Implementing Outcome Based Education through Problem Based Learning: A Case Study of Kotelawala Defence University

WCDK Fernando[1], and RP Kumanayake[2]

[1] *Senior Lecturer, Department of Civil Engineering, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka*
[2] *Senior Lecturer, Department of Civil Engineering, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka*
[1] *<kumari@kdu.ac.lk>,* [2] *<ramyakumanayake@yahoo.com>*

Abstract*—Outcome Based Education (OBE) is an innovative approach which helps in expanding the development horizons of education. Problem Based Learning (PBL), which is a strategy where the student acquires new knowledge during the process of resolving problems, is an approach in implementing OBE. The objectives of this research are to evaluate the role of PBL in implementing OBE in the BSc Engineering Degree in Civil Engineering at General Sir John Kotelawala Defence University, Sri Lanka and to identify potential improvements. This paper discusses how PBL activities have been introduced through the modules industrial training and industrial visits to facilitate achieving the programme outcomes. The quasi-experimental research design was used in the study incorporating pre-test and post-test approach. It was found that PBL is highly effective in achieving the objectives of OBE, especially for modules such as Industrial Training and Industrial Visits and helps in enhancing the students' ability in critical thinking, analysis and problem solving in a practical scenario.*

***Keywords*— Outcome Based Education, Problem Based Learning, Industrial Training**

I. Introduction

The Washington Accord is an international accreditation agreement signed in 1989 for professional engineering degree programs. Outcome Based Education (OBE) is being promoted under the Washington Accord and has become a trend in higher education adopted by many universities worldwide. Sri Lanka has recently become a Washington Accord signatory country and the Institution of Engineers Sri Lanka (IESL) is in the process of shifting its paradigm to an outcome based approach.

According to Lam (2009), OBE is a process of curriculum design, teaching, learning and assessment that focuses on what students can actually do (i.e. learning outcomes). OBE encompasses learning outcomes with the knowledge, skills, attitudes and values that match the immediate social, economic and cultural environment of the society.

Guide to OBE developed by Teaching and Learning Committee of The Hong Kong Polytechnic University identifies four important areas related to outcome based approaches in achieving quality of student learning.

- as the starting point define clearly what students should be able to do on completing their course of study *(intended learning outcomes)*
- design of curriculum, teaching, learning and assessment to enable students to achieve the intended learning outcomes *(alignment)*
- collect data on students' achievement of learning outcomes *(outcome assessment)*
- use outcome assessment data to inform further development and enhancement of the programme/module *(continuous improvement)*

In OBE, the teaching and learning outcomes emphasize on capacity rather than just on content knowledge; and the learning process is capacity building rather than content delivery. It goes beyond structured tasks by involving students in high level thinking and seeking for generic competencies of communication, critical thinking, creative thinking, problem solving and entrepreneurial teamwork.

Problem Based Learning (PBL), which is an active-learning and learner-centred approach where unstructured problems are used as the starting point and anchor for the inquiry and learning process, is one of the teaching learning strategies in implementing OBE.

Jonassen and Khanna (2011) describe PBL is an instructional strategy in which a unit, course, or curriculum is organized around problems authentic to practice rather than subject matter content. Rather than studying concepts, principles and theories and later applying them to problems, learning is organized and oriented by the problems. They identify the general characteristics of PBL programs as; student-centered learning, collaborative learning, Instructors as facilitators and self-directed learning.

Under the guidelines of the IESL, the General Sir John Kotelawala Defence University (KDU) at present is in the process of shifting its focus from a traditional teacher centred approach to a more student centred approach by introducing outcome based education strategies for the

design and implementation of engineering degree programmes. A major curriculum revision of the B.Sc. Civil Engineering degree was carried out in 2011 and as a result, the programme duration which had been three years was extended by one year from the Intake 28. As an initial step of embracing outcome based education, Intended Learning Outcomes (ILOs) were identified for all modules of the degree programme.

Introduction of new modules and appropriate assessment criteria, collection of evidence regarding the achievement of outcomes and continuous quality improvement systems were some of the changes implemented in the amended programme. Under the restructuring of the degree programme, the modules Industrial Training and Industrial Visits were introduced, which were expected to provide the students with industrial exposure to the contemporary engineering practices at the construction industry and also to enable them to develop competencies through problem based learning.

