinking skills requires students to ask questions, find relevant evidence, examine arguments and combine all these with the design principles to complete a design procedure for all structural members. This student shared his strategies in his journal entry:

I ask a lot of questions with the engineer so that I can clear my conscious mind.... so that I am able to proceed to design with confident

(S7-B)

Student learned to relate and understand the whole structural system design through project work. The student S3-A was excited when he managed to relate the structural system through project in his excerpts:

Project provided a great insight into the design methods learn during lecture and used in the design office. I got to see the whole components relate to each other.

(S3-A)

Students require the opportunity to apply their knowledge to solve the design solutions through project rather the problem solving activities (Chandrasekaran *et al.,* 2012). This reflect that this student had to use the problem solving skill in order to arrive at the understanding and be able to synthesize the whole structural design system to obtain the best answer to the problem.

The capacity for analytical and critical thinking can be created through creative problem solving in project. Stojcevski (2012) suggested that by recognition of the whole design system thinking and application of strategic knowledge in decision making would help students to develop efficient problem solving skills. This is endorsed by the following excerpt :

I'm excited because I can see the whole structural system design in this project. We learnt to integrate all the components designed in one structural system

(S8-A)

Student S8-A clearly understood the big picture of what he was designing, and the related potential applications. Students' understanding of the core concepts was much sharper as observed by the researcher. Asking the students on their design decisions in terms of concrete design theory proved this.

Project-based learning can be an extremely effective method that empowers students to learn both the fundamental principles of science and its application in solving engineering design problems. It also provides the opportunity for the students to value design from a systems perspective and develop an appreciation for technical challenges in design in the context of global, societal, economic and environmental requirements.

Students who were exposed to the FPjBL examined the outcomes of their design output confidently; knowing the procedure and able to see the whole integration of the building structure as proven from the following excerpts:

I make sure that I really understand the concept, the whole procedure and concepts we use in designing component such as beam, slab, column and footing are considered by formulating them clearly and precisely, gathers and assesses relevant information, testing them against criteria and standards.

(S5-A)

The overall project like the integration of the structural elements [whole design system] we develop in project was taught in the class but I didn't understand. Now I'm able to generalize the concepts of the design in different context especially in the task 3 and 4.

(S5-A)

The problems in project require the students to gather information, select the solutions and finalised their decisions. Hence, students have to carefully find before making any decisions.

I want to know why…..I gather information from lecture notes and texts, then I think about it and then decide how I want to implement.

(S2-A)

Students are able to develop their own critical thinking and search for meaning. Students tried using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions and approaches to design problems (Ambikairajah *et al.,* 2007). For example, when students were asked to design the structural elements, they need concrete reasoning in order to justify their assumptions. One student highlighted that:

> *I like to reasons out at things, relate and doing and thinking because I like the thing that I learnt that I can visualise ... When I learn, I want to get involved,..I like to be part and active in my learning and see the whole thing.*
>
> (S8-A)

Another student reiterated that:

> *I want deep understanding of the project. Sometimes to make assumptions for structural components sections that I don't have the skills... but the engineer assisted me with rule of thumbs. I have to be critical and proactive because this project is challenging.*
>
> (S5-A)

Giving full attention to what other people are saying, taking time to understand the points being made, asking appropriate questions and not interrupting at inappropriate times are some proactive thinking skills mentioned by Ambikairajah *et al.* (2007).

During the field project, brainstorming sessions were organised by the students to attain answers to their questions. These answers should help solve their project. This allows for interactions among the students and promotes critical thinking among them. It also allows students to make choices and make decisions at multiple points in the problem solving and design process. The observation performed by the researcher confirmed that the students discussed and brainstormed during their problem solving session. They fought for their ideas to be understood and accepted by the team members. The brainstorming method was applied in order to generate ideas at the early stages of design and during the project implementation.

Another critical theme that emerged in the investigation of student design ability is the students' engagement in professional skills. The professional skills highlighted are teamwork, professional and ethical responsibility, communication, understanding the impact of engineering solution in a global, economic, environmental and societal contexts.

4.3.4 Professional Skills

Criterion 3 in ABET (2000) listed 11 outcomes that graduates should possess. Shuman, Besterfield-Sacre and McGouty (2005) divide these outcomes into hard skills and professional skills. According the ABET (2000) professional skills are: ability to function on a multi-disciplinary team (3d), understanding professional and ethical responsibility (3f), ability to communicate effectively (3g), broad curriculum (3h), recognition of need by an ability to engage in life-long learning (3i), and knowledge of contemporary issues (3j).

This research will only highlight the teamwork and communication skills from the list of professional skills because of the substantial pressure from industry and professional body that emphasize on these two skills (Atman, 2005; Hadgraft, Carew and Blundell, 2008). According to Chandrasekaran *et al.* (2012), the professional behaviour of the engineering discipline can be brought about in project.

Teamwork is crucial in the design project. Students need to collaborate with each other to reach consensus on their decisions on design requirement. Teamwork is an important skill in engineering design practice (Dominick *et al.,* 2004) and a common element of the engineering experience in industry.

Another professional skill considered in this research is communication. This is because the data gathered in project is shared among the team members through communication.

4.3.4.1 Teamwork

Teamwork is an attribute desired of graduates in engineering (Sheridan, Evans, & Reeve, 2012). Methods to promote teamwork skills occur through the involvement project-based learning as suggested by Bronzino, *et al.* (1994). Project work develops teamwork skills because everything will be discussed and negotiated in groups (Noordin *et al.,* 2011). Project offers students rich learning opportunities to on the course material and cooperation and collaboration in teamwork play a very important role in the development of students' learning (Koehn and Koehn, 2008). Thus, the teamwork environments can be used to guide improvement of teamwork skills in engineering graduates while simultaneously enhancing their design abilities. The student also shared the responsibility through working in teams (Hasna, 2008). One student related his experience working in his team.

> *I have the opportunity to work in a team, sharing information and speed the process solving the problem in the project.... And I'm glad that we were able to accomplish the final project at targeted time.*
>
> (S8-A)

Collaborative learning as mentioned by Hasna (2008) is the learning that focuses on the process. Therefore, collaboration in a team can facilitate successful planning and enactment of project work (Krajcik *et al.,* 1998). The project work indirectly enhances the students' own experiences. As observed by the researcher, whenever the students wanted to complete their project, they would take the effort to consult many lecturers to assist them in understanding and explaining them. Working in a team gives excellent experience to the students (Koehn and Koehn, 2008). This is true because the respondents believed that working in teams has provided an excellent learning experience and has increased their confidence in teamwork.

My experience from working with project is that no one student has all the knowledge needed to complete design task, this requires multi skills such as teamwork. We strived to get all the information be it through the engineer or the lecturer.

(S2-A)

Technical skill, teamwork, interpersonal, communication and study independently. This project is immensely is helpful for my future as it improves my confidence level in working in a team environment especially assisted by engineer and friends.

(S8-A)

Figure 4.2 shows students work in a team to solve the design problems. This was described through one of the student's journal (S-4B). The student was actively involved in working with his colleagues, learned how to engage in teamwork and was exposed on how to collaborate with colleagues. The students in the study believed that working in teams is an excellent experience. The following quotes highlighted the students experience working with their team members.

I apply concepts taught by the lecturer, but for detailing drawings, that was my first time and also my weak point,.. with the group, we worked together and shared responsibilities to teach each other.

(S5-B)

We worked together in this group for this project is more effective than working independently especially detailing. We seek help from the engineer as well.

(S2-A)

Figure 4.2 : Students work in a team

It was found that the students were able to have clear goals after each task assigned to them in project. Not only that they enjoyed working in groups, they also enjoyed the peer too peer teaching and learning. As observed by the researcher, students interact with each other and sought experts' opinion (professional engineer) when they encountered problems. The on going feedback of the team and expert enable students to develop the capacity to make judgements and to clarify the actual characteristics of good design. The students also collaborated each other that allow them the opportunities to learn other skills such as decision-making, providing feedback to peers and working with others.

Below are some quotes on the teamwork engaged by the students.

> *I think in our group there was fair that everyone was very able in the group.*
>
> (S2-B)

> *I think everyone did quite an equal share of the work in the design.*
>
> (S4-A)

During the observation session, the researcher recorded some instances of teamwork among respondents. The photo in Figure 4.3 illustrates the student discussing in their team on how transformation should be done for the task assigned to them. Heavy discussion was evidence when everyone in the team took part and contributed toward arriving at the best solution. Confusion on some aspects of the project was evident but the students clarified those issues with the engineer at site.

Figure 4.3 : Students work collaboratively in a team

4.3.4.2 Communication

In design projects, the ability to communicate is vital because students need to engage among them, lecturers and professionals to generate ideas in projects. According to Mourtos, (2011) design begins with brainstorming of ideas, this takes place when students need to communicate to each other while working in teams and when decisions are required on the best course of action. From the observation carried out by the researcher, students communicated each with other in order to generate ideas and best solutions during the project activities assigned to them.

Another important aspect of communication is the presentation of students report writing. The students need to produce a solution to solve the design problem and were later required to produce the outcomes in the form of a report. When students were asked about the relevance of the written project report to their communicative ability, they indicated that the report writing requires them to demonstrate their written communication skill. They were also tested on their communication ability when they need to orally explain their project to the engineer at site as well as the lecturers.

The following quotes justify the students communicative engagement during the project completion:

I improved a lot [design concepts] because team-mate works hands-in-hand. I throw away my egoness and shyness and I ask them a lot to clarify my problems

(S8-A)

I'm happy and comfortable and I'm not shy anymore to communicate with colleques and the engineer at the consultant office.

(S1-A)

I searched through internet, read from text book and look for same(similar) problem… I ask the engineer also because he is very helpful. Interaction with the engineer gives us the chance to acquire knowledge in civil (structural) engineering design especially about the current practice.

(S5-A)

Teamwork and communication are the two common skills that the students highlighted in this study. Other professional skills such as leadership and research skills were not emphasized by the students, may be because they did not regard those skills as important.

4.3.5 Motivation and Engagement

It is also evident from the findings that motivation and engagement are the themes that constantly appear during the interview and in the journal entries. The research conducted by (Hilvonen & Ovaska, 2010); Bell 2010; Frank *et al.,* 2003; Thomas 2000; Helle *et al.,* 2006) confirmed that the integration of project-based learning in the design courses have increased motivation and engagement of students in their learning. They concluded students' motivation and interest increased substantially when engaging in project work. Students were willing to spend time gathering information, defining the problem as well finding and analysing information. It is through this process that students produce their knowledge (Blumenfeld *et al.,* 1991). One of the outcomes of using project-based learning is better understanding of key principles and concepts. Studies showed that PBL had a positive effect on the level of students' understanding of the subject content (Thomas, 2000). Thus, that will create a warm atmosphere for stimulating students to share experiences and ideas.

The researcher discovered that if the students were motivated, their engagement level in design would increase. Lecturers and engineers can motivate students because they are in control of the project (Koehn and Koehn, 2008). Lecturer and engineer's control over design project can be seen valuable in guiding and challenging students' learning while completing the project.

In addition, since the projects are carried out in teams, it is natural that the quality of teamwork influences the motivation of the individuals in the team (Koehn and Koehn, 2008). FPjBL involved students in the learning process, and resulted in increased motivation, satisfaction and confidence (Mills, 2002). Motivation is critical because the project will cause students to put in a huge effort to succeed and complete the task, and this enhances learning (Chandrasekaran *et al.,* 2012). Activities in project-based learning elevated students' motivation and self-image. Peer interaction emerges as a source of motivation. For example student (S8-A) was overjoyed when he succeeded with A in his tests and examination (DDA3164) due to his better understanding on the project work with the help of team mates in the excerpt below.

The two tests I undertook plus the final....I'm confident that I get A for the course. I'm so happy. Best.

(S8-A)

The differences in students' motivation in FPjBL was analysed under two different perspectives. First, one student considered future career undertaking as a motivation for him to do better in design project.

I'm serious in project because I want to get A for this course. I want to further study and I can use this knowledge and experience.

(S8-A)

Another factor that drives motivation is the external mentor, in this case the engineer who helped in the project.

Talking and discussing the project tasks with the engineer, stimulated my interest in design......because I understood the subject matter.

(S8-A)

I think I'm capable of independent practice of structural designing…a bit more confidence because I see how the engineers in consultant office do their design.

(S2-A)

According to Blumenfeld *et al.* (1991), students are more motivated to bring out and test their ideas and increase their level of understanding in PjBL design if the project is authentic. Authentic problems are real-world problems that provide complex problem which is generally ill-structured, open-ended and require many acceptable solutions that normally cannot be found by routinely applying a mathematical formula in a structured way. Students expressed the importance of the authenticity of the problem as below;

> *The project was good, there was like real… at the end of the project, I was very motivated as we would be guided and need clarification on our work.*
>
> (S8-A)

> *During the project, we discussed problems together, helped each other until it is finished. I appreciate that we were able to work in a group and each person tried hard to complete their work on time. Real project is authentic and is very good so that students are more eager to learn. Outside project is real project and practical. If all students can go participate is better still.*
>
> (S5-A)

> *Many tips from the engineer were taught that I can understand, I enjoy, that why I wanted to know more and reasons why we need to assume in design*
>
> (S7-A)

> *I always ask the engineer weather my assumption is correct or not. I need to feel confident when I start doing project.*
>
> (S2-A)

According to Blumenfeld *et al.* (1991) interest and value are other components in design project that can motivate students. The interest and value consists of a variety and novelty of tasks, the authenticity of problem, the complexity of problem, the end of the project, the freedom to choose on how to perform the project and the opportunities of collaborative work. In projects the tasks are authentic and complex enough and requires students to choose how to work. These elements probably increased their motivation level. In addition, students may feel "ownership" towards the project when they have the chance to solve the project on their own (Blumenfeld *et al.,* 1991).

Below are one student's comments on the project from his journal entry that relate to his motivation and engagement in design project.

> *Everything!; it was great; thought provoking, fun, enjoyable and interesting, practical, challenging and educational; understood why we are doing these things and this helped in learning; gave a better understanding of theory and various formulae; applying theory to a real life application; made me learn; designing and then detailing was a good way to see the structural components ready for construction design; enabled confusing theory to be put into practice; it gave me a whole lot of perspective on what or how design work that can be used in future house and construction development projects; going outside the campus break/change from tutorials and fun to interact with professional; ability to design beam, slab to carry a particular load; it is always good to design something yourself. The ability to actually see something I designed work as it was supposed to.*
>
> (S5-B)

The project approach is enticing because it offers the students more control of the learning process resulting in higher student involvement and motivation (Teck, 2009). Students prefer the field project's because it allows them to apply the theory and practice and this may motivate and engage them in their learning, evident from this excerpt:

> *Analysis and designing building helped me to learn basic design process; learning about a real life problem with a bit of fun; practical use of theory to do real things; creativeness and the competitive nature of the project; challenging and interesting.*
>
> (S6-B)

> *Writing report; got to know other people; group work; suspense of whether my design would work; sense of achievement and satisfaction*
>
> (S1-B)

> *But when I already in the project, it is not only to finish the project but I get something new…I like something challenging and new knowledge and new experience.*
>
> (S7-B)

Helle *et al.* (2007), have made similar findings in their research on the relationship between students' intrinsic motivation and self-regulation. The motivating aspects were due to the presence and involvement of professional engineer who acted as a mentor. The mentor inspired and motivated the students by facilitating the projects. In this research, students (S1-A), (S6-A) and (S7-A) felt hat the course was very motivating. Through the researcher's observation, these students have changed from passive into inquisitive students. At the end of this course of they were able to defend their ideas and opinions and being accepted by the teammates and the lecturer. This is supported by the research done by Sutterer and Descoteaux, (2002) that the project can be mentored to acquire knowledge and understand that knowledge. One of the students was keen on the function of the engineer in his project work:

I think that we had just enough support from the engineer. I begin to like this engineer because he gives us a lot of information that I may use for my project

(S6-A)

Students generally feel more fullfilled and motivated if they are able to be creative in engineering design. They are more motivated to learn when they have an immediate application of the knowledge in project-based learning (Hiscocks, 2012). This is because students were able to see the relevance of the problem in the project design and gave much effort to find a solution to their designs. The following students agreed that they could identify the relevance of their design project during FPjBL.

Of course I get the solid foundation in a structural design…we learnt task by task so I can apply principles and make justification and know the skills in design structure.

(S1-A)

I didn't have the knowledge to do justification ….I just follow the lecture and studio work but with this exposure at design firm, it really helps me to do assumptions and justification.

(S5-A)

The researcher observed that the students became more motivated during the semester. They were more comfortable with the FPjBL and embraced their freedom to manage their time effectively, to reflectively think about their experiences and to make connections between their classroom work and what is happening in the field.

4.4 Shortcomings and drawbacks in FPjBL

Some shortcomings and drawbacks were observed during the activities in projects. These are the problems encountered due to FPjBL implementation, as some students were unsatisfied with the field project implementation. This section presents their perceptions about the weaknesses of and difficulties with FPjBL. One of the drawbacks was the lack of support from the lecturer teaching the subject. This student communicated her disappointment below:

... but I am sad because the main lecturer of the course segregate my group because we chose to do project in design firm.

(S5-A)

The above student expected sufficient guidance by the lecturer during the design project but it did not occur because the aim of FPjBL is that students engage in independent learning. The lecturer merely acted as a consultant to the students, whereas students expected the lecturer to guide and support them when they faced difficulty in design problems. They would feel confident if the lecturer gave them support as sometimes the students need to seek help in solving their problems.

Another shortcoming of FPjBL was the difficulty in identifying and locating the required information related to the project. Students sometimes failed to consider a number of categories such as the practicality of certain design know-how. These difficulties have led to difficult situation at the early stage of students' projects work.

I don't know how to start the project because too many information that need to be put into place in project.

(S3-B)

Another problem related to FPjBL is the time allocated for deriving material specifications and loads distribution. The following complains came from students who are high achievers in the group.

More time could have been spent on the methods of analysing the way in which a structure acts as a whole, as it is new information, and I found it interesting and practical

(S4-A and S5-A)

I need more time to be spent on making assumptions such as specifications for materials used, deflection and serviceability designs. It was difficult to know what limits to take without enough design experience to realistically assume different things.

(S3-B)

Structural design course can be improved if time for project is longer.

(S5-A)

The students generally prefer that the time allocation for project be extended.

4.5 Issues in Implementing Project-based Approach

There are a number of challenges when implementing the FPjBL activities. The FPjBL process requires students to be very self-directed in their learning and to take "ownership" of their own education. Confident students are able to do this, however some of them are unable to apply the design principles when solving the problem. The student group must be from with a mixture of abilities so that they are able to help each other in completing the project tasks.

Project activities are very resource intensive for both the lecturer and the students. Students generally require time to complete the tasks because they need to recall the prior knowledge they gather in the previous semester. The students also need strong visualization of the structural layouts so that they could figure out the proper layout for the design structures. Project work is time-consuming because students initially felt disorganized and the lecturer may not able to control the flow of information. This may result in the difficulty of managing students' independence among team members and providing them with the support they need in completing the project.

Incorporation of technology in project may also slow down the completion due to lack of knowledge on the technology. If the higher learning institutions could provide the current technology facilities and provide easy access for students, it would accelerate the students' application of the technology into their work.

In addition, the researcher found that lecturers generally focused on addressing one or two challenges at a time during the design project. This is because they need to cover the syllabus as well as to coach the students in exploring the design skills outside the classroom. It is a burden to them in terms of workload and on top of that it is time consuming.

In addition, funding the projects is also difficult even though corporate partnerships are increasing in number. The large students' population may not be able to tolerate and develop realistic students' projects especially at the industry. Not only that, project-based instruction is also very dependent on the creativity of individual lecturers and this caused problems especially with new lecturers who have not been exposed to the requirements and issues in project design.

4.6 Conclusion

This chapter reports and discusses on the implementation of field project-based learning where students were attached to a local design firm. The enhancement of the design abilities of field project-based approach is extracted from interviews and reflections of the students in their journal entries as well as the observations by the researcher. Students indicated that projects at the design firm have opened up new perspectives to them as they gained both technical and professional skills through the field attachment. They gained deeper conceptual knowledge and content, they developed professional capacities and felt a sense of achievement and satisfaction upon completion of the field project. This reflects that project-based learning has stimulated the students' interest and motivation from the 'learning by doing' approach. In addition, the FPjBL allowed them to exercise greater control over their learning experience from the fieldwork. They were allowed to experiment technologies such as computer application software design tools that are now commonplace in the engineering industry.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides the conclusion for the research findings focusing specifically on the discipline of structural reinforced concrete design course (DDA3164). An approach of field project-based learning integrated in the course was proposed and presented involving field practical work at the industry in enhancing students' design abilities. The assessment proposed for written report, teamwork and communication are also presented. The recommendations and future research are also provided and highlighted.

