# IMPLEMENTATION OF THE OUTCOME-BASED EDUCATION SYSTEM IN ENGINEERING PROGRAMS FOR PAKISTAN ENGINEERING COUNCIL ACCREDITATION UNDER WASHINGTON ACCORD SIGNATORY

**Muhammad Kamran[1], Badar Un Nisa[2], Muhammad Rayyan Fazal[3], Muhammad Irfan Abid[4], Irsa Abid[5]**

[1,3,4,5]Department of Electrical Engineering and Technology, Riphah International University, Faisalabad, Pakistan

[2]Allama Iqbal Open University, Islamabad

[1]kamran_ramzan@outlook.com , [2]badarkamran26@gmail.com, [3]rayyan.m@yahoo.com, [4]mirfanabid@hotmail.com, [5]irsaabid@gmail.com

***ABSTRACT:*** *The conventional education system that is a teacher-oriented is not defining and achieving the expected learning outcomes of the engineering students in Pakistan. Being the full signatory of the Washington Accord, Pakistan Engineering Council (PEC) declared the implementation of OBE system compulsory for the engineering institutes to get accreditation. Many public and private institutes are yet hesitant to adopt and implement the OBE system due to its dynamic approach and built-in complexity. This paper presents the implementation of the outcome-based education system in the department of electrical engineering, Riphah International University, as a case study. However, the approach is to highlight and meet the major requirements for any engineering program. The OBE system was successfully implemented to meet the university mission and vision through Program Educational Objectives (PEOs), Program Learning Outcomes (PLOs) and the Course Learning Outcomes (CLOs) through a well-defined and certain approach. This paper will be a guideline for the public and private institutes in Pakistan, inclined to implement the OBE system under the Washington accord signatory of Pakistan Engineering Council.*

**Keywords**: Outcome-Based Education; Program learning outcomes; Course learning outcomes; Washington Accord; PEC.

## 1. INTRODUCTION

Globalization requires multi-skilled students, to get out of the routine circle and apply the blend of Knowledge, skills, and attributes [1]. For that purpose, we are required to shift our basic mindset related to education from conventional to some flexible one. Alvin Toffler, an American scholar, said: "The illiterate of the twenty-first century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn" [2]. A sharp inclination of educations systems can be observed in higher education in, last few decades, for the conversion of traditional systems focusing what is delivered to the Outcome-Based Education (OBE) system focusing what students have learned in actual [3].

In contrast to the conventional education system, which is the teacher-centric education system retorting what the teacher has taught, the Outcome-Based Education (OBE) system is a student-centered system retorting what the student will be able to learn among knowledge, skills, and attitude? After being the full signatory of the Washington accord, Pakistan Engineering Council (PEC) has clearly indicated the implementation of the OBE system in engineering programs for accreditation. PEC declared twelve graduate attributes as the learning outcomes that must be reflected in an engineer at the completion of the program. In Pakistan, all engineering programs are accredited by PEC under the Washington accord [4], all engineering technology programs are accredited by National Technology Council (NTC) under Sydney accord (NTC).

Outcome-based education (OBE) is a student-centered technique that emphasizes the achievements of students in three major levels, at the end of course, at the end of the program and 3-5 years after graduation. Students are expected to perform better as they are specially focused to be assessed and polished through direct and indirect assessment methods [6]. Some researchers have already discussed the implementation of OBE based learning and teaching methodology [7, 8, 9]. Malaysian Engineering Universities are considered the pioneers in this regard, they compared the conventional system with the OBE. An overall positive change was observed in students, from a learning perspective to its practical implementation [10, 11] has implemented competency-based learning outcomes in pharmacy education and successfully implemented the education reforms by accompanying the learning outcomes. [12] has discussed in detail the role of the Washington accord and the graduate attributes for engineering program accreditation. [13] has successfully implemented the learning outcomes, program objectives and the university mission of American University in Cairo. Others [14], presented the implementation of the OBE system for the National Engineering Accreditation Council of Malaysia. The research is the only survey-based and actual implementation has not been presented in this paper. [15, 16, 17] have discussed to use the Bloom Taxonomy in defining the CLOs.