The objectives of this research are to evaluate the role of PBL in implementing OBE in B.Sc. Engineering Degree in Civil Engineering at KDU and identify the potential improvements. The scope of the study was limited to two specific modules, Industrial Training and Industrial Visits. This approach corresponds with the macro level of PBL infusion as identified by Tan (2003) and shown in Figure 1, where PBL is applied to selected subjects of a programme.

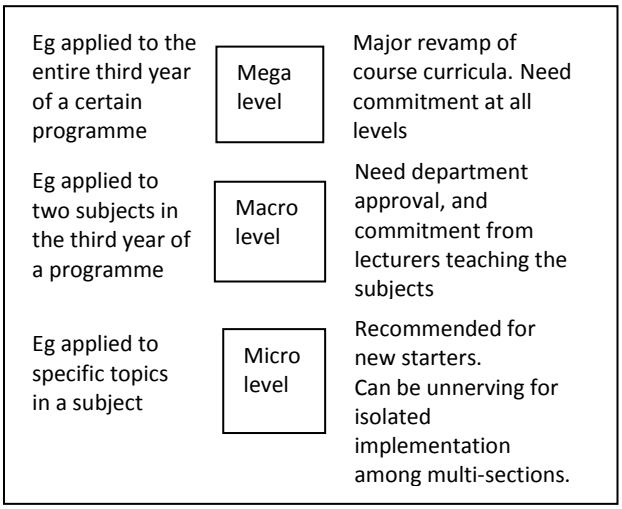

Figure 1: Different approaches of infusing PBL
(Source: Tan O.S. (2003). *Problem –based Learning Innovation: Using problems to power learning in the 21st century*)

Under the Industrial Training module, the students are assigned to engineering organizations to gain practical experience at the construction industry. The module Industrial Visits enable the students to observe and report how the theory and principles that they learned in the classroom is being applied in the real world of construction. Both of these modules offer opportunities for PBL at industrial setting and are aimed at enhancing the technical and professional competencies and soft skills of students, hence developing the attributes desirable in the engineering undergraduates.

Industrial Training and Industrial Visits are compulsory modules for the third year civil engineering undergraduates. Industrial Training is a six credit Non-Grade Point Average (NGPA) module which comprises the entire twenty weeks of the sixth semester of the programme. Industrial Visits is a one credit NGPA module which is offered in the fifth semester of the programme. Although both are NGPA modules, in order to complete the programme, passing them is a must. The KDU with the collaboration of the National Apprenticeship and Industrial Training Authority (NAITA) organizes industrial training at relevant construction related organizations. During the training period, KDU academic staff and the NAITA continuously monitor the training in terms of student performance, attendance and behaviour. Under the Industrial Visits module, one day visits to various types of construction projects outside and within the KDU premises are arranged and the students are expected to observe and report how the theory and principles that they have learned in the classroom is being applied in the real world of construction.

In his presentation, Badaruzzaman (2012), states Program Outcomes (POs) as "statements that describe what students are expected to know and be able to perform or attain by the time of graduation." Intended Learning Outcomes (ILOs) for a module specify what students should be able to do on completing the particular module. Felder and Brent (2003) in their study developed a course assessment matrix, which maps outcome-related learning objectives with program outcomes of a course. Similar to that, the PO – ILO matrices for the two modules are developed as shown in Tables 1 and 2 (Annexure). Entries of 1, 2 and 3 inserted in a cell of the matrix respectively indicate that an Intended Learning Outcome addresses a Programme Outcome slightly, moderately or substantively.

II. LITERATURE REVIEW

Aziz et. al. (2005) emphasizes the need for the contemporary engineers to be flexible and to be able to move across several engineering disciplines in a fast changing world. Training is a key factor in developing engineers who are capable of performing a range of functions in industry, able to communicate effectively , manage or lead organizations and having innovative thinking skills. With rapidly expanding knowledge, globalization and the changing emphasis in scientific fields, engineers must be prepared for future challenges. OBE, by providing the engineering students with the opportunity of developing professional competencies, generic competencies, attitudes and values provides a strong foundation to encounter these challenges.

Tan (2005) suggests that PBL is not just about problem solving processes; it is a pedagogy based on constructivism in which realistic problems are used in conjunction with the design of a learning environment where inquiry activities, self-directed learning, information mining, dialogue, and collaborative problem solving are incorporated. Figure 2 illustrates the key components in PBL process.