5.2 Research Findings

The discussion of each of the research questions described in Chapter 1 is presented in the following section.

5.2.1 Research question 1

What is the design abilities expected of civil engineering students?

In order to answer this research question, an analysis of the course learning objectives and the outcomes of the project in structural reinforced concrete design course was performed.

The students' design abilities for project in structural design was identified from the course learning outcomes, CLO of DDA3164 (refer to Table 3.6). These expected abilities were based on the requirements of the university engineering courses, which is in line with ABET (2000) requirements for engineering programs in USA and Malaysian Qualification Accreditation (MQA, 2007).

The mapping of the learning outcome (CLO) of project on the design abilities and design learning identified from College of Science and Technology (CST) is shown in Table 5.1. The CLO written for project in DDA3164 includes the four elements of design abilities; content knowledge, problem solving, professional skills and life-long learning skills. However, motivation and engagement of learning is not included in the CLO because of the following difficulty in measuring these elements via the course outcomes.

Items 1 - 4 in the CLO are associated with the theoretical concepts and understanding of principles in DDA3164. Students were able to apply their knowledge of mathematics, science and engineering as well as able to design a system and component to meet the design criteria assigned to them.

The research has discovered that in relation to design abilities, project has been given greater emphasis. From the interviews, it was evident that students' foremost goal were to gain understanding, instead of just wanting to pass the course with good grade. This implied that students put mastery learning goal as priority, which supports the finding of this study.

Table 5.1 : Mapping of learning outcome on design abilities

Item	Learning Outcome	Design abilities Expected of Engineering Students
1	Define and describe reinforced concrete design concept	1. Content Knowledge
2	Propose a suitable layout plan for typical building floors Tasks required: 1.Transform architectural drawing into structural layout plan. 2. Identify actions/loads as per specified in the architectural drawings given.	1. Problem Solving 2. Teamwork 3. Communication 4. Content Knowledge (prior)
3	Prepare a concise and optimum structural element for beam, slab, column and footing design calculations. Tasks required: 1. Analyse the structural elements 2. Identify design actions (SFD and BMD). 3. Design the structural concrete elements.	1.Problem solving 2. Life-long Learning 3. Content Knowledge
4	Produce detailing for the structural elements for beam, slab, column and footing.	1. Content Knowledge 2. Problem solving 3. Teamwork 4. Communication 5. Life-long learning
5	Respond and think logically to solve problems and make conclusions.	1.Problem solving 2. Life-long learning
6	Communicate clearly and effectively in oral and/or written forms.	1.Communication 2. Life-long learning
7	Work collaboratively as part of a team	1. Teamwork 2. Life-long learning
8	Demonstrate and understanding of professional and practice ethical value.	1.Professional skills 2. Life-long learning

Item 5 – 8 in the CLO are related to the practical and professional skills in project design. While designing the project, the students were able to identify, formulate and solve the design problems with confidence as well as to identify the design requirement and significantly engage in life-long learning.

Professional skills such as team working performance effectively trigger positive motivation towards the learning of the students. This can be seen from the high degree of interdependence among team members to achieve a common goal.

Information and resources were exchanged among team members to get better understanding of subject, apart from mentoring and actively sharing engineering knowledge among them. Projects encourage students to work individually and as part of the team. The quality outputs and solutions produced by the team showed strong written and verbal communication skills.

5.2.2 Research question 2

What are the design abilities of students engaged in the FPjBL tasks?

The set of instructional principles developed by Savery and Duffy (1998) and Khandani's (2005) five-steps design process are used to guide the researcher in answering this research question.

The expectations by industry practitioners of the skills and abilities needed in engineering graduates and reviews on the design education in engineering have also highlighted the need for engineering graduates to possess specific abilities to possess specific abilities when engaging in design projects. These literature input and the findings of the study proved the crucial importance of design abilities for engineering graduates. This study has also demonstrated that FPjBL further highlighted these abilities.

The study by Henshaw (1991) determined the attributes that employer's would seek in future employees. The author discovered that the most dominant attribute and skills requirement were communication skills, ability to work in a team, interpersonal skills and self-motivation. These are the 'soft-skills' attributes. Employers rated problem-solving ability as very high, while practicing engineers emphasized design skills as a very desirable ability in the engineering program.

The study carried out by Martin *et al.* (2005) confirmed the importance of technical skills as a basis of engineering practice, as well as the need for other skills such as communication, team-work and interpersonal skills in the workplace. Their study also showed that a clear link between the technical and non-technical attributes of engineering graduates in which technical background is the main strength required of the industry. Other skills that are also of paramount important are problem solving skills, formal communication skills and life-long learning abilities, working in multi-disciplinary teams, leadership, practical preparation and management skills. These design abilities that students developed in structural design projects affect the abilities students need for field project-based learning (FPjBL). These design abilities are in line with the conceptual framework in Chapter 1 and encompassed both the technical and non-technical skills. Most technical skills are cognitive, however, there are the psychomotor and affective skills that require the students to excel in design.

FPjBL activities challenged students to make connections beyond the technical aspects of a project given. For example, decision making in project enables students to define alternative solutions for a certain task in design. This activity connects theory into practice. The 'real-world' projects also forces students to make connections between courses and to seek and solve problems at set boundaries given in design. The projects were successful in improving the understanding of basic concepts and encouraging deep learning, creativity and a broader knowledge base. In addition, the projects have encouraged self-directed learning on the part of the students, as they have to source various types of information required to complete their projects.

Table 5.1 outlined the design abilities expected of the students engaged in FPjBL. These abilities emerge through feedback from the interviews and the students' journal entries. The emergence of these themes, that is content knowledge, problem solving, lifelong learning, teamwork and communication have endorsed that the students were experiencing the activities which require them to apply these design abilities in FPjBL.

Obviously, the design abilities required of student in line with the course objectives of DDA3164. The students have better understanding of the important role of design in civil engineering. All students in the research improved their design abilities and skills, particularly in the professional skills. Students were able to understand the impact of the social context within which they worked and are able to assess the long-term consequence of their learning. For example, students were willing to learn the software in the analysis even though it did not provide them with extra credit for the course. According to Stouffer, Russel and Oliva (2004), project promotes teamworks, communication, knowledge retention, ability to synthesize and make connections between courses and smooth transition from education to practice.

In this study, the design ability that is not outlined in the CLO (refer to Figure 5.1) the motivation and engagement aspects of the students. Student motivation and engagement involve group interactions and communication, support of the engineer at site and the lecturer's input in the class. Students motivation and engagement are included as the parameters of FPjBL and closely related to the effectiveness of PjBL as reported by Gao, Demian and Willmot (2008); these findings revealed that motivation and engagement deepen the students' understanding towards project instruction and affect the student design abilities in the course. Findings showed that students are generally more motivated to work in the projects through FPjBL exposure.

Students' motivation and engagement are related to the affective domain behaviour that deals with the students' emotion while engaging in design project. Field project-based learning in DDA3164 offers a wide range of benefits to students. Students were observed to become more responsible for their own learning, which tallied with to Dahlgren *et al*. (1998). The authors findings suggest that final results for some of the students recognized clearly the benefits of a project-based approach, high student motivation and the acquisition of soft skill. None of the students involved in this research failed not to attend the firm's visit as well as the studio work. They were very responsive and eager to learn and they participated in all the project activities. Students were observed to have better self-reliance and their attitudes towards learning. During the field visit, some students asked questions about their project and that boosted their leaning. Evaluations of design task around projects indicated that students were positively motivated by projects, which put what they have learned in a course into real perspective as possible. In addition, students were more enthusiastics to learn.

FPjBL is a very effective tool to bridge the industry when real-life project can be assigned to the students. The project in design course can simulate the real working environment to the students. Exposure to technologies and experience of a real work place for example, would increase the level of students' engagement in learning. They tend to show greater interest in the topics and demonstrated a deeper understanding in the concepts and theories related to the design project. The opportunity to simultaneously learn and apply theory to practice at the outset of the engineering course has improved student performance and motivation. Successful completion of projects in practice requires the integration of all areas of an engineer's undergraduate training.

Table 5.2 illustrates the five elements that enhance the design abilities of the students that have emerged from the research findings. On the content knowledge, students were able to grasp the mastery learning of the course and have better understanding on concepts, thus better their problem formulation skill. In addition, students' problem solving skills improved, especially their design thinking and they critically and creatively handled the project. Professional skill is another important skill that students developed from team working and communication. Students were able to realise the importance of life long learning as seen in Table 5.2. Finally, students were enthusiastic to work on the project, due to the authenticity of the project. This indirectly boosts their motivation and engagement in learning.

Table 5.2 : Design Abilities Gathered From FPjBL

Items	Design Ability	Domain
1	Content Knowledge	
CK1	Mastery Learning of Course 1.Ability to apply knowledge of basic science and engineering fundamentals. 2. In-depth technical competence in structural analysis and design 3. Prior knowledge of the properties of materials such as steel and concrete as well as structural analysis, design aids including computer programs and design manuals and construction. 4.A broad knowledge of relevant design aids and manual 5.Understand the need to produce engineering solutions that are functional, economical and technically correct. 6. Ability to apply knowledge to a new or an actual situations. 7. Find evidence to support generalization.	Cognitive, Affective And Psychomotor
CK2	Conceptual Understanding - Problem Formulation 1.Understand the basic principles, ideas and perspectives in structural design. 2.Understand loads and how their effects are modelled in structural system and analysis. 3.The ability to communicate design solutions through sketches and engineering drawings.	Cognitive And Psychomotor
2	Problem Solving Skills	
PS1	Design Thinking 1.Ability to undertake problem identification, formulation and solution. 2.Ability to utilise a systems approach to design and operational performance. 3.Finding and analysing information. 4.Remember previously learned information.	Affective and Psychomotor
PS2	Critical and creative thinking 1. The ability to reason critically on the basis of statistical and other forms of evidence. 2.The need to produce engineering solutions that are functional, economical and technically correct. 3.Discussing the findings and ideas and creating artefacts (design). 4.Organize and propose alternative solutions 5.Make and defend judgements based on propose evidence and criteria 6.Make connections between specific area and others, e.g. interdisciplinary learning	Cognitive and Affective
3	Professional Skills	
	Teamwork, leadership and management Ability to function effectively as an individual and as a member of a team, with the capacity to be a leader or manager.	Affective
	Communicate effectively 1.Use diverse methods to communicate effectively with engineering community and with society at large. 2.Having the ability to communicate design solutions through sketches and engineering drawings. 3.Ability to doubt and ask questions, debate ideas with teams and professional. 4.Ability to communicate effectively with professionals and community. 5.Understanding of professional and ethical responsibilities and commitment to them.	Psychomotor and Affective

Items	Design Ability	Domain
4	Lifelong Learning	
	1.Ability to recognize the need for and engage in independent lifelong learning and capacity to do so. 2.Ability for the students to practice self-directed learning, to find solutions to design problems that are sustainable and to recognize that they are part of a global community. 3.Ability to make connections between formal and informal learning. 4.Be self-responsible to initiate and direct the learning process. 5.Be able to adapt to change. 6.Ability to develop independent and lifelong learning skills. 7.Be able to develop industry relevant design skills. 8.Able to face the many challenges found within the industry.	Affective and Psychomotor
5	Motivation and Engagement	
	1.Increased motivation and interest in the subject area and active student engagement based on individuals commitment to living and value 2.Good assessment design motivates and engages students to learn and reinforces learning(Biggs & Tang, 2007) 3.Is influenced by the authenticity of project (the project is real and challenging), environment. 4.Is influenced by professional and teamwork Engagement in the subject. 1.Interested and valued the outcomes 2.Sense of ownership. 3.Freedom of choice. 4.Learning how to learn	Affective Affective

5.2.3 Research question 3

How does the project component enhance students' design abilities?

This study proposes a field project-based learning (FPjBL) instruction to enhance students' design abilities for DDA3164. The instruction requires teamwork with fieldwork attachment at the civil engineering design consultant office. The students were engaged with the real work on the design of a double storey building.

The proposed instruction for project in DDA3164 is shown in Figure 5.1. All six design-tasks must be completed and the outcomes must be compiled and presented in the project's written report.

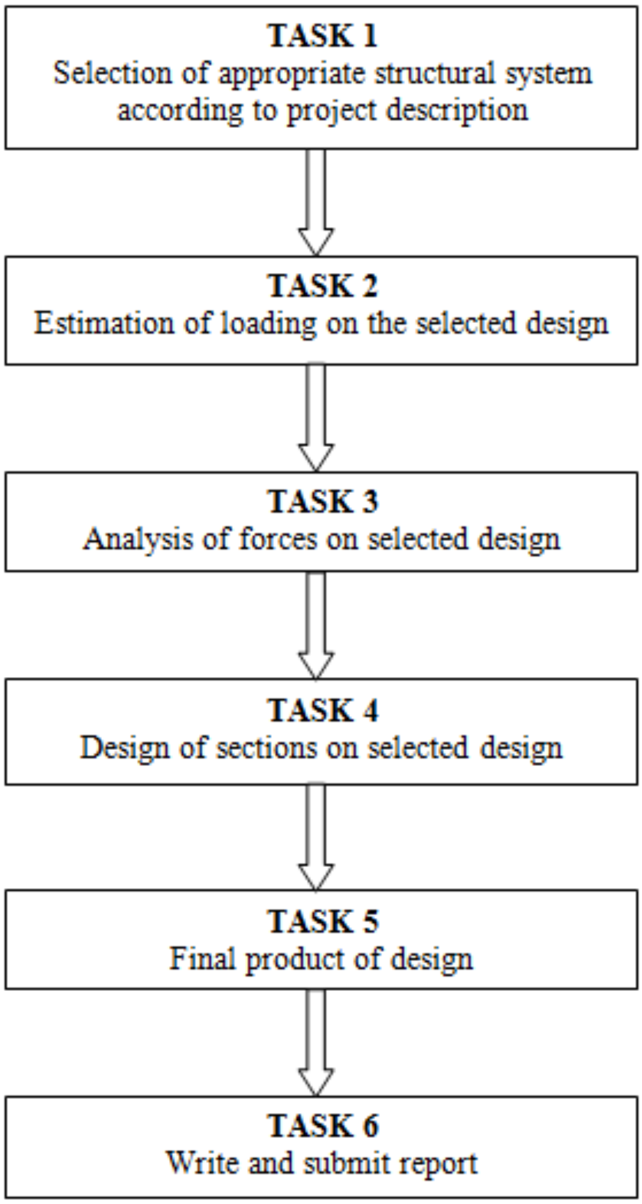


Figure 5.1 : The Field Project-based Learning (FPjBL) Instruction

Task 1 to Task 4 relate to the design process as mentioned by Khandani (2005). For example, in Task 1, the students must transform the architectural drawings into structural layout as demonstrated by the professional engineer. The project begins with the formulation of a problem, definition and analysis the problem within the subject. The students will then plan, manage and complete the project in order to solve the problem.

The required tasks in Figure 5.1 enhanced students' abilities in several ways.

1. Students learned the value of being active participants within their teams. Their FPjBL tasks required them to learn from one another and to teach one another within the collaborative learning environment.

2. Students learned first hand on the tasks required of them to complete the design project and they gained the satisfaction when the project was completed. The students also acquired valuable communication skills because it necessitates them to communicate with the engineer during the fieldwork.

3. Students received first hands-on experience to consolidate the information they gathered in the field because they were required to present their work in the written project report. This has indirectly fostered their lifelong learning skills in project design.

4. Students' communication skills were enhanced each time they were engaged in discussion with their team members.

5. Students used and honed their critical thinking abilities to consolidate their findings for each task.

6. Students realised the value of feedback from the lecturer and the engineer was used to create a better project design.

7. Students learned about the complexities of the teamwork and their chances for developing collaborative and leadership abilities were enhanced.

In order to materialize FPjBL, the following points should be considered prior to it implementation:

1. The students' team, the lecturer and the professional engineer need to establish their function and accountability. The students' teams should be between three to six students, a mixture of skills and backgrounds. This is beneficial if the team has a member who is experienced with AutoCAD to generate technical drawings. The lecturer and the professional engineer should serve as a coach or facilitator to the teams.

2. The design problem is clearly identified so that students can develop enough background knowledge to understand the application. For example, the problem in project must be carefully chosen so that the design constraints and do not hinder completion of the project. Too many design principles and relevant codes may frustrate the students and affect their learning experience. Therefore, projects must be based on problems with achievable solutions in relation to the course-learning outcome.

3. Parameters necessary to solve problems in project need to be detailed out so that students do not wind-up solving wrong problems or developing solutions that exceeds the requirements.

4. Brainstorming with teammates should be encouraged to formulate ideas before the students proceed to the next level of task or decided on a final design solution. This provides an oppurtunity for the students to reflect and discuss ideas with teammates and promotes teamwork among them.

5. Integration of technology should be encouraged to solve problems. For example, generating detail drawings using AutoCAD is an advantage in designing the project.

6. Design reviews are carried out at every task to assess the progress of the team and identify the areas where the lecturer needs to provide guidance.

5.2.4 Research question 4

What are the improvements that can be made to the Structural Reinforced Concrete Design course?

Earlier sections have discussed the answers for research question 1,2 and 3. Research question 4 questions the improvement that can be made to the structural reinforced concrete design course. The research proposes several improvement to the course based on the following components.

1. Project task

2. Assessment

1. Project Task

The proposed task comprises of six stages of task completion that must be followed according to the suggested sequence. Figure 5.1 elaborate on the new improvement on the project task that is addressed in this study.

2. Assessment

Assessment is an integral part of learning (Aziz, 2009). Therefore, one of the objectives of assessment is to determine the students' achievement in their learning. Linn and Miller (2005) stated that assessment methods should match the course objectives; learning activities and assessment tasks. Thus, different assessment methods are required to obtain a total representation of students' achievement.

Project report is commonly used in assessing the project in structural reinforced design course, DDA3164. The project involves the solution to a problem and necessitated a variety of educational activities. In addition, students need to produce design reports within a stipulated time frame hence, testing their ability in managing their project.

The findings of the study have identified several weaknesses on the current assessment in assessing students project reports' work especially on the generic skills such as communication and teamwork. Moreover, little attempt has been made using metrics for PjBL as reported by Gao, Demian and Willmot (2008). In most cases there was no specific assessment or incident that was linked to the generic skills (Mills, 2007) even though most of them were described in the course learning outcomes.

This research discovered that there is no standard and comprehensive marking scheme for projects as it depends on individual lecturer. The 20% weightage (refer Table 3.4) given to the project report depends on the lecturers' own understanding and their discretions. Therefore, projects in structural reinforced concrete design course are merely graded based on the written report and the lecturer's perspective on the students' work.

There are also no considerations on teamwork and communication on the project in DDA3164. Marks are given totally on the conceptual and principles of the structural components of design. However, there was only one lecturer who marked the project based on analysis, organization and creativity. Even then, when he was asked about the details of those assessments, he was not able to classify and justify the allocation of the marks.

In another instance, the lecturer gave marks because of the students' specific performance in the course. For example, a lecturer allocated the marks for the students' ability to analyse possible design structures, to demonstrate some elements of creativity and to manage working in a team, whereas other instructors do not use the same format of assessment. This has resulted in the students performing well in their design projects but failed to show equivalent accomplishment in their tests and examinations.

In view of the above problem, this research proposes the assessment criteria, which have been developed for project in DDA3164. The main goal of the project component in this course is to promote the integration of knowledge and technical skills to real problem in design.

The development assessment rubrics are guided by the conceptual framework (refer to Figure 1.1) and research findings. The student performance will only be assessed with respect to the written report, teamwork and communication for this research.

5.2.5 Proposed assessment rubric for written project

Currently, each lecturer used their own assessment criteria, although the course syllabus was the same. Other issues related to assessment were also highlighted in section 4.2.2. There is a need for standard assessment criteria on project work on design. The assessment consists of written report in which students will be assessed on their individual and group contributions in the project.

This research proposes an assessment rubric to be used by structural design lecturers as shown in Table 5.3. The researcher assigned some tasks to be assessed individually and in team. Referring to Table 5.3, task 1, task 2, task (3c), task 4 and task 5 are assessed in group, whereas task 3(a) and 3(b) are assessed individually because these tasks involved concept and principles in structural concrete design in which each student need to master.

The assessment of the written report is based on the tasks given to students. For example in Task 1, there are two activities that students need to carry out before proceeding into the next task. The assessment rubrics are guided by three different performance criteria in relation to students' activities being carried out. These performance criteria are rated as excellent, average and poor.