In the outcome-based education system,

- An assessment criterion and the expected outcomes are clearly defined at the start of the semester. These outcomes are mapped to the industrial and academic needs.
- The assessment process is a continuous one achieving the predefined outcomes. In case a learning outcome is not achieved, a CQI process is employed to improve the outcome.
- The student is judged whether he is competent or not. The term pass or fail is meaningless in this system. If he is weak in any outcome, he is advised to improve it in the future assessment.

OBE implementation is not an easy task typically in Pakistan's context, where the conventional educational system has deep penetrated roots. A basic roadmap and framework are present for the smooth transformation of the OBE system. However, lack of awareness regarding its implementation in engineering programs makes it increasingly onerous for educational institutions to get PEC accreditation under Washington Accord Signatory. In Pakistan already OBE has been understood and implemented but at extremely limited scale and slow pace. Some studies

have been conducted to show the effectiveness of OBE model for Pakistan's point of view [18, 19]. Hence, to bridge the gap, this paper endeavors to retort the following research questions. How to implement the OBE system for engineering programs? How to define and map the Program Educational Objectives (PEOs) to the university vision and mission? What is the graduate attributes to be attained at the completion of the program? How to define and assess the Course Learning Outcomes (CLOs)? What is the overall hierarchical structure for OBE? What is the continuous process to check and improve the overall OBE structure?

The organizational structure of the paper is as follows: Section 2 describes the assessment policy of the OBE system. Section 3 explains the redefining and the assessment process of the Program Educational Objectives (PEOs). Section 4 consists of the declaration of the graduate attribute as Program Learning Outcomes (PLOs) and their mapping to the PEOs. Section 5 describes the defining process of the Course Learning Outcomes (CLOs), assessment process and the revision process. Section 6 details the rubrics formed for various assessments under the OBE system.

## 2. QUALITY OBE SOFTWARE

The evaluation and assessment of the Outcome-Based Education system (OBES) were accomplished using the quality of one software. In each semester, the subjects of different batches were added in the software and allotted to the course instructors which could be viewed, edited and updated on the corresponding instructor portal. At the start of the semester, the instructors updated the CLOs, their taxonomy level and mapping of the CLOs to the PLOs, and their evaluating activities. During the semester, the marks of quizzes, assignments, midterm, and final terms were uploaded on the software and different reports related to the students, PLOs attainment, CLOs attainment, PEOs attainment with and without CQI were generated. All the features that are required to implement the OBE system are available in the Q-OBE software as shown in Figure 1.

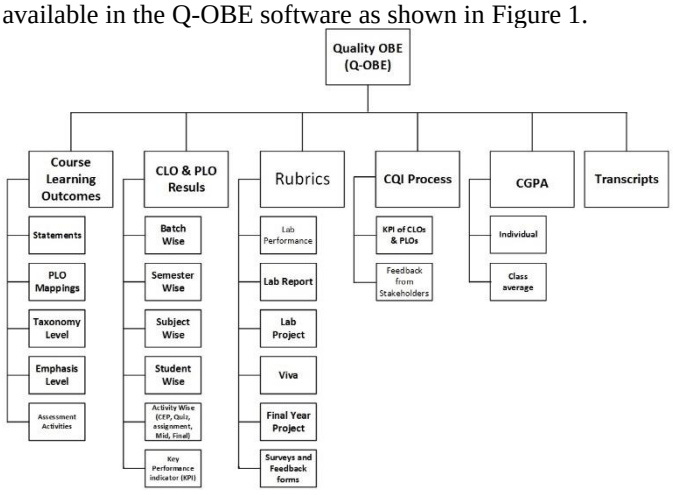


**Figure 1: Features of Q-OBE Software**

## 3. ASSESSMENT POLICY OF OUTCOME-BASED EDUCATION

The assessment strategy of the OBE system consists of three loops as shown in Figure 2. These three loops are interconnected showing the implementation of the university vision and mission in a systematic way. The inner loop shows the implementation and assessment of the CLOs and their mapping to the PLOs. The central loop is the assessment of the PLOs taking feedback from the inner loop of CLOs and showing its mapping to the PEOs in the outer loop. The outer loop is the assessment of the PEOs taking PLOs attainment feedback from the central loop and the alumni and employer survey feedback.