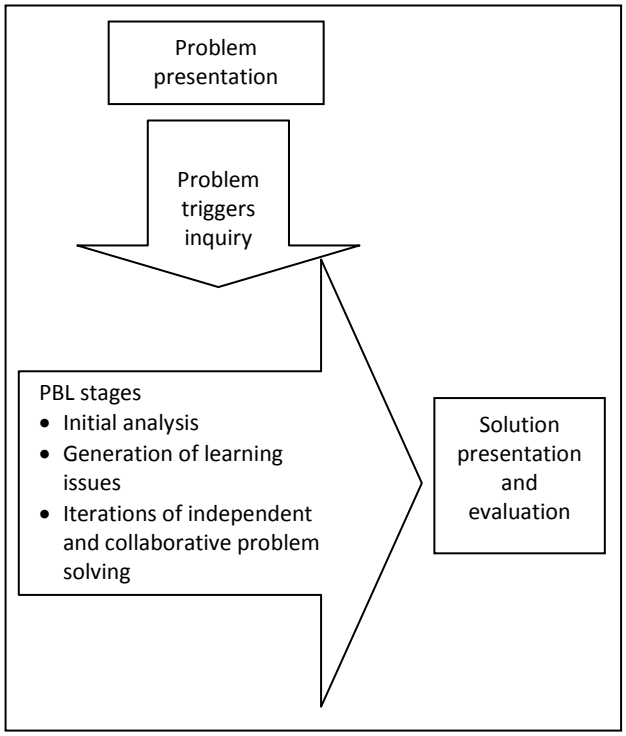

Figure 2: components of the PBL process
(Source: Tan O.S. (2005). *Problem–based Learning: the future frontiers*)

Sardana & Arya (2003) focused on the training evaluation of engineering students at Thapar Institute of Engineering and Technology in India. The impact of training was studied according to Motivation, Attitude, Skills and Knowledge (MASK) attributes. The analysis was done based on the self-assessment of students and the views of faculty members and industrial supervisors.

In their research Osman et. al. (2008) studied the perceptions of undergraduate students from Civil Engineering Department of the University of Kebangsaan , Malaysia on their industrial training programme. The performance improvement of the students in three main aspects, attitude, communication and work attitude were evaluated after the completion of the industrial training programme and compared with the same aspects before undergoing the industrial training.

Ayarkwa et. al. (2011) assessed the perceptions of undergraduate construction students in Ghana on industrial training, its challenges and possible measures to overcome them. Main three aspects, personal attitude, communication and work attitudes and 15 performance criteria under them were considered in the study and data analysis was based on mean scores of factors evaluated and the t-test was used to assess the significance of differences between student performance before and after undertaking industrial training.

III. METHODOLOGY

The quasi-experimental research design incorporating pre-test and post-test approach was used in the study to achieve the research objectives. In order to maintain the highest possible accuracy in the study, the total population was considered as the sample. The total population of the research for the two modules is shown in Table 3.

Table 3: Sample distribution of the study

Module	Intake 27	Intake 28	Intake 29	Intake 30	Total
Industrial Training	9	13	-	-	22
Industrial Visits	-	-	30	39	69

Two questionnaires were developed for the two modules in order to collect both qualitative and quantitative data from the students. They covered three main areas; profile of respondent, profile of training organization and feedback on industrial training/industrial visits. The questionnaire for the industrial training focused on three main aspects; personal attitudes, communication and work attitudes. Under these aspects, 15 attributes were considered and the students were asked to indicate their perception of the level of achievement of these attributes before and after undergoing industrial training. In the second questionnaire, perceptions of students on performance before and after site visits were assessed. The attributes and student performance were measured using five point Likert scales and the scores were used to find the mean values.

In relation with outcome based approach, one of the important areas to study is the assessment of the achievement of outcomes. Both questionnaires included questions on student feedback on the achievement of intended learning outcomes for the modules. Also, the students were asked to rank the benefits they achieved from industrial training in order of importance. In the last part of the questionnaire for industrial training, students were asked to identify a problem situation they encountered during industrial training and to briefly explain their solution to the problem. The questionnaire

on industrial visits requires students to state a situation they had observed where theory is practically applied at the construction site. These descriptive questions were used to collect student feedback on problem based learning strategy and challenges and issues that they encountered during industrial training or industrial visits. The questionnaires were distributed by hand and through e-mail. Out of 91 questionnaires distributed, 85 were returned fully completed, giving 93% response rate. The quantitative data analysis was carried out using Excel programme and the response to the descriptive questions were analysed qualitatively.

IV. RESULTS AND DISCUSSION

The results are discussed based on profile of respondents and training organization as well as the students' feedback on various aspects of the two modules.