Table 5.3 : Proposed assessment rubrics for project's written report

			Performance of Students		
No	**Task**	**Activity**	**Excellent**	**Average**	**Poor**
1	Select the most appropriates structural system and idealization of the structure into frames and elements	a) Transform Architectural Drawing Details into Structural Plan Layout.	Student is able to select all appropriate structural system for a project.	Student is able to select all appropriate structural system for a project at an average	Student is able to select all appropriate structural system for a project at minimum.
		Check Lists: 1.Footing Plan 2.Ground Beam Plan 3.Second Floor Beam Layout 4.Roof Beam Layout	The layout must reflect standard format of plan layout for the appropriate design.	The layout reflects average standard format of plan layout for the appropriate design.	The layout reflects minimal standard format of plan layout for the appropriate design.
		b) Identify one-way and two-way slab.	Student is able to identify all technical hurdles criteria and requirements for appropriate design.	Student is able to identify all technical hurdles criteria and requirements for appropriate design at an average.	Student is able to identify all technical hurdles criteria and requirements for appropriate design at minimum.
2	Estimate loading for structural component and analyse structural component. (Optimization of load combination)	a) Specify materials required for your design project. Refer to your architectural details: eg.f_{yk}=500 N/mm^2, f_{ck} =30 N/mm^2, f_{yv} = 250 N/mm^2 etc.	Student is able to correctly identify, select and list all relevant materials for appropriate design.	Student is able to correctly identify, select and list all relevant materials for appropriate design at an average.	Student is able to correctly identify, select and list all relevant materials for appropriate design at minimum.
			Materials selected must correspond to the estimated	Materials selected must correspond to the	Materials selected must correspond to the estimated

			Performance of Students		
No	**Task**	**Activity**	**Excellent**	**Average**	**Poor**
			loading.	estimated loading at an average.	loading at minimum.
		b) Analyse structural component: Shear forces and bending moments.	Student is able to analyse all structural components correctly for appropriate design.	Student is able to analyse some structural component correctly for appropriate design.	Student is able to analyse minimally structural component correctly for appropriate design.
3	Select and perform design of sections and detailing.	a) Select and perform design the structural component: i. Beam ii. Slab iii. Column iv. Footing	Student is able to correctly select section with respect to loading and comply standard codes of practice.	Student is able to correctly select section with respect to loading and comply standard codes of practice at an average.	Student is able to correctly select section with respect to loading and comply standard codes of practice at minimum.
		b) Produce calculations to accompany design sketches of sections.	Student correctly design structural component using appropriate formulas and comply standard codes of practice.	Student correctly design structural component using appropriate formulas and comply standard codes of practice at an average.	Student correctly design structural component using appropriate formulas and comply standard codes of practice at minimum.
		c) Produce final detailing of structural components for appropriate design.	Student demonstrates precise calculations for the selected structural component.	Student demonstrates precise calculations for the selected structural component at an average.	Student demonstrates precise calculations for the selected structural component at minimum.
			The design satisfies the	The design satisfies the	The design satisfies the

			Performance of Students		
No	**Task**	**Activity**	**Excellent**	**Average**	**Poor**
			practical aspect of construction. The design exhibits originality.	practical aspect of construction at an average. The design exhibits originality at an average.	practical aspect of construction at minimum. The design exhibits originality at minimum.
4	Ethics	Utilize safety and economic aspects in design.	Safety and economic aspects are fully considered in the design.	Safety and economic aspects are considered to a lesser in the design.	Safety and economic aspects are minimally considered in the design.
5	Use of technology	Use technological tools for drawings and analysis	Usage of two technological tools.	Usage of one technological tool.	No technological tools used.

5.2.6 Proposed assessment rubrics for teamwork and communication

Teamwork and communication have never been assessed in the project work of DDA3164. There is no emphasis by the faculty on this matter, even though these items are outlined in the CLO of the course.

Table 5.4 and Table 5.5 show the assessment rubric for teamwork and communication. For teamwork performance and communication, the performance is based on the contribution of the students towards their teams, their interaction and respect for others. These performances are rated as excellent, average and poor.

Table 5.4 : Teamwork Assessment

Teamwork Performance	Excellent	Average	Poor
Ability to develop team relationship, interact with colleagues and work effectively with other people to achieve mutual objective.	Students attend all meetings and arrive promptly, are punctual, and stay for entire meeting.	Students are present at the majority of the meetings. When student has to be absent, he/she inform the team or as agreed upon member of the team.	Student frequently miss meetings and does not inform the team, or an agreed upon member of the team. When he/she does come, he/she often late or leave early.
	Student introduces ideas, express and share opinion and knowledge openly.	Student introduces some ideas, express and share some opinion and knowledge.	Student does not introduce ideas, does not express, share opinion and knowledge.
	Gather information appropriately, and perform research when necessary	Gather some information appropriately, Perform some research when necessary	Gather information less appropriate, Perform less research when necessary.
Ability to understand and play a role sparingly with team leaders and other members	Share knowledge with others	Share some knowledge with others	Does not share knowledge with others.
	Consider and adopt suggestions from others.	Consider and adopt some suggestions from others.	Does not consider and does not adopt suggestions from others.
	Try to understand what other team members were saying.	Sometimes try to understand what other team members were saying.	Never try to understand what other team members were saying.
	Assist team members	Sometimes help someone on the team.	Never help someone on the team.
	Ask for help from team members.	Sometimes ask for help from someone on the team.	Never ask for help from someone on the team
	Responsible and	Self –responsible.	No leadership

Teamwork Performance	**Excellent**	**Average**	**Poor**
	share leadership role		quality
Ability to respect other people's behaviour	Complete tasks on time with high quality. Highly self-motivated Full commitment of the work and show respect for others. Committed to team goals.	Complete tasks on time with normal quality but sometimes late. Some commitment of the work and show some respect for others. Some commitment to team goals.	Complete tasks late with less quality. No self-motivated and needs chasing to get the work done. Little commitment of the work and less respect for others. No commitment to team goals.

Table 5.5 : Communication Assessment

Communication	Excellent	Average	Poor
Oral Communication	Clear communication with team members at all stages of project.	Some general communication with team members at all stages of project. May avoid discussing some topics.	Communication is limited with team members at all stages of project
	Listen to views and opinions of others, and consider the suggestions of others.	Listen to some views and opinions of others, some considerations on the suggestions of others.	Does not listen to views and opinions of others, does not consider the suggestions of others.
	Practices effective listening for receiving information accurately; exhibit proper verbal and non-verbal mannerism in interpersonal communication.	Practices some effective listening for receiving information accurately; exhibit proper verbal and non-verbal mannerism in interpersonal communication.	Practices less effective listening for receiving information accurately; exhibit proper verbal and non-verbal mannerism in interpersonal communication.
	Give suggestions, receptive t criticism records group activities and outcomes, ideas, date.	Give some suggestions, receptive to criticisms, records some group activities and outcomes, ideas, date.	Students do not give suggestions or receive criticism & suggestions, does not record group activities and outcomes, ideas, date.

5.3 Recommendations

From the findings of this research, several recommendations for future research associated with project-based learning are suggested.

Continuous Improvement To The Execution of FPjBL Approach

The findings have outlined the design abilities that the students demonstrated in design projects during FPjBL. This reflects that industry involvement influence the students' project take-up and industry thus continuous improvement such as involving industries in projects should be encouraged. The training at the industries should provide deeper and wider scope of design projects to the students. The effectiveness of FPjBL is closely related to the research on FPjBL. The following are several recommendations that could be useful to undertake the field project-based learning in design projects:

1. Exposure to project sites would encourage students to put theory into practice on real designs. Students' experience at the site would also broaden their design abilities.

2. FPjBL presents more samples on real life projects and make design project more meaningful to the students.

3. Provide opportunities for the students to engage in self directed learning and become independent learners without direct supervision from the lecturers.

4. The faculty should keep on adapting to the state-of-the-art computer applications software for students to utilise in completing their design project, similar to what the industry is employing.

Lecturers' industry experiences need to be more enhanced

There are fewer engineering lecturers with industry experience. This kind of experience is a crucial element in designing and supporting meaningful real-life FPjBL activities. Without this experience, it may limit the possibility of the use of FPjBL in the higher education institutions. One way to address this deficiency is to require the lecturer to undergo some professional training development in engineering design at the industry before teaching a design course. In fact, current reviews at the local institution stressed the importance of industrial experience that could be carried out at the industry to cater for some professional practice. This would enable them to develop design skills in the area of expertise, as well as to update their knowledge on current practices. Alternatively, industry practitioner should be invited to assist faculty with the students' design projects, or the institution may hire industry's professional to coach students in projects design.

Review assessments in projects

Project reports serve as the documentation of students' learning outcomes in the project component of the course. Very few studies have been looking at the learning outcomes demonstrated in project reports (Guerra and Kolmos, 2011). This is because the intended learning outcomes using project-based approach is the most difficult to be assessed (Mills, 2002). According to Mills (2002) the formal assessment in the PjBL approach such as examinations, tests and project report provide greater confidence to students in the assessments of design course.

The assessment on skills and abilities in projects are necessary in order to examine the project that corresponds directly to FPjBL. In addition, the allocation of marks on projects should be further reviewed because projects are time consuming to be completed. Perhaps, lecturers should also reduce the number of tests and re-allocate the marks into the project.

Review working space for project learning

The field project-based approach demands a high degree of supervision and office-space for students. Thus continual and guided supervision by a lecturer is required as well as providing studio/office space at the university.

5.4 Further Research

This research has identified the design abilities crucial for design projects and FPjBL. The researcher would like to recommend the following component for other researchers who are interested to work on FPjBL.

1. The use of FPjBL should be extended to other disciplines of the engineering profession. FPjBL provides a framework for embedding experiential and rich learning activities, integrated with discipline based curriculum that may improve employment and career outcomes of students' learning.

2. The obvious limitations of the research is the students were limited to a particular cohort of students, who undertook DDA3164 which was taught in a single semester in one institution. It is recommended that the research is conducted to other design courses with more participants. A larger scale would be necessary to see the significant results to of FPjBL implementation.

3. FPjBL can be characterised by group work and student self-directed learning. The true amount of students' learning time in project is important for their learning achievement. Therefore, it is recommended further research to study on the student time allocation in FPjBL.

4. Students were satisfied with FPjBL in the study especially about their learning experiences in learning by doing in industry. This reflects one of the

advantages of FPjBL, that is stimulating students' interest and motivation from the project work. Yet the satisfaction level needs to be explored.

5. Formal assessment results are not sufficient measures of the effectiveness in project-based learning. Therefore other means of assessing abilities and skills in projects are required. A survey instrument to determine the lecturers' perspective on the suitability of the proposed rubrics for written report as well as teamwork and communication should be developed. In addition, to determine the effectiveness of the proposed rubric, it is recommended that the assessment model be utilized for assessing students' achievement in project and the result is compared to the current assessment method. Hence, a research comparing the effectiveness of the proposed assessment model is recommended.

5.5 Concluding Remark

The responses to the field project-based learning in DDA3164 is very encouraging as it promoted a rich, diverse, and rewarding learning experience to students. Students have proved to have great adaptability and did not face difficulties in its implementation. The overall conclusion of the study is that field project-based learning (FPjBL) has enhanced several design abilities of students. It may be very effective method of learning in the field of structural reinforced concrete design, which modelled professional practice and instituted deeper learning against class based project. Students gained both technical skills in structural design engineering and generic skills relevant not only to engineering practice, but also to their ability to undertake lifelong learning including teamwork, communications, negotiation of understanding and evaluation of alternative solutions which increases their motivation and engagement of learning. The use of FPjBL should be encouraged not only within structural reinforced concrete design but also to other courses. FPjBL provides a framework for embedding experiential and rich learning activities, integrated with discipline-based curriculum that may improve employment and career outcomes.

This chapter has concluded the responses of the four research questions that are obtained from the study conducted. In addition, the significance and limitations of the study findings have been examined. Recommendations for improving project-based learning are highlighted for future research.

REFERENCES

A nation learning: vision for the 21st century. (1997). *Commission for a Nation of Lifelong Learning* . Washington DC: Commission for a Nation of Lifelong Learning.

Aalborg Univesity. (2010). *Principles of Problem and Project Based Learning,: The Aalborg PBL Model.*

Abdul Rahman, M., Mat Daud, K., Jusoff, K., & Abd Ghani, N. (2009). Project Based Learning (PjBL) Practices at Politeknik Kota Bharu Malaysia. *International Education Studies, 2* (4).

ABET. (2000). Accreditation Board for Engineering and Technology : Engineering Criteria 2000.

ABET. (2007). *Criteria for Accrediting Engineering Programs 2007-2008.* Retrieved August 2009, from http://www.abet.org

Academic Guide Book 2008/2009. (2008). Kuala Lumpur: College of Science and Technology.

Academic Guidelines: Undergraduate Degree Programme 2008/2009. (2009). Johor Bahro: Universiti Teknologi Malaysia.

Ahern, A. (2007). What are the perceptions of civil engineering lecturers towards using cooperative learning. *International Conference on Engineering Education.* ICEE2007.

Akili, W. (2007). A Practitioner? Faculty Coolaboration In Teaching Civil Engineering Design. *American Soceity For Engineering Eduction.*

Aman, C., Poole, G., Maijer, S., Hall, R., Taghipour, F., & Berube, P. (2007). Students Learning Teams: Viewpoint of team members, teachers and an observer. *Engineering Education Journal of the Higher Education Academy Engineering Subject Centre, 2* (1).

Ambikairajah, E., Freney, S. J., Epps, J., & Hesketh, T. (2007). Self-Directed Project Based Learning-A Case Study. *AaeE Conference*, (pp. 1-9). Melbourne.

Anderson, T. (2007). Experience With Practical Project Based Learning In A Developing Undergraduate Engineering Degree Program. *International Conference On Engineering Education - ICEE 2007.*

Andreas, A. (2003). *Project-based learning: Students learn important life skills through projects.* PMI Today, 14.

Ansell, H.G. (1998). Professor-driven, student-driven, and client-driven design projects. *Proceeding of Frontiers in Education Conference.* 149-154.

Arciszewski, T., & Lakmazaheri, S. (2001). Structural Design Education for the 21st Century. *International Juornal of Engineering Education* , pp. 446-454.

Ardington, A. (2011). Writing: An Essential and Powerful Communication Tool for Today's 'Three Dimensional' Engineering Graduate. *Journal of Academic Writing, 1* (1), 61–70.

Arumala, J. (2002). Student-Centered Activities To Enhance The Study Of Structures. *ASC Proceedings 38thAnnual Conference ASC*, (pp. 1-16). Virginia Polytechnic Institute and State University, Blacksburg, VA.

ASCE. (2006). *The Vision for Civil Engineering in 2025.* American Soceity for Civil Engineering.

Atman, C., Chimka, J., & Bursic, K. N. (1999). A Comparison of Freshman and Senior Engineering Design Process. *Design Studies, 20* (2), 131-152.

Avery, Z., Castillo, M., Guo, H., Guo, J., Warter-Perez, N., Won, D., et al. (2010). Implementing Collaborative Project-Based Learning using the Tablet PC to enhance student learning in engineering and computer science courses. *40th ASEE/IEEE Frontiers in Education Conference*, (pp. F1E 1 - F1E 7).

Aziz, A., Megat Mohd Noor, M., Abang Ali, A., & Jaafar, M. (2005). A Malaysian Outcome-based Engineering Education Model. *International Journal of Engineering and Technology, 2* (1), pp.14-21.

Aziz, A., Megat Mohd Noor, M., Abang Ali, A., & Jaafar, M. (2005). A Malaysian Outcome-based Engineering Education Model. *International Journal of Engineering and Technology, 2* (1), 14-21.

Aziz, S. (2009). Assessment for Learning in Engineering Design Within A Project-based Framework. *AAEE 2009*, (pp. pp 423-428).

Aziz, S. (2009). Assessment for Learning in Engineering Design Within A Project-based Framework. *AAEE 2009*, (pp. 423-428).

Babbie, E. (2002). *The Basics of Social Research.* Wadsworth, Thomson Learning.

Baillie, C. and Fitzgerald, G. (2000) Motivation and attrition in engineering students. *European Journal of Engineering Education,* 25 (2), 145-155

Bailey R, S. Z. (2006). Asssesing Engineering Design Process. *International Journal of Engineering Education, 22(3)*, 508-518.

Bandura, A. (1985). *Social Foundation of Thought And Action: A Cognitive Theory.* Prentice Hall.

Barak, M., & Maymon, T. (1998). Aspects of Teamwork Observed in a Technological Task in Junior High Schools. *Journal of Technology Education, 9* (2), 3-17.

Barron, B. J., Schwartz, D. L., Vye, N. J., Moore, A., Petrosino, A., Zech, L., et al. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *The Journal of the Learning Sciences, 7, 271-311, 7*, 271-311.

Baş, G. (2011). Investigatingtheeffectsofproject-basedLearning on students' academicachievementandattitudes towardsEnglishlesson. *The Online Journal Of New Horizons In Education , 1* (4).

Benard, R. (1994). Qualitative Data, Quantitative Analysis. *Cultural Antropology Methods Journal, 8* (1).

Bhavnani, S. and Alridge, M.D., Teamwork across disciplinary borders: a bridge between college and the workplace. *Journal of Engineering Education.,* January 2000, 13-16.

Biggs, J., & Tang, C. (2007). *Teaching for Quality Learning at University.* Berkshire: Mc Graw Hill.

Bloom, B. (1984). *Taxonomy of Educational Objectives, Handbook 1 Cognitive Domain.* New York: Addison Wesley.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the Doing, Supporting the Learning. *Educational Psychologist, 26* (3-4), 369-398.

Boaler, J. (1997). *Experiencing school mathematics: Teaching styles, sex, and setting.* UK: Open University Press.

Bogdan, R., & Biklen, S. (2007). *Qualitative Research For Education: An Introduction to Theory and Methods.* Boston: Pearson Education.

Bogusch, L., Turns, J., & Atman, C. (2000). Engineering Design Factors: How Broadly Do Students Define Problems? *30th ASEE/IEEE Frontiers in Education Conference.*

Boreggo, M., Douglas, E., & Amelink, C. (2009).Quantitative , qualitative and mixed research methods in engineering education. *Journal of Engineering Education 98(1), 53-66*

Borgford-Parnell, J., Deibel, K., & Atman, C. (2010). From Engineering Design Research to Engineering Pedagogy: Bringing Results ResultsDirectly To Students. *International Journal of Engineering Education*.

Boud, D., & Feletti, G. (1991). *The Challenge of Problem-based Learning.* London: Kogan Page.

Brackin, P., & Gibson, J. (2007). Capstone Design Projects With Industry : Using Rubrics To Assess Student Design Process. *American Society for Engineering Education.*

Bransford, J. D., & Stein, B. S. (1993). *The IDEAL problem solver (2nd ed.).* New York: Freeman.

Brinkman, G. W. (2003). Assesment of Communication Competencies in Engineering Design Projects . In *Technical Communication Quarterly* (Vol. 12(1), pp. 67-81).

Brodeur, D. R., & Crawley, E. F. (2009). *CDIO and Quality Assurance: Using the Standards forContinuous Program Improvement.*

Brodeur, D. R., Crawley, E. F., Ingemarsson, I., Malmqvist, J., & Ostlund, S. (2002). International Collaboration in the Reform of Engineering Education. *American Society of Engineering Education Conference.* Montreal, Canada.

Brookhart, S. M. Developing Measurement Theory Assessment Purposes and Uses. In *Educational Measurement: Issues and Practice* (Vol. 22(4), pp. 67-81).

Brown, A. L., & Campione, J. C. (1996). *Psychological theory and the design of innovative learning environments. On procedures, principles, and systems . In L. Schauble & R. Glaser (Eds.). Innovation in learning: New environments foreducation.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Brzustowski, T. (2004). Science and Engineering Research Canada: Design Engineering and the Innovation Strategy. *CDEN Conference.* Montreal : McGill University .

Byrd, J., & Hudgins, J. (1995). Teaming in the design laboratory. *Journal of Engineering Education, 84* (4), 335-341.

Caedella, M., Oakes, W., Zoltowski, C., Adams, R., Purzer, S., Borgford-Parnell, et al. (2011). Assessing Student Learning of Engineering Design. *41st ASEE/IEEE Frontiers in Education Conference.*

Cajander, A., M, D., McDermott, R., & Von Konsky, B. (2011). Assessing Professional Skills in Engineering Education. *13th Australiasian Computer ducation Conference.*

Campdell, S., & Colbeck, C. (2011). *search.asee.org/search/click?query...Ann.* Retrieved 2011.

Candy, P. (1991). *Self-Direction for Life-long Learning: A Comprehensive Guide to Theory and Practice.* San Fransisco, CA: Jossey-Bass.

Cardella, M., Oakes, W., Zoltowski, C., Adams, R., Purzer, S., Borgford-Parnell, et al. (2011). Assessing Student Learning of Engineering Design. *41st ASEE/IEEE Frontiers in Education Conference.*

Carew, A., & Therese, S. (2007). EMAP: Outcomes from Regional Forums On Graduate Attributes in Engineering . *18th Conference Of The Australasia On Enineering Education* .

Cassidy, S. (2004). Learning Styles: An Overview of Theories, Models and Measures. *Educational Psychology, 24* (4).