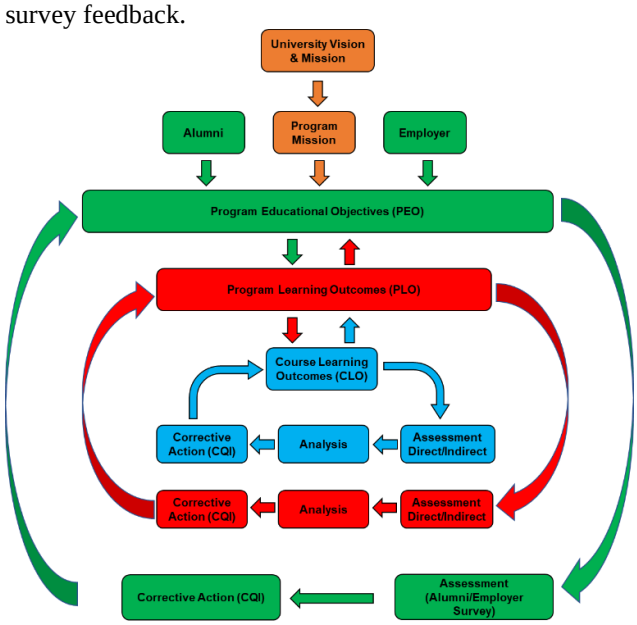


Figure 2: Assessment policy of the OBE system

## 4. PROGRAM EDUCATIONAL OBJECTIVES

The purpose behind the implementation of the OBE system was to implement the university mission and vision through the PEOs of the electrical engineering department. PEOs are the comprehensive statements depicting the university mission and vision and realize the attributes of a graduate by the completion of the degree program. The following four PEOs were defined for the electrical engineering department. Each PEO was defined such that it could be mapped to the twelve PLOs defined by the Pakistan Engineering Council (PEC).

**PEO1**: Our graduates will be proficient engineers in respective industries, academia or engage themselves in entrepreneurial activities.

**PEO2**: They will exhibit adaptation to advancements in knowledge for creating solutions to complex engineering problems.

**PEO3**: Graduates will contribute to effective team members and managers in their organizations.

**PEO4**: Graduates will exhibit ethical Islamic values and demonstrate a commitment to their responsibility toward sustainability and the safety of society and the environment.

Every year these PEOs are updated by the Alumni survey feedback, faculty feedback and the employer survey feedback collected by the QEC. The departmental board of studies seeks suggestions and recommendations from the QEC, WAC, CQI, and industrial advisory board to define and finalize the PEOs in the board of studies. On fulfilling the university and department mission and vision ensuring the graduates' attributes, the PEOs are approved by the academic council otherwise the departmental board of studies consult the above-stated entities and revise the process. The revision

process of the PEOs is shown in Figure 3. The 1st criterion of the Pakistan Engineering Council accreditation manual is the evaluation of PEOs, and the consistency of PEOs to the program mission and university vision and mission.