A. Profile of Respondents

All civil engineering students of Intake 27 and 28 are officer cadets, who underwent twenty weeks of industrial training in 2013 and 2014 respectively. Intake 27 students followed their training in 7th academic semester and Intake 28 in 6th academic semester. The categories of respondents are shown in Figure 3.

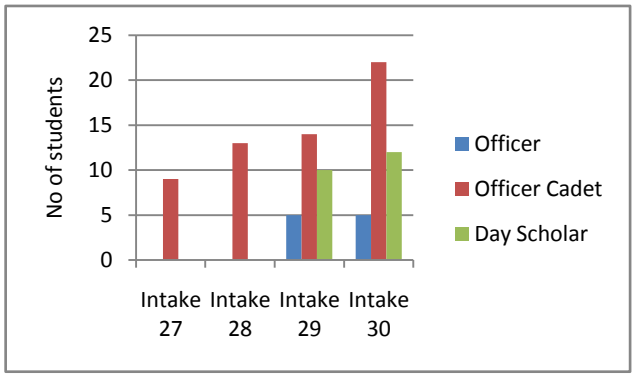

Figure 3: Categories of respondents

B. Profile of Training Organizations

Intake 27 students did their training in state sector contractor organizations whereas Intake 28 students were trained in both contractor and consultancy organizations in state and private sectors. The main area of work of contractor organizations is building construction, and road construction is the main area of consultancy organizations.

C. Level of perceived student attributes before and after Industrial Training

The respondents' perception of personal attitudes, communication skills and work attitudes were analysed using different attributes and the mean score of those aspects before and after training are shown in Table 4, 5 and 6.

As shown in Table 4, all six attributes were between 3.0 and 4.0 before training. It was clear that after training the values have reached fairly higher levels (> 4.2). Among the six attributes, self confidence was drastically improved (50%) through industrial training. The lowest percent improvement (13%) was for punctuality, which is obvious as due to the unique culture of the KDU, students are trained to be punctual as a basic requirement even before undergoing industrial training. It can be seen that curiosity and motivation, highly relevant attributes needed by professional engineers in the modern society, were also improved through industrial training.

Table 4. Comparison of personal attitudes

Attribute	Mean score		% increment
	Before training	After training	
Self confidence	3.0	4.5	50
Curiosity	3.7	4.5	22
Punctuality	3.8	4.3	13
Motivation	3.6	4.4	22
Self and time management	3.7	4.3	16

Table 5. Comparison of communication skills

Attribute	Mean score		% increment
	Before training	After training	
Oral communication	3.5	4.1	17
Written communication	3.9	4.1	05
Presentation skills	3.9	4.2	08
Discussion skills	3.7	4.5	22

Table 5 shows the comparison of communication skills before and after training. Results show that oral communication skills and discussion skills were much more improved than written communication skills and presentation skills. As trainees at construction sites are usually involved in oral communication and their chances of using written communication and presentations are low, that can be as expected. The improvement of discussion skills may be due to their involvement in teamwork. Also, the opportunities they have to discuss various issues/problems raised at the site with the site engineers, managers and other team members may have resulted in the improved discussion skills.

Seven attributes were discussed in Table 6 and most of the students felt that there was high improvement (45%) in their adaptability to the environment. Improvements in subject knowledge, problem solving skills and ability to work under pressure were also reasonably improved. When considering the improvements in leadership and teamwork skills, there is a consensus on the fact that the

training does not much improve these attributes when compared with the other attributes.

Table 6. Comparison of work attitudes

Attribute	Mean score		% increment
	Before training	After training	
Subject knowledge	3.3	4.5	36
Adaptability to environment	3.1	4.5	45
Problem solving skills	3.2	4.2	31
Leadership	3.7	4.3	16
Teamwork	3.7	4.3	16
Ability to work independently	3.4	4.4	29
Ability to work under pressure	3.3	4.3	30

D. Level of perceived student performance before and after industrial visits

The students' perceptions on performance were analysed using six aspects and the mean score of these aspects before and after training are shown in Table 7.

Table 7. Comparison of performance

Aspect	Mean score		% increment
	Before visits	After visits	
Ability to adapt with site environment	2.3	4.0	74
Ability to work in a group	3.0	4.3	43
Ability to function as a leader	4.2	4.3	2
Ability to identify problem situations	2.5	4.6	84
Identify solutions for a particular problem	2.9	4.5	55
Awareness of site safety practices	2.5	4.7	88

Results indicated that three performance criteria, 'ability to adapt with site environment', 'ability to identify problem situations' and 'awareness of site safety practices' were significantly improved after the visits. However, it was obvious that the student's ability to function as a leader was not much improved through industrial visits.