Ceylon, T., & Lee, L. (2003). Critical Thinking and Engineering Education. *American Society for Engineering Education.*

Chaedar, A. (2011). *Pokoknya Kualitatif.* Jakarta: Pustaka Jaya.

Chandrasekaran, S., Stojcevski, A., Littlefair, G., & Joordens, M. (2012). Learning Through Projects in Enginnering Education. *40th Annual Conference SEFI.*

Chapman, E.(2003). Alternative Approaches To Assessing Student Engagement Rates. *Practical Assessment, Research & Evaluation,* 8 (13).

Chi, M. (1997). Quantifying Qualitative Analysis of Verbal Data : A Practical Guide. *The Journal of Learning Sciences, 6* (3), 271-315.

Chowdhury, S., Guan, H., & Doh, J. (2005). Integrated Design Project- An Integration of Fundamental Engineering Courses. *4th Global Colloquium on Engineering Education.* Australasian Association for Engineering Education.

Coleman, R. (1996). *The Engineering Education Coalitions.* ASEE Prism.

Conley, M., Livingstone, A., & Meharg, S. (2006). Collaborative Problem-based Learning in a Peacekeeping Environment. *6th International Conference of Knowledge, Culture and Change in Organization.*

Cordon, D., Williams, B., Beyerlein, S., & Elger, D. (2007). Distinguishing Among Processes of Problem Solving, Design, And Research To Improve Project Performance. *American Society for Engineering Education.* ASCE.

Costa, R. (2009). Technologies and Learning – Work: Learning Topics.

Crawley, E., & Soderholm, D. (2007). Stakeholder Exoectations of Learning In First Year Project-Based Courses. *3rd International CDIO Conference.*

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches.* California: Sage Publications.

Cross, N. J. (2000). *Engineering Design Methods: Strategies for Product Design* (Vol. 3rd Edition). Chinchester, New York: Wiley.

Dahlgren, M.A., Castensson, R. and Dahlgren, L.O., PBL from the teachers' perspective. *Higher Ed.*, 1998, **36**(4), 437–447.

Dally, J., & Zhang, G. (1994). A Freshman Engineering Design Course. *Journal of Engineering Education, 83* (2), pp 83-91.

De Vita, G. (2004). Integration and independent learning in a business synoptic module for international credit entry students. *Teaching in Higher Education, 9* (1), 69-81.

Denzin, N., & Lincoln, Y. (1984). *Handbook of Qualitative Research.* Newbury Park: Sage Publication.

Dewey, J. (1916). *Democracy and Education.* New York: The Free Press.

Dewey, J. (1938). *John Dewey experience and education.* New York: McMillan.

Dickens, J. (1998). The Teaching of Civil Engineering Design, Flair, Process or Both? *In Design in Engineering Education SEFI International Seminar.*

Dochy, F., & Moerkerke, G. (1997). Assessment as a major influence on learning and instruction. *Educational Testing and Assessment, 27* (5), p. 415-432.

Dominick, P., Demel, J., Lawbaugh, W., Freuler, R., Kinzel, G., & Fromm, E. (2004). *Tools and Tactics of Design.* John Wiley & Sons, Inc. .

Droppelt, Y. (2003). Implementation and assessment of project-based learning in a flexible environment. *International Journal of Technology and Design Education, 13*, 255–272.

Du, X., Graaff, E., & Kolmos, A. (2009). PBL-Diverse In Research Questions and Methodologies. In X. Du, E. Graaff, & A. Kolmos, *Research On PBL Practices In Engineering Education* (pp. 1-7). Sense Publishers.

Dutson, A., Todd, R., Magleby, S., & Sorensen, C. (1997). A Review of Literature On Teaching Engineering Design Through Project-oriented Capstone Courses. *Jour Engineering Educationnal of, 86* (1), 17-28.

Dym, C. (1994). Teaching Design to Freshman: Style and Content. *Journal of Engineering Education, 83* (4), 303-310.

Dym, C. (2004). Design, Systems and Engineering Education. *International Journal of Engineering Education, 20(3)*, 305-312.

Dym, C. L., & Little, P. (2000). *Engineering Design: A Project-Based Introduction.* New York: John Wiley.

Dym, C., & Little, L. (2003). *Engineering Design: A Project-Based Introduction* (2nd ed.). New York: John Wiley.

Dym, C., Agogino, A., Eris, O., Frey, D., & Leifer, L. (2005). Engineering Design Thinking, Teaching and Learning. *Journal of Engineering Education, 94* (No 1), pp 103-120.

Dym, C., Wesner, J., & Winner, L. (2003). Social Dimensions of Engineering Design: Observations from Mudd Design Workshop III. An Educatiional Brief from Mudd Design Workshop III.

Engineering Accreditation Council;. (2010). *Engineering Programme Accreditation Manual.* Retrieved October 2011, from Engineering Accreditation Council Malaysia: http://www.eac.org.my/web/.

Eder, W. (1991). Engineering Design Education: Situation Report. *Design Studies* .

Educating The Engineer 2020 : Adapting Engineering Education to the New Century. (2005). Washington D.C: The National Academies Press.

Eggert, R. (2007). Engineering Design: Are We Teaching The Right Design. American Society for Engineering Education.

Eijkman, H., Kayali, O., & Yeomans, S. (2009). *Using Soft Systems Thinking to Confront the Politics of Innovation in Engineering Education. In A. S.Patil & P. J. Gray (Eds.), Engineering Education Quality Assurance: A Global Perspective.* New York.

Engineering, N. A. (2005). *Educating the Engineer of 2020:Adapting Engineering Education to the New Century.* Washington D.C: The National Academies Press.

Evans, D.L., Beakley, G.C., Crouch, P.E & Yamaguchi, G.T (1993). Attributes of engineering graduates and their impact on curriculum design. *Journal of Engineering Education, 82* (4), 203-211

Fallows, S., & Steven, C. (2000). *Integrating Key Skills in Higher Education : Employability, Transferable Skills and Learning for Life.* London: Kogan Page.

Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The Future of Engineering Education II.Teaching Methods That Work: Chemical Enginering Education. *34* (1), 26-39.

Felder, R., & Brent, R. (2001). Effective Strategies for Cooperative Learning. *Journal of Cooperation and Collaboration in College Teaching, 10* (2), 63-69.

Felder, R., & Brent, R. (2003). Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. *Journal of Engineering Education* , 7-25.

Felder, R., & Brent, R. (2005). Understanding Student Differences. *J. Engr. Education, 94* (1), 57-72.

Felder, R., & Silverman, L. (1988). Learning and Teaching Styles in Engineering Education. *Journal of Engineering Education, 78* (7), 674-681.

Fisher, A., & Foreit, J. (2002). *Designing HIV/AIDS Intervention Studies: An OperationsResearch Handbook* . Washington, DC Population Council.

Froyd, J., & Ohland, M. (2005). Integrated Engineering Curricula. *Jounal of Engineering Education, 94* (1), pp,147-164.

Gadner, H. (1991). *The Uncshooled Mind.* NY: Basic Books.

Gao, M., Demian, P., & Willmot, P. (2008). The Role and Effectiveness of Design Projects in Civil Engineering. *12th International Conference on Computing in Civil and Building Engineering* .

Garcia, J., & Perez, J. (2009). *A PBL Apllication Experience Supported by Different Educational Methodologies.* The Netherlands SEnses Publisher.

Gardner, H. (1993). *Multiple Intelligences/The Theory in Practice.* NY: Basic Books.

Gerdy, K. B. (1998-1999). *Gerdy, Kristin B. (19If Socrates Only knew: Expending Law Class discourse, J. Reuben Clark Law School, Brigham* .

Gibson, I. (2001). Group Project Work in Engineering Design-Learning Goals and Their Assessment. *International Journal of Engineering Education, 17* (3), 261-266.

Gibson, I. (2002). Assessment in Engineering Education- A European Perspective. *International Journal of Engineering Education, 18* (4), 465-471.

Gibson, I. (2005). *Handbook of Enquiry & Problem Based Learning : Designing Projects For Learning.* Galway: CELT.

Gibson, I. S. (1998). Assessment Criteria for Undergraduate Project Work in Engineering Design. *European Journal of Engineering Education, 23(3)*, 389.

Gillham, B. (2000). *Case Study Research Methods.* London and New York: Continuum.

Gillham, B. (2005). *Case Study Research Methods.* London and New York: Continuum.

Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research.* . Thousand Oaks: CA: Sage.

Göl, Ö., & Nafalski, A. (2007). Collaborative Learning in Engineering Education. *Global ournal . of Engineering Education., 11* (2).

Gonzales, A.H., & Nelson, L.M. (2005). Learner-centred Instruction Promotes Students' Success. *http://www.thejournal.com/magazine/vault/.*

Graaff, E. d., & Kolmos, A. (2003). Characteristics of Problem Based Learning. *International Journal of Engineering Education, 5*.

Graaff, E. d., & Kolmos, A. (2007). *Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering.* Rotterdam/Taipei: Sense Publishers.

Graaff, E., & A, K. (2007). *Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering.* Rotterdam/Taipei: Sense Publishers.

Graham, R., & Crawley, R. (2010). Making projects work: a review of transferable best practice approaches to engineering project-based learning in the UK. *Engineering Education.*

Greenberg, J., Delgutte, B., & Gray, M. (2003). Hands-On Learning in Biomedical Signal Processing: A Case Study Demonstrating Application of a Pedagogical Framework to Improve Existing Instruction. *IEEE Med. Bio. Mag* , 71-79.

greenschoolsforteachers.wikispaces.com/.../Key+Characteristics+of+P.. (n.d.). Retrieved 2012 йил June

Grigg, N., Criswell, M., Fontane, D., Saito, L., Siller, T., & Sunada, D. (2004 йил July). Integrated Civil Engineering Curriculum: Five-Year Review. *Journal of Professional Issues in Engineering Education and Practice* .

Groh, S., & Duch, B. (2003). *Assessment of learning in student-centred courses : Problem-based learning.* Retrieved 2012 from http://www.udel.edu.pbl.

Gronlund, N. (1995). *How to Write and Use Instructional Objectives.* Merril: Eaglewood Cliffs.

Guba, E., & Lincoln, Y. (1980). *Fouth Generation Evaluation.* California: Sage Publications.

Guerra, A., & Kolmos, A. (2011). *Comparng Problem Based Learning Models: Suggestions For Their Implementation.* Aallborg University Press.

Gülbahar, Y., & Tinmaz, H. (2006). Implementing Project-Based Learning And E-Portfolio Assessment In an UndergraduateCourse. *Journal of Research on Technology in Education* , 309-327.

Gültekin, M. (2007). The Effect of Project Based Learning on Learning Outcomes in theFifth-Grade Science Education. Elementary Education Online. *Retrieved on December 2012, 6* (1), 93-112.

Guskey, T. (2007). Closing Achivement Gaps Revisiting Benjamin S. Bloom's Learning For Mastery in Elementary and Secondary Classrooms. *Educational Leadership, 19*, 8-31.

Gustafion sson, G., Newman, D. J., Stafstrom, S., & Wallin, H. P. (2002). First-year Introductory Courses as a Means to Develop Conceive-Design-Implement-Operate Skills in Engineering Education Programme. *Societe Europeenne pour la Formation des Ingenieurs (SEFI) Conference.* Florence, Italy.

Hale, M., Freyne, S., & Durham, S. (2007). Student Feedback and Lessons Learned From Adding Laborarory Experiences to the Reinforced Concrete Design.

Hancock, D., & Algozzine, B. (2006). *Doing Case Study Research.* New York: Teachers College.

Harris, D. (2001). A Case for Project-Based Design Education. *International Journal of Engineering Education, 17* (4 & 5).

Harris, M., & Cullen, R. (2009). A Model for Curricular Revision: The Case of Engineering. *Innovative Higher Education, 34*, 51-63.

Harris, T., & Jacobs, H. (1995). On Effective Methods to Teach Mechanical Design. *Journal of Engineering Education, 84* (4), 343-349.

Hashim, R., & Mohd Din, M. (2009). Implementing Outcome Based Education Using Project Based. *European Journal of Scientific Research, 26* (1), pp.80-86.

Hasna, A. (2008). Problem Based Learning in EngineeringDesign. *SEFI 36TH Annual Conference, European Society for Engineering Education* .

Hassan, B., Mohd Zaidi, O., Zainal, M., Abang Abdullah, A., Abdul Hamid, H., Nik Abdullah, N., et al. (2007). *The Future of Engineering Education in Malaysia.* Ministry of Higher Education.

Hattum-Janssen, N., & Lourenco, J. (2005). Peer Assessment and Group Work In Civil Engineering. *5th AECEF: Symposium In Civil Engineering In The New Decade.*

Heitmann, G. (1996). Project- Oriented Study and Project-organized Curricula : A Brief Review of Intentions and Solutions. *European Journal of Engineering Education, 21* (2), 121-131.

Helle, L., Tynjälä, P., Olkinuora, E., & Lonka, K. (2007). 'Ain't nothin' like the real thing', Motivation and study processes on a work-based project course in information systems design. *British Journal of Educational Psychology, 77* (2).

Hellström, D., Nilsson, F., & Olsson, A. (2009). Group assessment challenges in project-based learning - Perceptions from students in higher engineering courses. *Utvecklingskonferensen för Sveriges ingenjörsutbildningar, LTH 2-3 december 2009.*

Hermon, J., & McCartan, C. (2010). Assessing The Development of Personal and Professional Skills in Group Projects. *6th International CDIO Conference.*

Heywood, J. (2005). *Engineering Education: Research and Development in Curriculum and Instruction.* IEEE Press, John Wiley and Sons, Inc, Publication. Hoboken, New Jersey.

Hill, R. B. (1997). *The Design of an Instrument to Assess Problem Solving Activities in Technology Education.* Blacksburg, Virginia: Virginia Polytechnic Institute and State University.

Hilvonen, & Ovaska, P. (2010). Student Motivation in Project-Based Learning. *International Conference on Engaging Pedagogy* .

Hiscocks, P. D. (2012). *www.syscompdesign.com/AppNotes/pbl.pdf.* From Project-Based-Learning: Outcomes, Descriptors and Design.

Howard, J. (2002). Technology-enhanced project-based learning in teacher education:Addressing the goals of transfer. *Journal of Technology and Teacher Education* .

Hoyt, B., Prince, M., Shooter, S., Hanyak, M., Mastascusa, E.J., Synder. (2003). Engineering Education: A Conceptual Framework For Supporting In Adopting Collaborative Learning. American Society for Engineering Education.

Hsieh, H.-F., & Shannon, S. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15* (9), 1277-1288.

Hung, I.W., & Choi, A.C. K (2003). An Integrated Problem-based Learning Model For Engineering Education. *Journal of Engineering Education, 19(3),* 734-737.

Ismail, K., Puteh, M., & Mohammad, S. (2009). A Preliminary Study On The Learning Style Of. *The International Congress On Engineering Education(ICEED 2009).*

Jaafar, M., Nordin, N., Wagiran, R., Aziz, A., Noor, M., Osman, M., et al. (2008). *Assessment Strategy for an Outcome Based Education.* Retrieved 2010 from www.iceehungary.net/download/fullp/full_papers/full_paper46.pdf.

Jacques, D. (1998). *Learning: The Treasure Within.* UNESCO Publishing.

Johnson, D., Johnson, R., & Smith, K. (1998). *Active Learning: Cooperation in the College Classroom.* Interaction Book Company.

Johnson, R. B., & Christensen, L. B. (2004). *Educational research: Quantitative, qualitative, andmixed approaches.* Boston: Allyn and Bacon.

Jonassen, D., & Rohrer-Murphy, L. (1999). Activity Theory as a Framework for Designing Constructivist Learning Environments. *Educational Technology Research and Development, 47* (1), 61-80.

Juhdi, N., Jauhariah, A., & Shaharuddin. (2007). Study On Employability Skills of University Graduates. *The Business Wallpaper, 2*.

Kartam, N.A. (1994). Integrating Design Into Civil Engineering Education. *Journal of Engineering Education.* 18(2).

Kashefia, H., Ismail, Z., & Yusof, Y. (2012). The Impact of Blended Learning on Communication skills and Teamwork of Engineering Students in Multivariable Calculus. *Research Centre for Engineering Education* .

Katchalov, E. & Milton, J. (1995). Engineering problem-centred learning - an experiment in teaching. In P. Little, M. Ostwald & G. Ryan (Eds.), *Research and development in problem based learning. Vol 3. Assessment and evaluation* (pp. 257-264). University of Newcastle, NSW: Australian Problem Based Learning Network.

Kaufmann, D., & Felder, R. (2000). Accounting for Individual Effort in Cooperative Learning Teams. *Journal of Engineering Education, 89* (2), 133-140.

Khandani, S. (2005). *Engineering Design Process :Education Transfer Plan* . IISME:Solectron .

Kjersdam, F., & Enemark, S. (1994). *The Aalborg Experiment : Project Innovation in University Education.* Aalborg University Press.

Knowles, M.S. (1975). *Self-directed Learning : A Guide For Learners and Teachers.* Association Press, Chicago.

Koehn, E., & Koehn, J. (2008). Peer Assessment of Team Work and Collaborative Learning In Construction/Civil Engineering. *American Society for Engineering Education.*

Kolmos, A. (1996). Reflections On Project Work and Problem-based Learning. *European Journal of Engineering Education, 21* (2), 141-148.

Kolmos, A., Graaff, D., E, & Du, X. (2009). *Research On PBL Practice in Engineering Education.* Sense Publishers.

Kolodner, J., Crismond, D., Fasse, B., Holbrook, J., & Puntembakar, S. (2003). Putting a Student-Centred Learning by Design, Curriculum into Practice : Lesson Learned. *Journal of the Learning Sciences, 12* (4).

Kraft, N. (2005). Retrieved 2011 from http://www/rmcdenver.com/useguide/pbl.htm.

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredericks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts bymiddle school students. . *The Journal of the Learning Sciences* (7), 313-350.

Krajcik, J. S., Blumenfeld, P. C., Marx, R., & Soloway, E. (1994). *The Elementary School Journal 94(5, 94* (5), 483-497.

Krajcik, J., & Blumenfeld, P. (2012). *Project-based Learning.* Retrieved 2012 from sitemaker.umich.edu/soe/faculty/da.../pbs_krajcik_blumfeld1.pdf.

Lang, J.D., Cruise, S., McVey, F.D. & McMasters, J. (1999). Industry expectations of new engineers: A survey to assist curriculum designers. *Journal of Engineering Education, 38* (1), 43-51.

Le, V., Stecher, B., Lockwood, J., Hamilton, L., Robyn, A., Williams, V., et al. (2006). *http://www.rand.org/pubs/monographs/2006/RAND_MG480.pdf.* Retrieved 2012

Lee, L.-S., & Lai, C.-C. (2007). Capstone Course Assessment Approaches and Their Issues in Engineering Programs in Taiwan. *International Conference on Engineering Education & Research.*

Lee, L., & Lai, C. (2007). Capstone Course Assessment Approaches and Their Issues in Engineering Programs in Taiwan. *International Conference on Engineering Education & Research.*

Levine, A., & Cureton, J. (1998). *When Hope and Fear Collide.* San Fransisco: Josser-Bass.

Lewis, T. (2005). Coming to Terms with Engineering Design as Content. *Journal of Technology Education, 16* (2).

Lingard, R. (n.d.). *Teaching and Assessing Teamwork Skills in Engineering and Computer Science.* Retrieved 2011 йил June from www.iiisci.org/journal/cvsl/sci/pdfs/GQ826EX.pdf

Linn, R., & Miller, M. (2005). *Measurement and Assessment in Teaching.* Upper Saddle River: Pearson.

Lou, Y., & MacGroger, S. K. (2004). Enhancing Project-Based Learning Through Online Between-Group Collabration. *Educational Research and Evaluation, 10* (Nos. 4-6), 419-440.

Lucas, W., & Barge, S. (2010). Effects of Project-base Practice on Self effacacy and the Pursuit of Engineering Studies. *AaeE Conference.* Sydney.

Lutz, F.C. and Schachterle, L., Project in undergraduate engineering education in America. *European. Journal of Engineering Education.*, 1996, **21**(2), 207–214.

Lynch, R., Seery, N., & Gordon, S. (2007). An Evaluation of CDIO Approach To Engineering Education. *International Symposium Engineering Education.*

Macpherson, A. (2008). *Cooperative Learning Group Activities For College Courses : A Guide For Instructors.* Kwantlen University College .

Mahendran, M. (1995). Project-based Civil Engineering Courses. *Journal of Engineering Education*.

Malaysian Qualification Agency. (2007) : *Malaysian Qualification Framework.* Kuala Lumpur.

Malaysia's Science & Tecnology Policy For the 21st Century. (2009).

Manry, D., Bray, H., & Phoha, P. (2012). A Web-Based Peer Evaluation Tool. *4th ASC Annual International Conference Proceedings* .