E. Level of attainment of learning outcomes

Table 8 shows the level of attainment of each learning outcome through the industrial training as perceived by the students. It is evident that the students did not have much opportunity to experience the importance of the financial and economic limitations in engineering activities (LO 6). On the other hand, it can be seen that the students' understanding of the real life situations at work sites (LO 1) is rather high. Also it seems that they have learned that in the field of engineering, learning has no limitations (LO 8), which is a very important lesson learnt for their continuous development as professional engineers in future. Based on the results, it can be argued that the extent of student achievement of learning outcomes is significantly high except the sixth learning outcome.

Table 8. Level of attainment of learning outcomes

Learning outcome (LO)	Mean score	Learning outcome (LO)	Mean score
1	4.7	7	4.3
2	4.3	8	4.7
3	4.6	9	4.3
4	4.5	10	4.5
5	4.1	11	4.4
6	3.9		

F. Ranking of benefits achieved from industrial training

The students' assessment of the benefits they gained from industrial training is shown in Table 9.

Table 9. Ranking of benefits achieved from industrial training (1 – lowest to 5 – highest)

Benefits	Ranking (%)				
	1	2	3	4	5
Improve skills, knowledge and attitudes	6	0	0	7	87
Improve job prospectus	0	26	27	47	0
Improve confidence on job qualification	0	13	53	27	7
Provide guidance on job selection	13	53	20	7	7
Improve communication skills	13	45	18	18	6

It is shown that the top ranking was given to improving skills, knowledge and attitudes, while improving job prospects and the confidence on job qualification took the second and third places respectively.

G. Student point of view on industrial training as a PBL activity

The following excerption highlighted how one of the students identified industrial training as a PBL activity.

"At .....site, a problem occurred at steel bending where the bended areas of the steel bars were getting cracked after bending. We were asked to check and identify the reason for it. First, we checked the steel for its material composition standards and from the test results found that the steel composition was not in proper order.....In these situations, we learnt how to identify the problem step by step and how to decide the appropriate remedial action."

In the above situation, the identified real–world problem was the starting point of his learning. The problem challenged his current knowledge and competencies so that he needed to harness a variety of knowledge by self-

directed learning. Also, collaborative and cooperative learning process was clearly included in this process.

V. CONCLUSIONS

This research was conducted for the purpose of evaluating how PBL activities can be used for the implementation of OBE in the civil engineering degree programme of the KDU. The concepts of OBE and PBL are relatively new to the university, therefore this study can be considered as an initial attempt in familiarizing the KDU with these concepts. In the study, the improvement of some student attributes such as self confidence (50%), adaptability to environment (45%), subject knowledge (36%), problem solving skills (31%) after industrial training was found to be significant. Although the PBL process consists of three main stages of initial analysis, generation of learning issues and iterations of independent and collaborative problem solving, this study mainly concerned with the first stage, the initial analysis. As a continuous quality improvement process, the research will be extended to the next two stages in future, and the practice of OBE and the use of PBL activities in achieving the programme outcomes will be continued with modules other than industrial training and industrial visits. This study identifies the areas that need to be further improved in the modules concerned and as a result the module outcomes and the system of assessment will be better aligned with the programme outcomes. Also, with the increased experience of using PBL as an OBE strategy, it may be attempted to be applied to the entire degree programme in future.

LIST OF REFERENCES

Ayarkwa, J., Agyekum, K., Adinyira, 2012. Perceptions of undergraduate construction students on industrial training in Ghana. *Journal of Science and Technology (Ghana)*, Vol.32, No. 1.

Aziz et. al., 2005. A Malaysian outcome-based engineering education model. *International Journal of Engineering and Technology*, Vol.2, No. 1, pp. 14-21.

Badaruzzaman, W.H.W., 2012. Accreditation expectations to Washington accord standard. *Training programme on outcome based education and accreditation as par Washington Accord guidelines.* The Institution of Engineers Sri Lanka, 25-27 June 2012.

Felder, R.M., Brent, R., 2003. Designing teaching courses to satisfy the ABET engineering criteria, *Journal of Engineering Education*. Vol. 92, Issue 1, January 2003, pp.7-25.

Guide to outcome-based education, Learning and Teaching committee of the Hong Kong Polytechnic University (http://www.polyu.edu.hk/obe; accessed in June, 2014.

Jonassen, D.H., Khanna, S.K., 2011. Implementing problem based learning in Materials Science. *Annual conference of the American Society of Engineering Education*.

Lam, S.Y.W., 2009. Outcome-based approach to teaching, learning and assessment in Geomatics higher education: the Hong Kong experience. *Surveyors key role in accelerated development, FIG working week 2009*, Eilat, Israel, 3-8 May 2009.

Osman et.al., 2008. The importance of industrial training: student' perceptions in civil engineering sector. In: WSEAS (WorldScientific and Engineering Academy and Society), *7th international conference on education and educational technology.*

Sardana, K.H., Arya, P.P., 2003. Training evaluation of engineering students: a case study. *International Journal of Engineering Education*, Vol.19, No. 4, pp 634-645.

Tan, O.S., 2003. Problem-based learning innovation: using problems to power learning in the 21st century. Singapore: Thomson Learning.

Tan, O.S., 2005. Problem-based learning: the future frontiers. Temasek centre for problem- based learning, Temasek Polytechnic, Singapore.

BIOGRAPHY OF AUTHORS

[1]Author is a senior lecturer of Civil Engineering of General Sir John Kotelawala Defence University, Sri Lanka. She graduated with BSc Eng. degree in Civil Engineering and also received MEng and PhD degrees in Civil Engineering from the University of Moratuwa, Sri Lanka. Her research interests include Water Resources Management, Disaster Management and Engineering Education. She has produced several research publications to her credit.

[2]Author is a senior lecturer of Civil Engineering of General Sir John Kotelawala Defence University, Sri Lanka. She graduated with BSc Eng. degree in Civil Engineering from University of Moratuwa, Sri Lanka, and has a MBA from University of Colombo, Sri Lanka. Her research interests include Construction Project Management, Building Energy and Engineering Education. She has produced several research papers and is an Associate Member of the Institution of Engineers, Sri Lanka.

Annexure

Table 1: PO – ILO matrix for module Industrial Training

Intended Learning Outcomes (ILOs) of the module Industrial Training	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10
Understands the ways of industry and develop the necessary skills, knowledge and attitudes so that he/she commence a career as an engineer in future		2			1			1		
Understand real life situations in the industrial organizations and the related environment					2			3		
Practice the execution of informed judgement and learn associated responsibilities	3									2
Experience that financial and economic limitations play an important role in all engineering activities			2					1		
Understand the formal and informal relationships in an industrial organization so as to promote favourable human relations and teamwork						3				
Appreciate that engineering is an expanding field and that learning has no limitations							2		3	
Understand that the problems encountered in the industry rarely have unique solutions and gaining experience to select the optimal solution from the available	3		3							
Experience the industry safety practices , requirements and appropriateness			3	3						
Develop a sense of responsibility towards society in general										2

Table 2: PO – ILO matrix for module Industrial Visits and Report Writing

Intended Learning Outcomes (ILOs) of the module Industrial Visits and Report Writing	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10
Describe important aspects of industrial processes and environment		3		2						
Demonstrate the ability to understand the application of theory in practice	2					3				
Appreciate the real life applications of engineering principles	2									
Appreciate the responsibilities of an engineer in the industrial sector				2						

1 = ILO addresses programme outcome slightly 2 = moderately 3 = substantially

Programme Outcome 1: Evaluate a given problem situation and synthesize solutions, utilizing knowledge on civil engineering together with mathematics and other subject knowledge
Programme Outcome 2: Apply knowledge of simulation tools, laboratory and field techniques and equipment
Programme Outcome 3: Assess social, health, safety, legal and cultural issues and integrate action to eliminate/mitigate them in the proposed solutions
Programme Outcome 4: incorporate good management, safety and legal practices as well as relevant standards in all professional activities considering the needs of the sustainable development
Programme Outcome 5: Function/manage under strenuous and most demanding conditions
Programme Outcome 6: Carry out tasks as a member of a multi-disciplinary team and communicate effectively using reports, presentations and other means
Programme Outcome 7: Engage in innovation, design, research and development and entrepreneurship
Programme Outcome 8: Respond and adapt to changing situations and proprieties
Programme Outcome 9: Engage in continuous professional development and lifelong learning
Programme Outcome 10: Work with the highest level of professionalism to achieve the highest ethical standards.