Martin-Garcia, J., & Lloret, J. (2008). Improving Teamwork with University Engineering Students. The Effect of an Assessment Method to Prevent Shirking. *WSEAS Transaction on Advances in Engineering Education, 5* (1).

Martin, R., Maytham, J., & Fraser, D. (2005). Engineering Graduates' Perception of How Well They Were Prepared For Work In Industry. *European Journal of Engineering Education.* 30(2), 167-180.

Marx, R., Blumenfeld, P., Krajcik, J., & Soloway, E. (1997). Enacting Project-based Science. *The Elementary School Journal, 97* (4), 341-358.

Maykut, P., & Morehouse, R. (1994). *Beginning Qualitative Research: A Philosophic and Practical Guide.* Washington DC: The Falmer Press.

Mc Millan, J., & Schumacher, S. (2001). *Research in Education. A Conceptual Introduction.* New York: Logman.

McClelland, S. (1995). *Organizational needs assessments: Design,facilitation, and analysis.* Westport,CT:Quorum.

McHenry, A., Depew, D., Dyrenfurth, M., Dunlap, D., Keating, D., Stanford, T. (2005). Constructivism: The Learning Theory That Supports Competency Development of Engineers For Engineering Practice and Technology Leadership Through Graduate Education . *American Society for Engineering Education Annual Conference & Exposition* .

McKenzie, L., Trevisan, M., Davis, D., & Beyerlein, S. (2004). Capstone Design Courses and Assessment. *ASEE Anual Conference and Exposition.*

Meier, R.L., Williams, M.R. and Humphreys, M.A., Refocusing our efforts: assessing non-technical competency gaps. *Journal of Engineering Education.,* July 2000, 377-385.

Mergendoller, J. (2006). *Project Based Learing Handbook* (2nd ed.). Novatto,California: Buck Institute of Education.

Merriam, S. (2009). *Qualitative Research: A guide to Design and Implementation.* San Francisco, CA: John Wiley and Sons, Inc.

Merriam, S. (1998). *Qualitative Research and Case Study Applications in Education.* San Francisco: John Wiley & Sons, Inc.

Miles, M., & Huberman, A. (1994). *Qualitative Data Analysis.* Thousand Oaks:SAGE Publications.

Mills, J. (2002). A Case Study of Project-based Learning in Structural Engineering. *American Society for Engineering Education Annual Conference And Exposition.*

Mills, J. E. (2007). Multiple assessment strategies for capstone civil engineering class design project. *AaeE conference.* Melbourne.

Mills, J. E., & Treagust, D. F. (2003). Engineering Education-Is Problem-Based or Project-Based Learningthe Answer? Australasian Journal of Engineering Education. *Austrailan Journal of Engineering Education* .

Montufar-Chaveznava, R., Yousuf, M., & Caldelas, I. (2008). Projects Proposals to Improve Engineering Learning. *Internationa lConference Engineering Education.*

Mosborg, S., Adams, R., Kim, R., Atman, C., Turns, J., & Cardella, M. (2005). Conceptions of the Engineering Design Process: An Expert Study of Advanced Practicing Professionals. *American Society for Engineering Education.*

Mourtos, N. (2011). Teaching engineering design skills. *Proceedings International Engineering and Technology Engineering Conference, IETEC 11.*

Mourtos, N., & Furman, B. (2002). Assessing the Effectiveness of An Introductory Engineering Course For Freshman. *32nd ASEE/IEEE Frontiers in Education Conference.*

Mourtos, N., Okamoto, D. J., & Rhee, J. (2004). Defining, teaching, and assessing problem solving skills. *7th UICEE Annual Conference on Engineering Education.* Mumbai, India.

Moylan, W. (2005). Leading transformational change in higher education. *Internation Journal of Knowledge, Culture & Change, 5*.

Moylan, W. (2008). Learning by project: Developing essential 21st century skills using student team projects. *The International Journal of Learning, 15* (9).

National Academy of Engineering, NAE (2005).

Nepal, K. P., & Steward, R. A. (2010). Relationship between self directed learning readinessfactors and learning outcomes in third year project-basedengineering design course. *Proceedings of the 2010 AaeE Conference.* Sydney.

Nguyen, D. (1998). The Essential Skills and Attributes of an Engineer: A comparative Study of Academics, Industry Personnel and Engineering Students. *Global Journal Of Engineering Education, 2* (No 1).

Nicolai, L. (1998). Viewpoint: An Industry View of Engineering Design Education. *International Journal of Engineering Education, 14* (1), 7-13.

Nolen, S. B. (2003). Learning environment, motivation, and achievement in high school science. *Journal of Research in Science Teaching* .

Noordin, M., Md Nasir, A., Ali, D., & Nordin, M. (2011). Problem-Based Learning (PBL) and Project-Based Learning (PjBL) in engineering education: a comparison. *IETEC'11 Conference.*

Oakes, W. (2004). Design Process.

Oakley, A., Felder, R., Brent, R., & Elhajj, I. (2004). Turning Student Groups into Effective Teams. *Journal of Student Centred Learning, 2* (1), pp 9-34.

Oehlers, D. J. (2006). Sequential Assessment of Engineering Design Projects at University Level. *European Journal of Engineering Education, 31(4)*, 487.

Oehlers, D. J., & Walker, D. (2006). Assessment of Deep Learning Ability for Problem Solvers. *International Journal of Engineering Education, 22(6)*, 1261-1268.

Olds, B., Moskal, B., & Miller, R. (2005). Assessment in Engineering Education : Evolution, Approaches, and Future Collaborations. *Journal of Engineering Education* .

Oliveira, J., & Estima de Oliveira, J. (2009). Retrieved 2012 йил July from www.sefi.be/wp-content/abstracts2009/oliveira.pdf.

Palmer, S. and W. Hall, (2011), An evaluation of a project-based learning initiative in engineering education. *European Journal of Engineering Education.*

Pang, G. (2004). *Self-regulated Learning: Principles and Educational Applications.* Huadong Moral University Press, Shanghai.

Papert, S. (1991). *Perestroika and Epitemological Politics in Harel.I & Papert, S.* Norwood, NJ: Alex Publishing Corporation.

Partnership for the 21st century. (2009). *Partnership for the 21st century* .

Paterson, K., Bielefeldt, A. and Swan, C. (2009). *An interactive panel session on measuring the impacts of project-based service learning on engineering education*. American Society for Engineering Education Conference and Exposition, Austin, TX, USA.

Patton, M. (2002). *Qualitative Research and Evaluation Methods.* CA: Sage: Thousand Oaks.

Paul, R., & Elder, L. (2002). *Critical Thinking: Tools for Taking Charge of Your Professional and Personal Life.* Upper Saddle, NJ: Prentice Hall.

Payne, G., & Payne, J. (2004). *Key Concepts in Social Research.* London: Sage.

PBLE: A Guide to Learning Engineering Through Projects. (2003). Retrieved 2012 йил December from http://www.pble.ac.uk.

Penuel, W., & Means, B. (2000). *Designing a performance asessment to measure students' communication skills in multi-media-supported, project-based learning.* New Orlean: Paper presented at the Annual Meeting of the American Educational Research Assoc.

Perez, J., Garcia, J., Mufloz, I., & Alonso, A. (2010). Cooperative Learning vs. Project Based Learning. *IEEE EDUCON Education Engineering 2010-The Future of Global Learning Engineering Education.*

Perry, N. E., Phillips, L., & Dowler, J. (2004). Examining features of tasks and theirpotential to promote self-regulated learning. *Teachers College Record* .

Petroski, H. (1996). *Invention by Design: How Engineers get from Thought to Thing.* Cambridge: Harvard University Press.

Piaget, J., & Inhelder, B. (1969). *The psychology of the Child.* New York: Basic Books.

Platanitis, G., & Pop-Iliev, R. (2010). Establishing Fair Objectives And Grading Criteria For Undergraduate Design Engineering Project Work:An Ongoing Experiment. *IJRRAS, 5* (3).

Pop-Iliev, R., & Nokleby, S. (2005). Concurrent Approach to Teaching Concurrent Design Engineering. *CDEN International Conference on Design Education, Innovation, and Practice.*

Powell, P., & Weenk, G. (2003). *Project-led Engineering Education.* Utrecht: Lemme Publishers.

Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions,Comparisons, and Research Bases. *Journal of Engineering Education, 95* (2), 123-138.

Punch, K. (2009). *Intoduction to Research Methods in Education.* Los Angeles: Sage Publications.

Puteh, M.,Ismail, K. (2011). Quality Assurance Through Innovation Policy:The Pedagogical implications. *International Journal of Quality Assurance in Engineering and Technology Education, 1* (1), 66-74.

Puteh, M., Ismail, K., & Mohammad, S. (2010). Project-based Engineering Design Education: A Malaysian Case. *European Journal of Social Sciences, 16* (3).

Ralston, P., & Bays, C. (2010). Refining A Critical Thinking Rubric For Engineering. *American Society for Engineering Education.*

Reed, S. (1998). *http://www.nd.edu/~frhwrite/issues/1998-1999/fa98/Reed.html.* Retrieved 2010 йил May

Reeves, T. C., & Laffey, J. M. (1999). *Design, Assessment and Evaluation of a Problem-Based Learning Environment in Undergraduate Engineering* (Vol. 18(2)). Higher Education Research & Development.

Reidsema, C. (2005). Fostering Creativity Problem Solving and Coloborative Skills Through Impromtu Design in Engineering Design Courses. *4th Global Colloquium On Engineering Education.*

Rhoads, R., Paulson, K., Camphell, S., & Fairweather, J. (1995). *Engineering ojectCoalition of Schools for Excellence in Education and Leadeship Technology Reinvestment Pr.* The Pennsylvania State University, Center for the Study of Higher Education.

Richards, L. (2005). *Handling Qualitative Data: A Practical Guide.* Sage.

Riddell, W., Simone, M., Farrel, S., & Jansson, P. (2008). Communication In A Project Based Learning Design. *American Society of Engineering Education.*

Robson, C. (2002). *Real World Research.* 2nd edition, Blackwell Publishing.

Rubin, H., & Rubin, I. (2005). *Qualitative Interviewing: The Art of Hearing.* Thousand Oaks, California: Sage Publications, Inc.

Ryan, G. B. (2003). *Field Methods : Techniques to Identify Themes.* Sage Publication.

Safoutin. (2000). *A Design Attribute Framework for Course Planning and Learning Assessment.* New York: Institute of Electrical and Electronics Engineers.

Sageev, P. and Romanowski, C.J., A message from recent engineering graduates: results of survey on technical communication skills. *Journal of Engineering Education.,* October 2001, 685-692.

Savage, J. (2000). "Participative observation: Standing in the shoes of others?". *Qualitative Health Research, 10* (3), 324-339.

Savage, R., Chen, K., & Vanasupa, L. (2006). Integrating Project Based Learning Throughout the Undergraduate Curriculum. *American Society of Engineering Educators Pacific Southwest Section Conference.*

Savage, R., Vanasupa, & Stolk, J. (2007). Collaborative Design of Poject-based Learning Courses: How to Implement a Mode of Learning That Effectively Builds Skills For The Global Engineer. *American Society for Engineering Education.*

Savery, J. R. (2006). Overview of Problem-basedLearning: Definitions and Distinctions. *The Interdisciplinary Journal of Problem-based Learning* .

Savie-Baden, M. (2000). *Problem-based Learning in Higher Education : Untold Stories.* Buckingham: SRHE & Open University Press.

Sax, L., Keup, J., Gilmartin, S., Stolzenberg, E., & Harper, C. (2002). *Findings From The 2000 Administration of "Your First College Year" National Aggreagates.* Higher Education Research, Los Angeles.

Schlemer, L., Alptekin, S., & Bangs, K. (2012). Integrating Courses Through Project Based Learning. *Proceedings of the 2012 ASEE PSW Section Conference.*

Scott, G. and Yates, K.W., Using successful graduates to improve the quality of undergraduate engineering programmes. *European Journal of Engineering Education.,* 2002,24,363-378.

Shafie, L., & Nayan, S. (2010). Employability Awareness Among Malaysian Undergraduates. *International Journal of Business and Management* .

Shaker, A. (2007). Active Learning and Reflection in Product Development Engineering Education. *European Journal of Engineering Education, 32* (2), 125-133.

Sharon Yam, L., & Rossini, P. (2010). Implementing a Project-Based Laerning Approach in an Introductory Property Course. *16th Pacific Rim Real Estate Society Conference*, (pp. 1-18). Wellington.

Sheppard, S. (2003). A Description of Engineering: An Essential Backdrop for Interpreting Engineering Education.

Sheppard, S., & Jenison, R. (1997). Examples of Freshman Design Education. *International Journal of Engineering Education, 13* (4), 248-261.

Sheridan, P., Evans, G., & Reeve, D. (2012). A Proposed Framework For Teaching Team Effectiveness In Team-Based Projects. *American Soceity For Engineering Education.*

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET 'Professional Skills' - Can They Be Taught? Can They Be Assessed? *Journal of Engineering Education* , 41-55.

Siaw, I. (2002). Foster Self-Directed Learning Readiness By Way Of PBL Interventions In Business Education. *2nd Asia Pacific Conference On PBL.*

Silverman, D. (2005). *Doing Qualitative Research.* London: SAGE Publications.

Simon, H. (1981). *The Sciences of the Artificial.* Cambridge: MIT Press.

Simon, J. (1996). *The Sciences of the Artificial* (3rd ed.). Cambridge: MIT Press.

Smith, C. (1991). Cases Verses Papers in Design Education. *Design Studies, 12* (4), 268-271.

Smith, K. (2000). Strategies for Developing Engineering Student's Teamwork and Project Management Skills. *2000 ASEE Annual Conference.Session 1630.* ASEE 2000.

Smith, K., Sheppard, S., Johnson, D., & Johnson, R. (2005). Pedagogies of Engagement: Classroom-Based Practices. *Journal of Engineering Education* , 87-101.

Sobek II, D., & Jain, V. (2004). Two Instruments for Assessing Design Outcomes of Capstone Projects. *Conference and Exposition, American Society for Engineering Education Annual Conference.* ASEE.

Sovoie, J., & Hughes, A. (1994). PBL as a Classroom Solution. *Educational Leadership, 52* (3), 54-58.

Spinks, N., Silburn, N., & Birchall, D. (2006). *Educating Engineers for the 21st Century: The Industry View.* Henley Management College for The Royal Academy of Engineering.

Srisiriwat, A. (2010). Assessment Criteria for Undergraduate Engineering Project. *1st International Conference on Technical Education (ICTE2009)*, (pp. 40-44).

Stake, R. (2005). *Qualitative Case Study. In N.K Denzin, & L.Y.S The Sage Hand book Of Qualitative Research.* Sage Publications.

Steffe, L., & Gale, J. (1995). *Constructivism in education.* Hillsdale New Jersey: Lawrence Erlbaum Associates.

Sternbeg, J., & Grigirenko, E. (1995). Styles of Thinking in the School. *European Journal for High Ability, 6*, 201-219.

Steward, R. A. (2007). Evaluating the self-directed learning readiness of engineering undergraduates: a necessary precursor to project-based learning. *European Journal of Engineering Education, 32* (4), 453–465.

Stojcevski, A. (2012). *Learning to Solve 'Design Problems' in Engineering Education.* Retrieved 2012 from www.sefi.be/wp-content/abstracts/1204.pdf.

Stouffer, W., Russel, J., & Oliva, M. (2004). Making The Strange Familiar: Creativity and the Future of Engineering Education. *American Soceity for Engineering Education Annual Conference & Exposition* . ASCE.

Strauss, A., & Corbin, J. (1998). *Basic Qualitative Research: Techniques and Procedures for Developing Grounded Theory.* Thousand Oaks: Sage Publications.

Strobel, J., & Van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-based Learning., 3* (1), 44-58.

Svinicki, M. (2011). *A Guidebook on Conceptual Frameworks for Research in Engineering Education*. Retrieved 2012 from http://cleerhub.org/resources/6.

Swan, B. (1994). A Preliminary Analysis of Factors Affecting Engineering Design Team Performance. *1994 ASEE Annual Conference.* ASEE 1994.

Tam, M. (2000). Constructivism, Instructional Design and Technology: Implication for Transforming Distance Learning. *Educational Technology and Society, 3* (2), 50-60.

Teck, L. (2009). Provide Holistic Development Through Project-Based Learning In Engineering Modules. *5th CDIO Conference.*

Tedford, D., Seidel, R., & Islam, M. (2006). Project and Team Based Learning-An Integrated Approach. *2nd International CDIO Conference*, (pp. 1-14).

Thomas, J. (2000). *A review of research on project-based learning.* San Rafael, CA: Autodesk Foundation.

Thomas, J. W., Mergendoller, J. R., & Michaelson, A. (1999). *Project-based learning : A handbook for middle and high school teachers.* Novato, CA: The Buck Institute for Education.

Thomas, S., & Busby, S. (2003). Do Industry Collaborative Projects Enhance Students'Learning? Education & Training. *45* (4), 226-235.

Thomson, K., & Beak, J. (2007). The Leadership book: Enhancing the Theory-practice Connection Through Project-based Learning. Retrieved December 2012 from http://jme.sagepub.com/cgti/content/abstract/31/2/278.

Todd, R., Sorensen, C., & Magleby, S. (1993). Designing a capstone senior course to satisfy industrial customers. *Journal of Engineering Education, 82* (2), 92-100.

Treagust, D.F., Duit, R., & Fraser, B.J. (1996). Improving Teaching and Learning In Science and Mathematics. New York: Teachers College Press.

Ullman, D. G. (2003). *The Mechanical Design Process* (3rd ed.). Boston, MA: McGraw-Hill.

Venkatesan, S., Molyneaux, T., & Setunge, S. (2007). An evaluation of problem based learning in civil engineering. *ICEER Conference.*

Vogel, D., Wagner, & Ma, L. (1999). Student-Directed Learning: Hong Kong Experiences. *32nd Annual Hawaii International Conference* .

Voland, G. (2004). *Engineering by Design* (2nd ed.). Upper Sadle River, NJ: Pearson/Prentice Hall.

Wallace, K. (1996). *Engineering Education: Changing the System ti Improve the Interface Between the Community and The Profession.* Institution of Engineers, Australia. Changing Culture: Engineering Education Into The Future.

Wallace, K. (2005). *Educating Engineers in Design: Lessons Learnt From the Visiting Professors Scheme.*

Wang, J., Fong, Y., & Alwis, W. (2005). Developing Professionalism in Engineering Students Using Problem Based Learning. *Regional Conference on Engineering Education*, (pp. 1-9). Johor.

Ward, J., & Lee, C. (2002). A Review Problem-based Learning. *Journal of Family and Consumer Sciences Education, 20, 16-26, 20*, 16-26.

WCEC. (2004). *How Does Chemical Engineering Education Meets The Requirement of the Employment.* World Chemical Engineering Council .

Williams, A., & Williams, P. (1994). Problem Based Learning: An approach to Taeching Technology. *Research and Development in Problem Based Learning, 2*.

Willmot, P., & Crawford, A. (2007). Peer Review of Team Marks Using A Web-based Tool: An Evaluation, Engineering Education. *Journal of the Higher Education Academy Engineering Suject Centre, 2* (1).

Woods, D. (1996). *Problem-based learning: helping your studeents gain the most PBL.* Ontario, Canada: Waterdown.

Woods, D., Hrymak, A., Marshall, R., Wood, P., Crowe, C., Hoffman, T., et al. (1997). Developing problem solving skills: The McMaster problem solving program. *ASEE J of Engng Educ, 86* (2), 75-91.

Wurdinger, S., & Rudolph, J. (2009). Teaching Practices that Improve Student Learning: Five Experiential Approaches. *Journal of teaching and learning, 6* (2).

Yilmaz, L. (2008). *Collaborative Technology: Improving Team Cooperation andAwareness in Distance Learning for IT Education.* Chapter 8 in the Handbook ofDistance Learning for Real-time and Asynchronous Information Technology. (Eds.Negash S, Whitman M., Woszczynski A., Hoganson K., Mattord H.

Yin, R. (2003). *Case Study Research: Design and Methods.* Thousands Oak: Sage Publications.

Yusoff, M. (2001). *Penyelidikan Kualitatif: Pengalaman KerjaLlapangan (Qualitative research: experiences from the fieldwork).* Kuala Lumpur: Universiti Malaya Press .

Zaharim, A., Yusoff, Y., Omar, M., Mohamed, A., Muhamad, N., & Mustapha, R. (2009). Perceptions and Expectations Toward Engineering Graduates by

Employers : A Malaysian Case. *WSEAS Transaction On Advances In Engineering Education, 6* (9).

Zhang, Y., & Wildemuth, B. (2009). Qualitative analysis of content. Westport, CT: Libraries Unlimited.

APPENDIX A1 : CLO for Structural Reinforced Concrete Design (DDA3164)

UNIVERSITI TEKNOLOGI MALAYSIA
COLLEGE OF SCIENCE & TECHNOLOGY
(salinan pelajar / pensyarah)

Lecturer :
Room No. :
Telephone No. :
E-mail :

Synopsis : This course presents the introduction to design of reinforced concrete structural elements such as beam, slab, column and footing.

LEARNING OUTCOMES

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

No.	Course Learning Outcome	Programme Learning Outcome(s) Addressed	Taxonomy Level and Generic Skills	Assessment Methods
1.	Describe reinforced concrete design concept	PO1	C1	Test, Exam, Project
2.	Identify and analyse the design loadings	PO3	P3	Test, Exam, Project
3	Analyse the structural elements.	PO1	C4	Test, Exam, Project
4.	Organise and transform architectural drawing into structural layout elements	PO2	P4	Project
5.	Design and sketch structural concrete elements.	PO2	P5	Test, Exam, Project
6.	Respond and think logically to solve problems and make conclusions.	PO3	P4 CTPS1-CTPS3	Test, Exam, Project
7	Communicate clearly and effectively in oral and/or written forms.	PO4	P4 CS1-CS3	Project
8.	Work collaboratively as part of a team	PO5	A3 TW1-TW3	Project
9.	Acquire and manage knowledge for further study.	PO6	A3 LL1-LL2	Not Assess
10	Demonstrate and understanding of professional and practise ethical value.	PO8	A3 ET1-ET3	Project

APPENDIX A2 : CLO for Structural Reinforced Concrete Design (DDA3164)

COURSE OUTLINE

Department & Faculty: Dept. of Civil Engineering *UTMSPACE*	Page : 2 of 4
Course Code: Reinforced Concrete Design (DDA 3164) Contact Hours: 56 Hours	Semester: 2 Academic Session: 2011/2012

STUDENT LEARNING TIME

Teaching and Learning Activities.	Student Learning Time (hours)
1. Face-to-Face Learning	
a. Lecturer-Centered Learning	
I. Lecture	28
b. Student-Centered Learning	
I. Tutorial	28
II. Student-Centered Learning activities	-
2. Self-Directed Learning	
a. Non Face-to-Face or Non Student-Centered Learning (SDL) such manual, assignment, module, e-learning	40.5
b. Revision	20
c. Assessment Preparations	8
3. Formal Assessment	
a. Continuous Assessment	3
b. Final Exam	2.5
Total (SLT)	120

TEACHING METHODOLOGY
Lecture and Discussion, Co-operative Learning, Independent Study

WEEKLY SCHEDULE

Week 1 : 1.0 **Introduction**
- Design concrete concepts and principles
- Concrete compressive strength
- Reinforcement tensile strength

Week 2 : 2.0 **Design of beam**
- Flexural strength of section
- Singly reinforced section

Weeks 3 : 3.0 **Design of beam**
- Flexural strength of section
- Doubly reinforced section

APPENDIX A3 : CLO for Structural Reinforced Concrete Design (DDA3164)

COURSE OUTLINE

Department & Faculty: Dept. of Civil Engineering *UTMSPACE*	Page : 3 of 4
Course Code: Reinforced Concrete Design(DDA 3164) Contact Hours: 56 Hours	Semester: 2 Academic Session: 2010/2011

Weeks 4 : **4.0 Design of beam**
- Shear strength of sections
- Design of links.

Weeks 5 : **5.0 Design of beam**
- Check for deflection
- Detailing of Sections

Weeks 6 : **6.0 Design of slab**
- Solid slabs spanning in one direction

Weeks 7 : **7.0 Design of slab**
- Solid slabs spanning in two direction

Test 1

Weeks 8 SEMESTER BREAK

Weeks 9 : **8.0 Design of slab**
- Restraint slabs.
-

Weeks 10 : **9.0 Design of column**
- Short and slender column
- Reinforcement details.

Quiz 2

Week 11 **10.0 Design of column**
- Short and slender column
- Reinforcement details

Week 12 **11.0 Design of footing**
- Pad footing
- Reinforcement details.

Test 2

APPENDIX A4 : CLO for Structural Reinforced Concrete Design (DDA3164)

COURSE OUTLINE

Department & Faculty: Dept. of Civil Engineering *UTMSPACE*	Page : 4 of 4
Course Code: Reinforced Concrete Design (DDA3164) Contact Hours: 56 Hours	Semester: 2 Academic Session: 2010/2011

Week 13 **12.0 Design of footing**
- Double footing
Reinforcement details.

Week 14 **13.0 REVISION WEEK**

Week 15 14.0 REVISION WEEK

Week 16 STUDY LEAVE

Week 17 - 19 Final Exam

REFERENCES : **Courses Notes:**

W.M.C. McKenzie (2004) Design of structural Elements, Palgrave Macmillan

Other References:
1. BS8110 Part 1, 1997, *Structural use of concrete*, British Standard Institution, UK

GRADING

No.	Assessment	Number	% each	% total	Dates
1	Test	2	15	30	
2	Project	1	20	20	
3	Final Exam	1	50	50	
	Overall Total			100	

APPENDIX B : Schedule of the field project in DDA3164

Week		Description	Remarks
	15/12/10	Green Card Application for students to CIDB	Completed
Week 1	05/01/11	Introduction and briefing to students: Scheme, Student Team Formation, Company Allocation	
Week 2	13/01/11	OFFICE VISIT: 2.30pm-5.30pm Project: Design a 2-storey bungalow. Tutorials with design consultant: Introduction to Design of Reinforced Concrete Project.	1. Students prepare Reflexive Journals. 2. Observation on field PjBL by Researcher
Week 3	19/01/11 20/01/11-Thaipusam	TASK 1 and TASK 2 : Lecturer-assisted Transformation of architectural drawings into structural layouts and specifications of building	
Week 4	27/01/11	OFFICE VISIT : 2.30pm-5.30pm Co-taught by practitioner Structural layout using AUTOCAD	1.Students prepare Reflexive Journals. 2.Observation on FPjBL by Researcher
Week 5	02/02/11	MID SEMESTER BREAK	01/02/11-H.Wilayah 03-04/02/10 – Chinese New Year
Week 6	10/02/11	TASK 3 : Lecturer assisted Determine Loadings for the building Structural analysis	
Week 7	16/02/11	OFFICE VISIT: 2.30-5.00pm TASK 4: Co-taught by practitioner Design beam, slab, column and footing	1. Students prepare Reflexive Journals. 2.Observation on FPjBL by Researcher
Week 8	23/02/11	OFFICE VISIT: 2.30pm-5.30pm CONTINUE TASK 4: Co-taught by practitioner Design beam, Slab, Column and Footing	1.Students prepare Reflexive Journals. 2.Observation on FPjBL by Researcher
Week 9	03/03/11	Continue TASK 4	
Week 10	10/03/11	TASK 5: Lecturer assisted Detailing of structural elements	
Week 11	17/03/11	OFFICE VISIT : Co-taught by practitioner Continue Detailing of structural elements	1. Students prepare Reflexive Journals. 2.Observation on FPjBL by Researcher
Week 12	23/03/11	Consultation of project	
Week 13	31/03/11	Consultation of project	
Week 14	07/04/11	Submission of project	

APPENDIX C : Validation By Expert

Name: MOHAMED ZAHRY OTHMAN

Signature: Zahry

MOHAMED ZAHRY BIN OTHMAN
Head Department of Civil Engineering
Centre for Diploma Studies
SPACE
Universiti Teknologi Malaysia Kuala Lumpur
Jalan Semarak, 54100 Kuala Lumpur

Designation/Expertise: Civil Engineering

Experience: 27 years

APPENDIX D : Consent Form of Student Participation

TITLE OF PROJECT : Project-based learning(PjBL) to enhance design ability of structural design of civil engineering students

SUPERVISOR : Associate Prof Dr. Marlia Puteh

RESEARCHER : Kamsiah Mohd Ismail

I have read and understood the information provided about this research project dated ______________________________________.

I have had the opportunity to ask questions and to have them answered.

I understand that the interview to be audiotaped and transcribed.

I understand that I may withdraw myself or any information that I have provided for the project at any time prior to completion of the data collection, without being disadvantaged in any way.

If I withdraw, I understand that all relevant tapes and transcripts, or parts thereof, will be destroyed.

I agree to take part in this research.

Participant's signature

____

Participant's name

____

Participant's contact details :

Date :

APPENDIX E : Interview Guide/Questions

Date :
Start :
End :
Venue :

1	What is your goal in FPjBL? What skills (abilities) do you to learn from project? What kind of knowledge?
2	What kinds of knowledge you need for design project? What knowledge you want to get from FPjBL in design? For example, when you analyze the tasks, what do you do?
3	What are the things you consider, before you do/start your design project?
4	In what way that this project has help you in your design knowledge and skills? To what extent has this project contribute to your learning in this course?
5	Do you try to relate ideas in design project to those in other courses? Do you try to relate materials you already know in design project?
6	How do you approach/strategize the problems in project? Give examples: how you make decision/justification in your project? Do you pull important information from different sources for your project? e.g. readings, discussions and lectures
7	Please comment for having the project at consulting firm? How successful are you in your project? Rate yourself 1-10
8	How do you collaborate with others in project? Advantages/disadvantages working in a team?
9	How do you describe yourself after completing the task/project ? Do you feel happy? Motivated? Are you interested more in structural design?
10	What are your difficulties in this project? Suggest ways to improve/enhance this project.
11	Please comment on the social and professional ethics in your project?
12	Relate this project in your future career. What is your opinion on the project at consulting firm?

APPENDIX F : Validation By Expert

Instrument Validation by Expert

I hereby acknowledge that the instruments designed and adapted by **Kamsiah Mohd Ismail** from Universiti Teknologi Malaysia International campus has been checked and ready for validation. Thank you.

Signature :

Full Name : MOHAMAD SALLEH BIN YASSIN

Designation : SENIOR LECTURER

Years of Experience in Teaching : 21 YEARS

Name and Address of Employer : CIVIL ENGINEERING FACULTY
UNIVERSITI TEKNOLOGI MALAYSIA
SKUDAI

APPENDIX G : Verification Of Translation To English

Instrument Validation by Expert

I hereby acknowledge that the transcriptions translated by **Kamsiah Mohd Ismail** from Universiti Teknologi Malaysia International Campus have been checked and are ready for validation. Thank you.

Signature : [signature]

Full Name : Norazmah Suhailah bt Abd Malek

Designation : English language lecturer

Years of Experience in Teaching : 15

Name and Address of Employer : Language Academy
UTM Kuala Lumpur Campus
Jalan Semarak
54100 Kuala Lumpur

Stamp of Employer : **Language Academy**
UTM International Campus
54100 Jalan Semarak
Kuala Lumpur

APPENDIX H : Observation Guide

Item	Descriptions of activity	Observation categories
1	Content Knowledge	1.Integration of new knowledge 2. Interdisciplinary knowledge 3. Relationship between theory and practice 4. Collaborative learning
2	Problem Solving	1. Open and ill-defined problems 2. Lectures 3. Problem projects 4. New problems
3	Professional Skills	1. Teamwork 2. Collaborative learning 3. Individual learning 4. Construction of their own knowledge
4	Motivation and engagement on students' learning	1. Thoughts and behaviours 2. Adaptability 3. Student's personal bests 4. Ability to deal with setbacks and pressure 5. Effort/strategy/attitude
5	Engineer's facilitation	1. Engineer's role
		2. Engineer's skills
6	Assessment and evaluation	1. Individual
		2. Group
		3. Lecturer

APPENDIX I : Letter of Authorization from Industry

Our Ref: ALA/ADM_T/19241
3 January 2011

AZMAN, LIM & ASSOCIATES SDN BHD
211312-P

"TO WHOM IT MAY CONCERN"

Dear Sir/Madam,

FIELD PROJECT-BASED LEARNING FOR UTM STUDENTS

I am very delighted to allow some civil engineering students from UTM to do structural design practical training at my company from 13 January to 23 February 2011. This is as part of the company obligation towards society and the company will assign one professional engineer for the purpose.

I hope that the students can be exposed to some valuable skills that they are learning with regard to structural reinforced concrete design work.

Thank you.

Yours sincerely,
For **AZMAN LIM & ASSOCIATES SDN. BHD.**

Ir. Dr. Azman bin Ahmad
Director

APPENDIX J : Observation Checklist

	S1-M	S2-J	S3-D	S4-Z	S5-SH	S6-WN	S7-WS	S8-S
Cooperating								
Dependent								
Exploring								
Helping others								
Independent								
Initiates activity								
Reading/demonstrating								
On-looker								
Participating								
Requesting help								
Uncooperative								
Uninvolved/wandering								
Using materials appropriately								
Using appropriate manners								
Waiting								
Student showed interest in what she/he was learning								
Students offered prior knowledge								
Students make connections								
Student listened when others explained								
student shared thought during group discussion								
Student shared new information learned during discussion								
Student responded to questions to new information								
Other notes								

S1-S8 are the codes given to the respective students

APPENDIX K : Expert Validation (Peer Validation)

Instrument Validation by Expert

I hereby acknowledge that the instruments designed and adapted by **Kamsiah Mohd Ismail** from Universiti Teknologi Malaysia International campus has been checked and ready for validation. Thank you.

Signature :

Full Name :

ASSOC. PROF. ABDUL MUTA'ALI OTHMAN
Head of Industrial Design Dept.
UTM RAZAK School of Engineering and Advanced Technology
Universiti Teknologi Malaysia International Campus
Jalan Semarak,
54100 Kuala Lumpur.
Tel: 03-2615 4514 Fax: 03-2693 4844

Designation :

Years of Experience in Teaching : 27 YEARS

Name and Address of Employer :

APPENDIX L : Self-reflection for journal entry

Name:

Reflect on field project-based learning in structural design course you just completed and answer the questions. Let your answers be short and clear. Be self-critical, but also do not forget to praise yourself where needed!

How satisfied are you with the field project-based learning? How far did you reach your goals? How do you know? How much progress you are making?
If you are making a fantastic progess---give yourself a 5
If you are making some progress, but still get confused sometimes---give yourself a 3
If you still don't have the skill or knowledge---give yourself a 1

What did you do in the field project-based work? List activities regarding knowledge, values and skills. Be brief and precise.

Knowledge :
Values :
Skills :

How did you feel during the field project-based work (e.g. were you interested, bored, relaxed…)?How do you know? How much was this due to methods used and how much due to yourpersonality?

What did you learn and what is the evidence?

I HAVE LEARNED	PROOF

How effective were the field project-based approaches and methods for reaching your goals and for any progress made by you? How could you change or improve them?

APPROACH/METHOD	IMPROVEMENTS

List highlights of the project-based field work. Why do you consider these to be highlights?

HIGHLIGHTS	REASON

For your teamwork/group only:
How was the cooperation with your team members?
How did you plan and perform the design project?
Evaluate your part and your partner's part of the process?
What difficulties did you encounter?

Try to identify 5 different types of problems do you think exist in design project?
Identify 5 ways in which teamwork could impact upon how you solve your problem?
Do you enjoy participating in field work for this project-based design? Why or why not? Have you ever felt a benefit from being physically active in university? (i.e. more energy in the afternoon, better concentration, etc.)
Have you ever been influenced by peer pressure? Are you influenced by your friends and/or the media to make good or bad choices about design? Explain.
Suggest changes for the project-based learning for future use.

APPENDIX M : Sample of Test

DDA 3164

TEST 1
SEMESTER 2 – SESI 2006/2007
DESIGN OF REINFORCED CONCRETE

Q1. A rectangular beam with b = 200 mm and d = 400 mm is provided with As = 1257 mm^2 on the tension side only. Determine the maximum ultimate moment capacity of the section if f_y = 460 Nmm^2 and f_{cu} = 30 N/mm^2. (5 marks)

Q2. Determine the main reinforcement required for a rectangular section of 300 mm width and 600 mm effective depth, if the ultimate moment to be resisted is 320 kNm. Assume f_{cu} = 35 N/mm^2 and f_y = 460 N/mm^2
Indicate the reinforcement on the cross-section. (10 marks)

Q3. A beam of rectangular section is reinforced with 6 Nos. 20 mm diameter bars in tension and is supported on an effective span of 5.0 m, the beam being 300 mm wide and 700 mm effective depth. The beam carries a uniformly distributed design load of 42 kN/m. Design the shear reinforcement considering only 3 T 20 is provided near support reactions.

Data:

f_y = 460 N/mm^2
f_{cu} = 35 N/mm^2
f_{yv} = 250 N/mm^2
Assume 8 mm diameter links.

Sketch the reinforcement on the cross-section and the elevation. (15 marks)

Total: 30 marks.

APPENDIX N : Sample Final Examination 1/5

UNIVERSITI TEKNOLOGI MALAYSIA
PROGRAM PENGAJIAN DIPLOMA
PROGRAM KERJASAMA

FINAL EXAMINATION
(PEPERIKSAAN AKHIR)
SEMESTER I – SESSION 2007 / 2008

SUBJECT CODE *(KOD MATA PELAJARAN)*	:	DDA 3164
NAME OF SUBJECT *(NAMA MATA PELAJARAN)*	:	DESIGN OF REINFORCED CONCRETE/ *REKABENTUK KONKRIT BERTETULANG*
NAME OF COURSE *(NAMA KURSUS)*	:	DIPLOMA IN CIVIL ENGINEERING
DURATION *(TEMPOH)*	:	3 HOURS
DATE *(TARIKH)*	:	DEC 2007

INSTRUCTIONS:
(ARAHAN):

1. **Answer all questions .**
(Jawab semua soalan)

2. Candidates are required to follow all instructions given out by the examination invigilators.
(Calon dikehendaki mematuhi semua arahan dari penyelia peperiksaan)

REMINDER :
(PERINGATAN)

Examination invigilators may bar, or take action against, any candidate who does not adhere to the regulations stated on page 2.
(Penyelia peperiksaan boleh menahan, atau bertindak terhadap calon yang tidak mematuhi peraturan yang dinyatakan pada muka surat 2.

This examination paper consists of ...8.... pages including the front cover.
(Kertas soalan ini terdiri dari ...8.....muka surat termasuk muka hadapan)

APPENDIX O : Sample Final Examination 2/5

Q1. A typical floor plan layout of a multi-storey apartment building as shown in Figure Q1 is provided with continuous beams. The concrete slabs are cast integrally with the supported beams.

Given the data below :

Live load	=	4.0 kN/m^2
Finishing	=	1.0 kN/m^2
Thickness of slab	=	150 mm
f_{cu}	=	30 kN/m^2
f_y	=	460 kN/m^2
f_{yv}	=	250 kN/m^2
Density of concrete	=	24 kN/m^3
Size of all beam	=	225 x 450 mm
Diameter of tension reinforcement	=	20 mm
Diameter of shear reinforcement	=	10 mm
Cover	=	30 mm

i. Design all the main reinforcement for beam 3/A-D.
ii. Design the shear reinforcement for span A-B only.
iii. Check for deflection and cracking.
iv. Sketch the detailing for beam 3/A-D.

APPENDIX P : Sample Final Examination 3/5

Q2. Refer Figure Q1 .

i. Determine the design load (kN/m^2) for slab.
ii. Using 10 mm diameter reinforcement bar, design all the reinforcement for the panel slab. Design as continuous one-way slab. Assume slab cover 20 mm.
iii. Check the shear, deflection and cracking.
iv. Sketch the detailing.

Rujuk Rajah Q1,

i. Tentukan beban rekabentuk (kN/m^2) untuk papak.
ii. Menggunakan tetulang berdiameter 10 mm, rekabentuk semua tetulang untuk panel papak. Rekabentuk sebagai papak selanjar satu hala. Anggap penutup papak 20 mm.
iii. Semak ricih, pesongan dan keretakan.
iv. Lakarkan perincian.

(30 marks/*markah*)

Q3.(a) Figure Q3(a) shows a column section 400 mm x 450 mm. Using the data given

f_{cu} = 30 N/mm^2
f_y = 460 N/mm^2
N = 1650 kN
M_x = 110 kNm
M_y = 95 kNm

i. Determine the main reinforcement.
ii. Determine the suitable links.

Rajah Q3(a) menunjukkan keratan sebatang tiang 400 x 450 mm. Menggunakan data yang diberikan

f_{cu} = 30 N/mm^2
f_y = 460 N/mm^2
N = 1650 kN
M_x = 110 kNm
M_y = 95 kNm

(15 marks/*markah*)

APPENDIX Q : Sample Final Examination 4/5

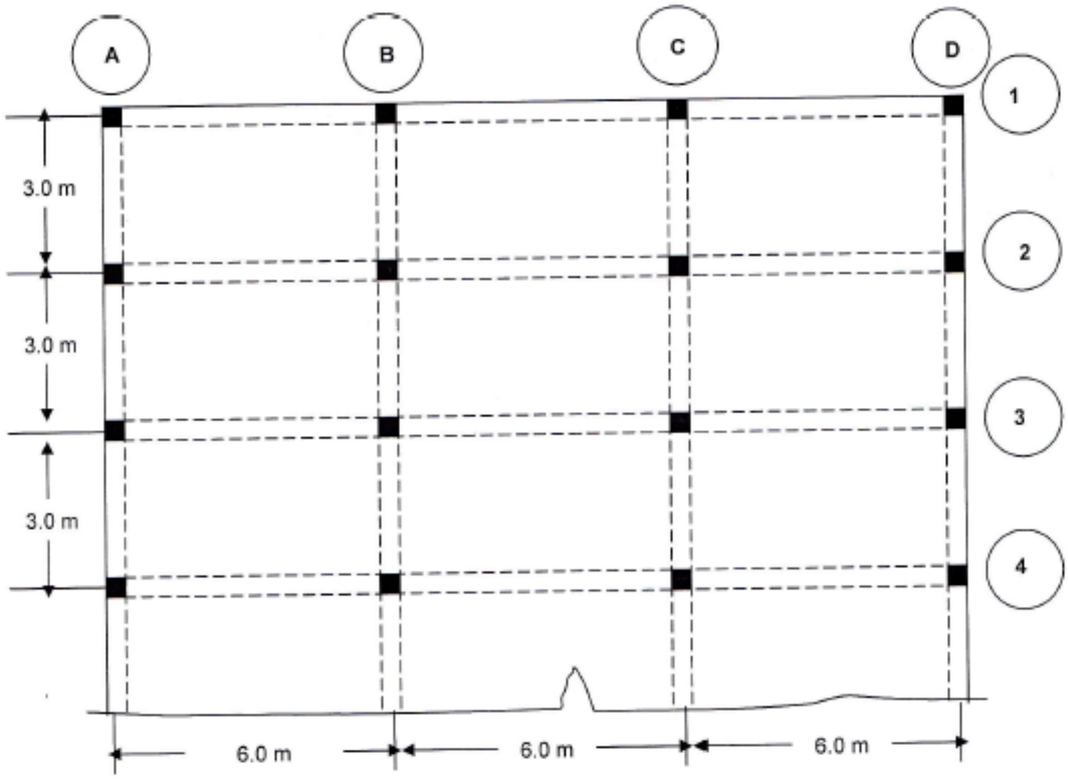


Figure Q1/ *Rajah Q1*

APPENDIX R : Sample Final Examination 5/5

- 8 -
DDA 3164

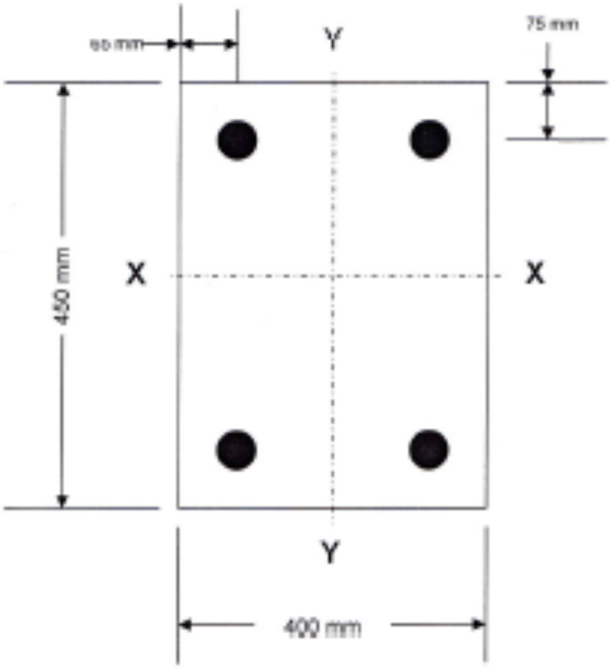


Figure Q3(a)/ *Rajah Q3(a)*

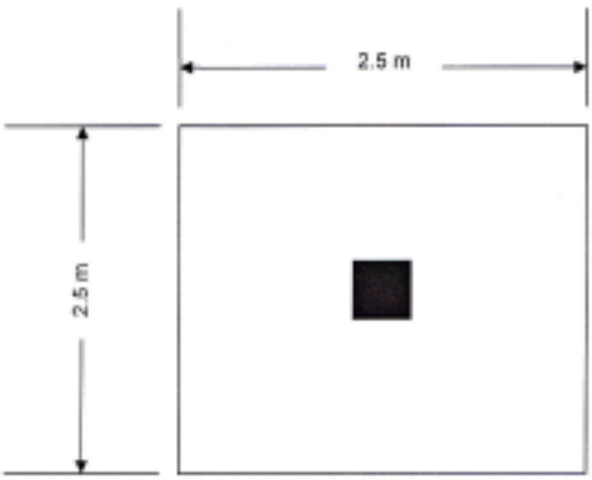
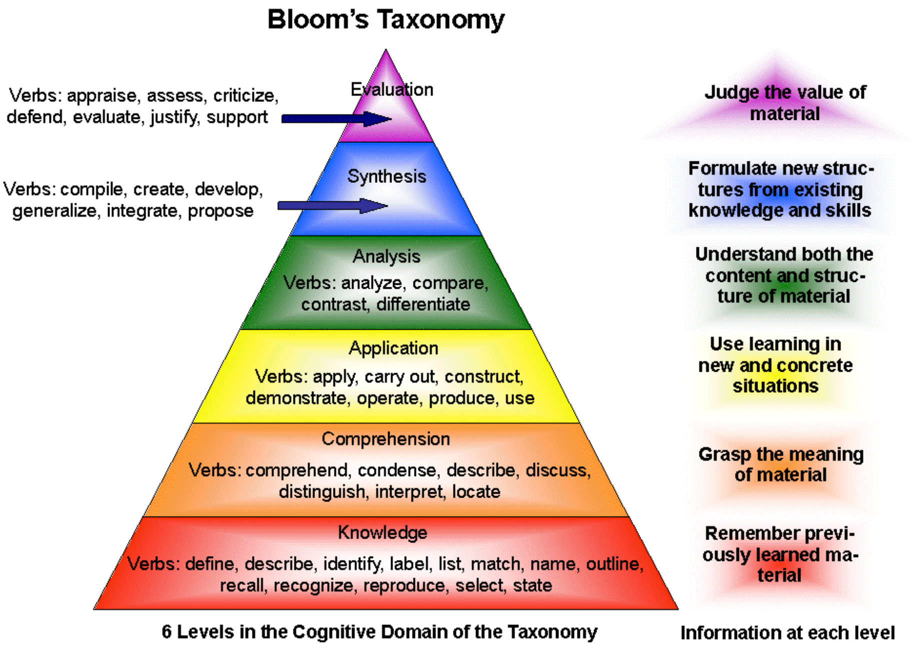
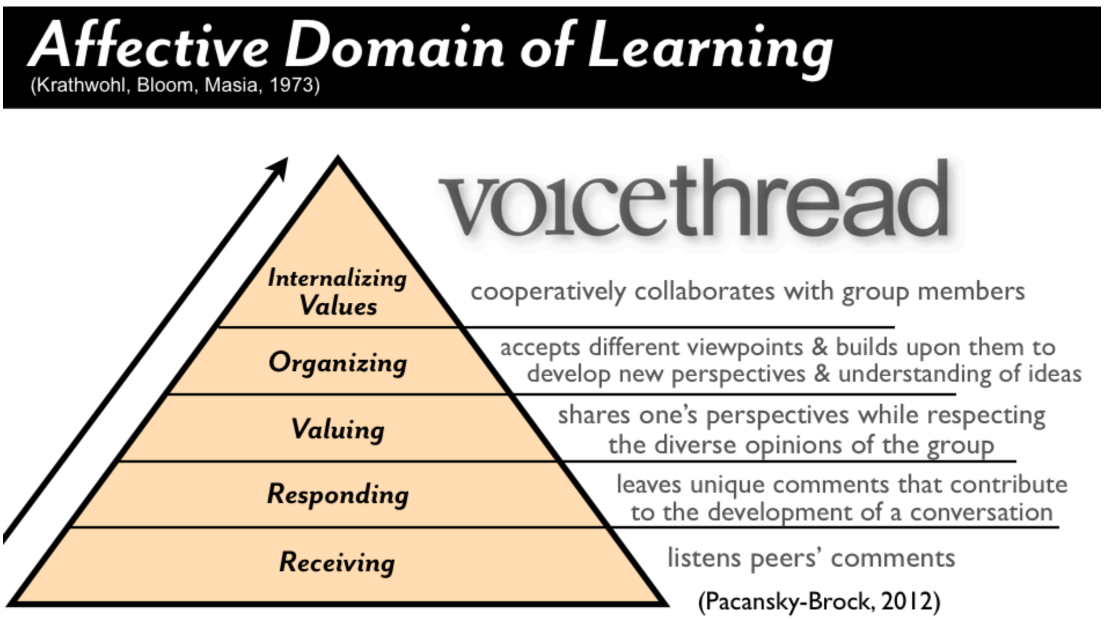


Figure Q3(b)/ *Rajah Q3(b)*

APPENDIX S : Bloom's Taxonomy (Cognitive and Affective Domain)





APPENDIX T : Bloom's Taxonomy (Psychomotor Domain)

Level	Verb
1. Receiving	to differentiate, to accept, to listen (for), to respond to
2. Responding	to comply with, to follow, to commend, to volunteer, to spend leisure time in, to acclaim
3. Valuing	to increase measured proficiency in, to relinquish, to subsidize, to support, to debate
4. Organization	to discuss, to theorize, to formulate, to balance, to examine
5. Characterization by value set	to revise, to require, to be rated high in the value, to avoid, to resist, to manage, to resolve

APPENDIX U : Lists of Journals and Conference Papers

1. Puteh, M**., Ismail**, K.M, & Mohammad, S. (2010). Project-based Engineering Design Education: A Malaysian Case. *European Journal of Social Sciences* , 16 (3).

2. Putih, M., &**Ismail, K. M** (2011). Quality Assurance Through Innovation Policy:The Pedagogical implications. *International Journal of Quality Assurance in Engineering and Technology Educatio*n , 1 (1), 66-74.

3. Ismail, K. M, Puteh, M., & Mohammad, S. (2009). A Preliminary Study On The Learning Style Of Civil Engineering Students in Malaysia*. International Conference On Engineering Education*(ICEED 2009).

4. K**.M.Ismail**and Puteh, M (2008). Engineering Technology: A Malaysian Case. *INEER*, Budapest

5**. Ismail, K.**M and Puteh, M, (2009). *International Conference On Engineering and Education*. Kuala Lumpur

6. N. M. Nor, N. Rajab and **K.M. Ismail**(2009) . Educating the Engineer of 2020: Malaysian Scenario. *INEER*, Budapest.

APPENDIX V : PjBL Engineering Design Education – A Malaysian Case

European Journal of Social Sciences – Volume 16, Number 3 (2010)

Project-based Engineering Design Education: A Malaysian Case

Marlia Puteh
Universiti Teknologi Malaysia International Campus Kuala Lumpur, Malaysia
E-mail: marlia@ic.utm.my

Kamsiah Mohd Ismail
Civil Engineering Department, Universiti Teknologi Malaysia
International Campus Kuala Lumpur, Malaysia
E-mail: kamsiah@ic.utm.my

Shahrin Mohammad
Civil Engineering Faculty, Universiti Teknologi Malaysia, Skudai Johor, Malaysia
E-mail: shahrin@utm.my

Abstract

Project –based learning approach is directly related to the application of knowledge as part of an effort to prepare graduates for their professional practice. In response to the evolving nature of engineering design and the integration of new ideas into existing system, the development of projects is placed as an important aspect of engineering. This is due to the fact that it offers students the opportunity to apply fundamental engineering concepts to real life activities, hence assist them to better grasp the engineering theories. This has raised several questions on the implementation of project-based approach in the engineering curriculum. To what extent has the project contribute to students' learning outcome? What types of problems does the faculty experience when utilizing this teaching method? What are the students' expectations on the project element in their studies? This paper evaluates the implementation of a Reinforced Concrete Design course in a civil engineering undergraduate program. Specifically, it will examine the project-based learning which is integrated as the course component. Views from the teachings staff in implementing the design project will be reported and students' perceptions of the project component is investigated and further analysed. The research will contribute to the growing discussions on the diverse approaches employed in the teaching and learning of engineering design courses.

Keywords: Project-based approach, engineering education, engineering design, self-directed learning

1. Introduction

'Cries' from industries when receiving the graduate engineers from higher learning institutions must be dealt with if higher education institutions are serious about supplying creative and innovative engineering workforce for the 21st century. Hence, there is a grave need to improvise the engineering education pedagogies to accommodate the demands from industries. This issue must not be taken lightly as a decade ago, Felder at.al has warned us of the non-progressive kind of teaching approach applied in the engineering programs. According to the authors, "…many engineering classes in 1999 are taught in exactly the same way that engineering classes in 1959 were taught" (Felder et.al, 2000, pp. 26). Indeed, this is a shocking revelation. What has engineering educators been doing for the past forty years? Mills and Treagust (2003) further criticized that "the existing teaching and learning strategies…in engineering programs is outdated and needs to become more student-centered" (pp. 4). This has prompted a number of researchers (Doppelt et al, 2008; Dym et.al, 2005; Gao et. al, 2008; Smith et.al, 2005; Thomas & Busby, 2003) to work on identifying the most suitable and affordable teaching approach applicable for engineering education worldwide.

The emphasis on student-centered learning has succeeded in facilitating the quest for alternative teaching and learning approach which exposes students to constructivist learning (Tam, 2000). Learner-centered constructivist approaches is currently a prerequisite for an accredited engineering degree programme by the Board of Engineers, Malaysia (BEM) and the Malaysian Qualification Agency (MQA). The MQA also stressed that graduates should demonstrate and achieve a set of specified learning outcomes in preparing for future employment. This is in line with the elements of the engineering criteria outlined by the Accreditation Board for Engineering and Technology (ABET, 2001). ABET requires that engineering programs must formulate, among others, the program educational objectives, a set of program outcomes and course learning objectives for accreditation purpose (Felder & Brent, 2003).

2. Project-based Approach in Engineering

In view of the importance of fostering self-directed learning, this paper examines the implementation of project-based learning in design education. In the United States, design-based learning is embedded in the curriculum initiatives in the science education reform for K-12 education. The US National Centre for Engineering and Technology Education, for example, has introduced engineering design for K-12 curriculum in order to instill design education which involves problem solving and analytical skills for K-12 students through technology education (Hailey et.al, 2005). As feeders to engineering schools in higher institutions, there is much pressure for design and technology education to play a crucial role in the K-12 curriculum, hence the introduction of Design-Based Learning (DBL). According to Doppelt et al (2008: pp 2), "DBL provides a reason for learning the science content by engaging the student in design and using a natural and meaningful venue for learning both science and design skills."

How important is engineering design to engineering education? Engineering design is critical to engineering education as according to Dym and Little (2004: pp 7), "engineering design is the organized, thoughtful development and testing of characteristics of new objects that have a particular configuration or perform some desired functions that meets our aims without violating any specified limitations." The authors also argued that engineering design necessitates a creative process which requires techniques and tools in managing a design project. This highly requires a proper project management tools which involves the *work breakdown structure* to determine the scale of the project and the *linear responsibility chart* to establish the human resources responsible to accomplish the project (Dym & Little, 2004: pp 157). This paper attempts to address critical issues related to the practice of engineering design education particularly the accomplishment of project-based learning approach to enhance the design ability in undergraduate civil engineering.

There are several reasons that rationalize the application of project-based approach in engineering programs. Firstly, project tasks are closer to professional reality (Mills & Treagust, 2003) and relate to the fundamental theories and skills of an engineer. Secondly, almost every task in an engineering profession involves the development of projects bearing the differences in time scales and levels of complexity. Not only that, project component also address critical issues of engineering education as it fosters student-centered learning, promote team working, communication and problem solving skills (Gao et. al, 2008; Prince & Felder, 2006; Sheppard & Jenison, 1997). Therefore, successful completion of projects requires the integration of all areas of undergraduate training which an engineer has been exposed to. However, there are many challenges facing the faculty which is keen in implementing project-based approach in design education.

3. Challenges in Implementing Project-based Approach

Instructors face a number of challenges in their implementation of student-centered instruction vis-a-vis project-based approach. Firstly, project approach is implemented in a variety of ways which Heitmann (1996) referred as "project-oriented studies" and "project-organised curriculum." This diversity in implementation has brought about the increased number of projects in individual courses and the instigation of projects throughout the curriculum as mooted by the CDIO model respectively. The latter is introduced recently and has a number of standards (Crawley, 2001). The diversity in itself is not a problem but implementing them is an issue as "project-oriented studies" depends very much on individual instructor whereas "project-organised curriculum" is a faculty-wide effort and requires substantial funding and cooperation from institutional leaders.

Secondly, Gibson (2000) has warned that project-based learning is not effective with large classes. Limited faculty funds and facilities as well as lack of devoted engineering lecturers who are willing to engage in project design have affected the ratio of students in most engineering classes, resulting in large number of students in engineering courses. Faculties have to tolerate these numbers and are challenged to develop realistic students' projects especially for classes with considerable number of students. Not only that, project-based instruction is also very dependent on the creativity of individual instructors and this caused problems especially with new lecturers who have not been exposed to the requirements and issues in project design.

Finally, in its attempt to produce human resource for the innovation-led economy, higher learning institutions are challenged to promote innovative thinking and creative experimentation of future engineers. Engineering projects can provide this expertise as activities that engage scientific development generally originate from the engineering field (Ashford, 2004). This research attempt to investigate the expectations of the students on the project component in their studies, the role of previous courses in assisting the implementation of project-based approach and the types of problems faced by faculty members and the challenges when implementing project-based education in engineering education.

4. Reinforced Concrete Designs at Universiti Teknologi Malaysia

44 students from the Civil Engineering faculty in UTM answered a short survey on their perception of project-based learning carried out in the faculty. 11 short open-ended questions were given to gauge their views on the project components in RC1 and RC2. In addition, two instructors were interviewed to evaluate their problems and challenges when implementing project-based learning in their teaching.

The discussions below are constructed from faculty academic guides, program and course information available on the faculty website, responses from students and instructors on various issues in lieu with the implementation of the courses.

This research is aimed at soliciting responses of students on two Reinforced Concrete Design course offered at the Civil Engineering Faculty of UTM. Firstly, Reinforced Concrete Design I (RC1) aims at providing students with the understanding and ability to analyse and design structural elements. Secondly, Reinforced Concrete Design II (RC2) aims at exposing students to a wider scope of reinforced concrete design and act as a sequel to the Reinforced Concrete Design I. RC1 is the pre-requisite for RC2. Preparation of structural design reports, drawing plans and detailing are covered in both design courses.

The introduction of RC1 and RC2 transpired due to the open-ended and ill-structured design problems that are common in the Malaysian setting. Students are required to work in small teams in solving design problems created by non-profit clients. The project works encompass lectures and reading on design theory and methods, project management techniques as well as engineering ethics. RC1 and RC2 are conducted with a total of 6 credit hours and currently do not provide much exposure to design concepts in the curriculum. Therefore, it is difficult to determine the amount of 'significant design' in these courses as per ABET requirement.

4.1. Current Course Structure and Contents

Numerous changes have been made to both courses since its introduction in 1975. However, the underlying emphasis on project-based teaching has remained unchanged. The recent curriculum review exercise has revised the structure and format of the course to meet the requirement of the accreditation board i.e. Institute of Engineers Malaysia, as well as the Malaysian Qualifications Agency. Attempts have been made to improvise the current course contents to prepare students for the engineering practice at the professional level. However, to date no comprehensive study has been carried out to determine suitable courses for undergraduate engineering degree programs. This has resulted in difficulties in benchmarking the course structure and contents of existing engineering undergraduate degree program.

RC1 and RC2 are divided into theory and practical classes. These courses consist of 2-hour lecture and 2-hour practical training. The learning goal is to enable the students to describe, analyze, design and organize the project individually and in a team. Students are given a project and exercises. The lecturer delivers and controls the content. These courses are in the form of project-assisted learning and have been practiced over many years. The implementation of project-based learning is carried out by individual courses within the traditional engineering program. The project-based approach is carried out in a class size of 40 to 60 students with one instructor in charge to monitor students' learning and assessment. The lecturer is also the supervisor to the students' project. The students work in groups of 4 to 6 assigned by the lecturer.

One of the common features of project-based learning courses is the oral presentation. The oral presentation component is not applied in RC1 and RC2 because it contributes to only a portion of the total learning outcome. Hence, for the purpose of this paper, oral presentation is not analysed. Project reports are used instead. Students have been reported to be highly motivated and have also succeeded in demonstrating better teamwork and communication skills as well as the application of their knowledge. The following section will discuss this issue further.

4.2. Project Supervision

Currently, it is rather too much to handle for the instructors with 40-60 students in a class. Normally with 60 students per section; the class is broken up into 12 groups with 5-6 students in a group. Regular meetings with students are conducted during the 2-hour tutorial classes which are mainly allocated for the projects.

4.3. Project Report Assessment

At UTM, project report is widely used as part of project-based learning in Reinforced Design. The course learning outcome is to organize the project in a team and to produce design report within a stipulated time frame. There is no standard marking scheme for projects as it depends on individual instructor. The 15% weight given to the projects depend on the instructors' own understanding and discretion. For example, a lecturer has allocated the marks for project based to include the ability of the students to analyse possible design structures, to demonstrate some elements of creativity and to manage working in a team, whereas other instructors do not use the same format of assessment. This has resulted in the students performing well in their design projects but failed to show equivalent accomplishment in their assignments and tests.

5. Discussion

Having discussed the current implementation of both the Design courses, the following sections reports on the extent to which the project has contributed to the students' learning outcomes. It elaborates on the responses of the students and the views of the instructors on the following issues:

5.1 Expectations of students and instructors in project-based approach
5.2 Role of previous courses
5.3 Challenges faced by instructors and faculty management in project-based approach

Elaborations are based on the excerpts of the open-ended survey given to the students and interview excerpts from the instructors. Some of them answered in the Malay language and their responses have been translated by the researchers. In the case of English responses, the structure and grammar are retained to protect the originality of the responses. The students and the instructors are given codes to safeguard their identities and to retain confidentiality.

5.1. Expectations of Students and Instructors in Project-based Approach

Below are some expectations of students and instructors in regards to the project component introduced in the Design course. For the purpose of authenticity, the grammatical structures of the responses are retained to avoid misinterpretation of the comments.

Several students anticipated that the project component could **prepare them for the actual working environment**. They expected to:

...be very prepared to be an engineer (esp. in designing) (S13)

...apply all the knowledge gathered into the project assignments given to me when I enter the working field (S14)

...increase my knowledge in Concrete Design and to assist me in my future work (S32)

A number of students have high hopes that the projects would **assist their understanding of the whole course**. They agree that projects:

...enhance better understanding in Design through the application of theory into practice i.e. the projects (S31)

...enhanced my knowledge more in terms of understanding the course (S35)

These students have high expectations that the course projects would **enhance better practice in Design.**

I will be able to learn more various methods in designing appropriately and correctly (S16)

I want to have more experience and skillful in Design (S28)

Several students anticipate that they will **get better grades in the course** through the project component.

I expect to get good grades (S39)

I expect to more understand and can achieved A (S15)

When the students were asked about the skills they expect to gain from the projects, a number of them listed working in a team, solving design problems, organizing projects, applying software in designing, engaging in creative thinking and exposure with problem solving as among the skills they anticipated to be trained. Several students are very keen to learn about designing important building structures like slab, column and staircase. Some of the interesting comments are listed below:

[I would want to be skillful] *in upgrading on wise thinking and able to choose the most economical design element without jeopardizing the safety of the building itself (S9)*

[I want to be able] *to design correctly or known as 'engineering judgment'. I think that is very important for engineers (S39)*

Expectations of instructors are more related to the contributions of the project towards the whole course. This instructor is more concerned with how the students evaluate the project which he later associates this with students' knowledge on preparing the project report.

*When I give one project to the students, they will come up with a few alternatives which they will later discuss with me. If I disagree, they will re-do [*the project*]. In the process, I will determine how the students have evaluated the project in regards to their understanding on how to prepare the project report.* (L1)

Notice that the instructor is more concerned with the final product of the project i.e. the project report rather than the whole process of integrating the project into the course. This instructor, on the other hand, is more worried with the students' understanding, as he expressed his concerns below:

For me, the project is very important. Because if the students want to understand Design, they have to engage in the project. If they do not do the project, there is a likelihood that that they would fail the course because they do not understand. (L2)

5.2. Role of Previous Courses

Several students are positive that the knowledge gained from previous courses has given them better perspectives in designing the projects. The excerpts below indicate the students' perceptions towards the courses that they have undertaken prior to the design courses.

Other courses are directly related to designing stable structures. For example, in Foundation Design, I was taught on identifying types of soil. This is very important in designing buildings because the soil functions to sustain the loading of the building (S21)

The project is an integration of previous courses (S23)

Theory structure gives a lot of help especially in calculation (S36)

The previous course gave me the basic idea of designing and this helps me a lot in the project (S37)

Previous knowledge are related to the project, especially economy, you design for the constructed building, it's very important. I think subject basic Economy is very important (S38)

Guided by their instructors, some students reported that they have performed the checklist of important items for their projects. This checklist includes loadings and critical components of project design, work distribution among team members and tasks and time scheduling. Other than that, the projects have also encouraged self-directed learning on the part of the students as they have to source various types of information in order to complete their projects. These resources include searching for related reading materials from the library and the Internet and discussing among team members and their respective instructors. Some even consulted the seniors on the previous projects and firm consultants in completing their projects.

Several students are positive that the knowledge gained from previous courses has given them better perspectives in designing the projects. This tallies Heitmann's (1996) claim that projects focus on application and the integration of previously acquired knowledge. However, this student believes the opposite.

[Previous courses] *do not help much because the instructor does not relate the subject with other courses. It is only during the final semester that we have the Professional Project (PAP) (S39)*

This student's view should not be taken lightly. His response might reflect many other students that have similar conception. It is an indication that some students fail to apply the knowledge and skills gathered through the projects to other courses. Prince & Felder (2006) have warned that simply informing the students that certain skills and knowledge are highly needed is not effective in encouraging students to engage in learning. Instead, teachers should engage in inductive teaching and learning (see Prince & Felder, 2006 for further elaborations on *inductive teaching and learning*). Such belief from the students might also be attributed to the late introduction of the project component in the Design subject i.e. the final semester of the 3rd year. This might also rationalize why most students failed to understand the objective of the project to the whole course and perhaps to their future work setting.

5.3. Challenges Faced by Instructors and Faculty Management in Project-based Approach

With regards to earlier comment given by student S39, even though the student was in his 4th year, it does not necessarily mean that he is able to see the rational of the project component in the Design courses. This student (and others) suggests the following;

1. Total dependency on the instructor. This does not indicate that instructors are 'spoon-feeding' the students with much information. It basically means that students are depending too much on the instructor for support and further instructions. Some students even need the instructors to supply them with the rationales of engaging themselves on the design project in the first place.
2. Inability to see the objectives beyond the project component
3. Failure to relate the content of other subjects to the project component

Nevertheless, it is rather unfair to entirely blame the students on this issue as this also demonstrates some lack of commitment from the instructors and faculty management. Instructors feel challenged to monitor the groups and the respective projects. This instructor in particular has to force the students to engage in the 15% worth of projects.

Students complained that they have to do a lot of work, not worth with only 15% of the total grade for the course. For me, if the students do not engage in the project, they will think that Design is not an important subject. So, I have to force them. Luckily they work in groups; it is easier for them to do the project work. (L1)

Instructors also need to closely monitor the students especially from the beginning i.e. the formation of the teams.

I will assign so that the students do not take their friends even though they are classmates. Perhaps they are familiar with their friends and prefer to work together. I do not let them. I will assign them. This means that friends or foe will have to work together because we need to complete the project. In real working world, we have to complete the project despite individual differences. (L1)

Some instructors even encourage their students to participate in competitions such as bridge competition in order to expose the students to diverse ideas in Design. However, according to this instructor, he does not promote such effort.

Some instructors allow the competition to be accepted as the students' projects. But for me, I have never done that because it is difficult to evaluate the students' work. (L1)

6. Conclusion

The responses gathered in this study have indicated that students have high expectations of the Design courses in preparing them for workplace environment. However, an innovative approach in the instruction of Reinforce Concrete design courses is crucial in making the Design courses relevant to the students and the engineering program. Design courses need to embrace the exemplary nature of the civil engineering profession and to address concerns of employers that engineering graduates are unprepared and poorly trained to face the engineering profession. The introduction of project-based learning therefore, is important because as a constructivist learning pedagogy (Steffe & Gale, 1995), project-based approach emphasizes 'learning by doing' through students' engagement in hands-on projects performed either individually or with their teams.

The Reinforced Concrete Design course in Universiti Teknologi Malaysia is described as a teacher-facilitated project where the lecturer controls the classrooms. Despite this, the lecturer is still the enabler of the learning as he still utilizes a hands-on approach in facilitating the project. Nevertheless, the approach at UTM requires further enhancement on opportunity for the students to engage in self directed learning and become independent learners without direct supervision from lecturers. The following are several recommendations that could be useful to some faculty which plan to undertake project-based learning in their Design classrooms.

- introduce more updated computer software which can be used in designing
- bring students to project sites that would expose students to more original designs and site conditions that affect designs
- introduce students with cases handled by existing local consultants
- presenting students with more samples of real projects
- introduce project-based approach earlier in the undergraduate year i.e. from first year onwards

- assessment on projects should be further increased as projects are time consuming to be completed. Perhaps, instructors should also reduced the number of tests and absorb the marks into the project
- more opportunities for the students to engage in self directed learning and become independent learners without direct supervision from lecturers.

Several of the above recommendations were proposed by the students themselves. Hence, instructors should be more sensitive to their students' constraints and requirements to assist students in familiarizing with what they have learnt and how to apply those knowledge and skills in the future work setting. Project-based instruction is an excellent vehicle for teaching engineering subjects such as Reinforced Concrete Design because students can be taught in contextual situations. Knowledge and skills are not isolated from one another; instead they complement each other. Therefore, project-based learning is an excellent approach in teaching engineering design as students are able to link all theoretical frameworks to real world applications.

References

[1] ABET, Criteria for Accrediting Engineering Programs. Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology, Baltimore, Maryland, (2001). Available on-line at http://www.abet.org/criteria.html

[2] Ashford, N. A. (2004). Major Challenges to Engineering Education for Sustainable Development. *International Journal of Sustainability in Higher Education, 5*(3), 239-250.

[3] Crawley, E. F. (2001). The CDIO Syllabus. Available at www.cdio.org. Retrieved May, 2010.

[4] Doppelt, Y., Mehalik, M. M., Schunn, D. C., Silk, E., & Krysinski, D. (2008). Engagement and Achievements: A Case Study of Design-Based Learning in a Science Context. *Journal of Technology Education, 19*(2).

[5] Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education*, 103-120. **94**(1): 103-120.

[6] Dym, C. L., & Little, P. (2004). *Engineering Design: A Project-Based Introduction* (2nd ed.). New York: John Wiley & Sons, Inc.

[7] Felder, R. M., & Brent, R. (2003). Designing and Teaching Courses to Satisfy the ABET Engineering Criteria. *Journal of Engineering Education, 92*(1), 7-25.

[8] Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The Future of Engineering Education II. Teaching Methods That Work. *Chem. Engr. Education, 34*(1), 26-39.

[9] Gao, M., Demian, P., & Willmot, P. (2008). *The Role and Effectiveness of Design Projects in Civil Engineering Teaching and Learning.* Paper presented at the 12th International Conference on Computing in Civil and Building Engineering, Beijing.

[10] Gibson, I. S. (2000). Group Project Work in Engineering Design-Learning Goals and Their Assessment. *International J. Engineering Education*, *Vol. 17* (No.3), pp.261-266.

[11] Hailey, C. E., Erekson, T., Becker, K., & Thomas, M. (2005). National Center for Engineering & Technology Education. *The Technology Teacher: The Voice of Technology Education, 64*(5), 23-26.

[12] Heitmann, G. (1996). Project-oriented study and project-organized curricula: A brief review of intentions and solutions. *European Journal of Engineering Education*, *Vol.21* (No.2), p. 121-131.

[13] Mills, J. E., & Treagust, D. F. (2003). Engineering Education - Is Problem-Based or Project-Based Learning the Answer? *Australasian J. of Engng. Educ.*, Online publication 2003-2004. Available at http://www.aaee.com.au/journal/2003/mills_treagust2003.pdf

[14] Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *J. Engr. Education, 95*(2), 123-138.

[15] Sheppard, S., & Jenison, R. (1997). Examples of Freshman Design Education. *Int. J.Engng Ed., 13*(4), 248-261.

[16] Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of Engagement: Classroom-Based Practices. *Journal of Engineering Education*, 1-15. . 94(1): 87-102

[17] Steffe, L., & Gale, J. (1995). *Constructism in Education*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

[18] Thomas, S., & Busby, S. (2003). Do Industry Collaborative Projects Enhance Students' Learning? *Education & Training, 45*(4), 226-235.

[19] Tam, M. (2000). Constructivism, Instructional Design and Technology: Implication for Transforming Distance Learning. *Educational Technology and Society, 3*(2), 50-60.

APPENDIX W : DATA ANALYSIS ON DESIGN ABILITIES

Interview	Student	Description	Core Meaning	Coding
What is your goal in FPjBL? What skills (abilities) do you to learn from project? What kind of knowledge you need for design project? What knowledge you want to get from FPjBL in design? For example, when you analyze the tasks, what do you do?	ABET 2000 S4-A S4-A S3-B S8-B	*"Students should be able to apply knowledge of mathematics, science and engineering and to identify and formulate engineering problems"* *Knowledge and experience {practice} on how to do proper design (building).....* *Analysis and designing [building] helped me to learn basic design process; learning about a real life problem with a bit of fun; practical use of theory to do real things; challenging and interesting.* *I think now it make sense why I'm studying other courses because now I am able to relate materials from previous courses. For example, construction specification, I must have knowledge on construction materials. Their strength characteristics are important to structural design.* *Analysis in this project is difficult, but I manage to have better understanding of design.*	**CK- Content knowledge** **Better understanding of key principles and concepts** Use techniques, skills and tools necessary to engineering design practice. Able to use theory to analyze Able to use theory to design Awareness of technical subjects related to design to develop the ability to find relevant information Apply appropriate analysis, measurements and meaningful format	CK1-Problem Formulation
	S8-A	*I was able to identify the missing requirements [in beam design] through evaluating the best design solutions from the resources we discussed among*	Perform necessary analysis Convey interpretation of the results	CK2 - Mastery of Subject

Interview	Student	Description	Core Meaning	Coding
	S3-A S5-A	*I discuss with team mate for possible layout(alternatives), then consult the engineer and sometimes ask lecturer to confirm the solution before proceeding to the next task [advance task]....I really understood the subject matter that allow me to do so.* *Now I understand the content and the practical aspect of how loads are transferred throughout the structure.....this task is important to be understood before proceeding into the next task*		
How do you approach/strategize the problems in project? Give examples : how you make decision/justification in your project? Do you pull important information from different sources for your project? e.g. readings, discussions and lectures		Lifelong Learning Skills - LL	Recognize the need for and engage in LL 3 characteristics of SDL 1. Self Management-SM 2. Desire for Learning-DFL 3.Self control- SC	Student-directed Learning - SDL
	S8-A	*I'm able to choose suitable formula for the problem and decidet the technique to use in relation to the problem in project.....[design project]can help me to have a deeper understanding about the problem.*	Able to choose Able to make decision Understand the differences	SDL – Desire for Learning

Interview	Student	Description	Core Meaning	Coding
	S5-A	*For me, before I start any problem in design, I would diagnose the problems...need realistic value with the help of the engineer and friends.*	Able to diagnose what to learn Able to diannose what's needed	SC – Self Control
	S5-A	*I prefer to search through internet, read from text book and look for same(similar) problem… I ask the engineer also to give me the clear information about the design.*	Take initiative in using different resources Able to indentify appropriate materialls resource Able to indentify appropriate people to help	SM – Self Management
	S3-A	*The project assigned by the design firm is very usefull and worthwhile. Creating something real through the project is the most benificial achievement. I think it will provide[me] an insight as to go about creating real life design later for work or further study.*	Able to create a plan Able to set learning goals	DFL – Desire for learning
	S3-A S4-A	*The experience in this project is important because next time when I start my career, I will have less problem of adjusting my working life and environment. I like challenging project because that drives me to learn something new....and upon finishing the project, I felt a sense of achievement in my study.* *[I want] knowledge and to experience on how to do proper design (building), ..I wan t to explore new software(technology) used in design and in industry....*	Able to identify learning goals Able to recognized when student has attained his/her learning goal Able to identify the learning needs Able to identify the usefullness of what is learnt	SM- Self Management SM – self management

Interview	Student	Description	Core Meaning	Coding
What are the things you consider, before you do/start your design project?	S2-A	**PROBLEM SOLVING – PS** *Actually I want to know theory fully. At the moment we know the basic.....beam analysis, bending moment, etc. and than I think about it and then decide how I want to implement[design]....what I learn from project, I wanted to know what is[deep understanding] if I can use it further in other problems.*	Ability to apply and understanding to identify, formulate and solve problems using established methods - PS	PS – Problem Solving
	S4-B S2-A S7-B	**Design Thinking – PS1** *When I do analysis in structural components, I break up them into various parts and think critically and creatively to understand them better.* *Now I can make justification (critical thinking) based on the connection between analysis and design…..but to confirm I ask the engineer (pro-active thinking)…..so that I am more confident because I got first hand knowledge how engineers work in their daily life.* *I ask a lot of qustions with the engineer so that I can clear my concious mind.... so that I am able to proceed to design with confident*	Design Thinking	PRS1 - Professional Skill- Teamwork

Interview	Student	Description	Core Meaning	Coding
		Project provided a great insight into the design methods learn during lecture and used in the design office. I got ot to see the whole components relate to each other.		
	S3-A	*I'm excited because I can see the whole structural system design in this project. We learnt to integrate all the components designed in one structural system*		
	S8-A S5-A	*I make sure that I really understand the concept, the whole procedure (The whole system design) and concepts we use in designing component such as beam, slab, column and footing are considered by formulating them clearly and precisely, gathers and assesses relevant informations, testing them against creteria and standards.*		
	S5-A	*The overall project like the integration of the structural elements [whole design system] we develop in project was taught in the class but I didn't understand. Now I'm able to generalize the concepts of the design in different context especially in the task 3 and 4.*		
		[I want to know why].. I think about it and then decide how I want to implement.		
	S2-A	*I like to reasons out at things[see the logic], relate and doing[identify alternative solutions] and thinking because I like the thing that I learnt that I can visualise ... When I learn, I want to get involved,..I like to be part and active in my learning*		

Interview	Student	Description	Core Meaning	Coding
	S5-A	*and see the whole thing [system thinking]* *I want deep understanding of the project. Sometimes to make assumptions for structural components sections that I don't have the skills... but the engineer assisted me with rule of thumbs.I have to be critical and proactive because this project is challenging.*		
		Communication		
	S8-A	*I improved a lot [design concepts] because team-mate works hands-in-hand. I throw away my egoness and shyness and I ask them a lot to clarify my problems*	Use diverse methods to communicate effectively with engineering community and with society.	PRS 2- Professional Skill - Communication
	S1-A	*I'm happy and comfortable and I'm not shy anymore to communicate with colleques and the engineer at the consultant office.*	Students' behaviour	PRS 2- Professional Skill - Communication
	S5-A	*I searched through internet, read from text book and look for same(similar) problem… I ask the engineer also because he is very helpful. Interaction with the engineer gives us the chance to acquire knowledge in civil (structural) engineering design especially about the current practice.*	Finding other sources Ask engineer for help	PRS 2- Professional Skill - Communication
How do you describe yourself after completing the task/project ? Do you feel happy? Motivated? Are you interested more in		**MOTIVATION AND ENGAGEMENT**	**MOTIVATION** personally relevant to their interests and goals 1. The level of lecturer control over the project.	M-motivation E -Engagement

Interview	Student	Description	Core Meaning	Coding
design?			2. Context with engineer affect motivation 3. Teamwork influences Presence and involvement of engineer	
	S5-A	*I'm serious [project] because I want to get A for this course. I want to further study and I can use this knowledge and experience.*	**Engagement**(Learning Point Associates, 2004). Student engagement is characterised by four criteria, namely 1. responsible learning, 2. strategic learning, 3. collaborative, and 4. energised by learning (Learning Point Associates, 2004).	
	S8-A	*Talking and discussing the project tasks with the engineer, stimulated my interest in design......because I understood the subject matter.*		
	S2-A	*I think I'm capable of independent practice of structural designing…a bit more confidence because I see how the engineers in consultant office do their design.*		
	S8-A	*"The project was good, there was like real… at the end of the project, I was very motivated as we would be guided and need clarification on our work"*		
	S5-A	*During the project, we discussed problems together, helped each other until it is finished. I appreciate that we were able to work in a group and each person tried hard to complete their work on time..... ....Real project [authentic] is very good so that students are more eager to learn. Outside project[real project] is practical. If all student can go [participate] is better still.*		

Interview	Student	Description	Core Meaning	Coding
	S7-A	*Many tips [from the engineer] were taught that I can understand .....I enjoy, that why I wanted to know more and reasons why we need to assume in design*		
	S2-A	*I always ask the engineer weather my assumptions is correct or not. I need to feel confident when I start doing project.*		