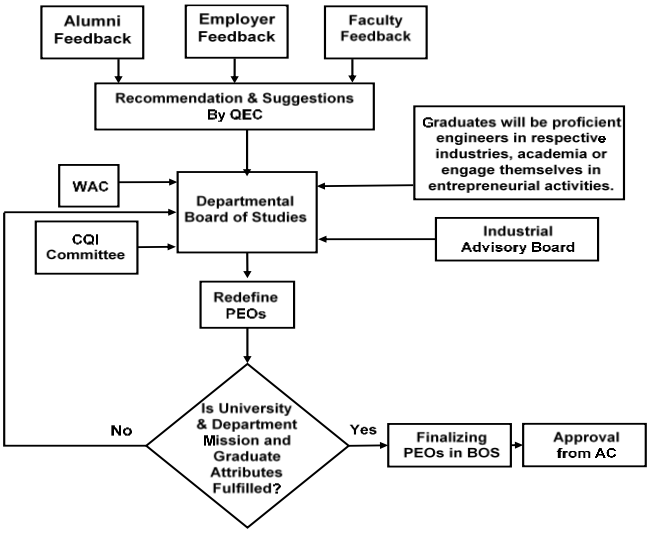


**Figure 3: Process for establishing and redefining the PEOs**

### 4.1. Alumni feedback

To evaluate whether the PEOs are fulfilling the university mission and vision, and alumni feedback survey was conducted based on the attributes mapped to the PEOs shown in Table 1. The survey was based on the questioner consisting of the organizational profile, alumni profile and, attributes. The attributes were evaluated on a Likert scale which was scaled on excellent, good, fair and, poor. The identity of the respondents was kept confidential. The data collected was processed and analyzed using SPSS software. Figure 4 shows the results of the alumni feedback survey. The survey revealed that the results were satisfactorily fulfilling the attributes and their concerned PEOs.

In the 2nd part of the survey feedback form, they were asked about the PEOs of the department whether they have been achieved or not on a Likert scale with options not achieved at all, slightly achieved, mostly achieved, completely achieved. Based on their experience, they were also asked to recommend any change in the PEOs.

**Table 1: Alumni feedback questions' mapping to PEOs**

| Attributes | | PEO1 | PEO2 | PEO3 | PEO4 |
|---|---|---|---|---|---|
| Q1 | Engineering knowledge | ✓ | | | |
| Q2 | Problem formulation and solving skills | | ✓ | | |
| Q3 | Time management skills | | | ✓ | |
| Q4 | Collecting and analyzing appropriate data | | ✓ | | |
| Q5 | Ability to link theory to practice | ✓ | | | |
| Q6 | Professional development | | | | ✓ |
| Q7 | Ability to design a system component or process | ✓ | | | |
| Q8 | Software knowledge and usage | | ✓ | | |
| Q9 | Discipline | | | ✓ | |
| Q10 | Oral communication | | | ✓ | |
| Q11 | Report writing | | | ✓ | |
| Q12 | Independent thinking | | | ✓ | |
| Q13 | Presentation skills | | | ✓ | |
| Q14 | Ability to work in teams | | | ✓ | |
| Q15 | Judgment | | | ✓ | |
| Q16 | Appreciation of ethical values | | | | ✓ |

### 4.2. Employer feedback

The employer feedback survey was conducted through the employer feedback forms dispatched to the employers either giving jobs to the graduates or internships to the engineering students. The survey questions are mapped to the PEOs shown in Table 2. Figure 5 shows the employer feedback survey results. The questionnaire is specially designed and approved by competent authorities through a well-defined process to include all the characteristics required from industrial point-of-view. Employer feedback form is designed through the suggestions of students, faculty members, members of OBE committee and CQI committee of Riphah International University, Faisalabad. Moreover, this questionnaire was discussed in detail and modified carefully after the suggestions given by the members of the Industrial Advisory Board (IAB). It is then approved by the Departmental Board of Studies, Board of Faculty and Academic Council respectively. While special consideration was given to PEOs during this whole process.

**Table 2: Employer feedback questions' mapping to PEOs**

| Questions | | PEO1 | PEO2 | PEO3 | PEO4 |
|---|---|---|---|---|---|
| **Q1** | Technical Work Potential | ✓ | | | |
| **Q2** | Work Quality | ✓ | | | |
| **Q3** | Communication skills | | | ✓ | |
| **Q4** | Team Work capacity | | | ✓ | |
| **Q5** | Individual Work capacity | | | ✓ | |
| **Q6** | Takes initiative | | ✓ | | |
| **Q7** | Creative skills | | ✓ | | |
| **Q8** | Honesty | | ✓ | | |
| **Q9** | Integrity | | | | ✓ |
| **Q10** | Coworker relation | | | | ✓ |
| **Q11** | Client relation | | | ✓ | |
| **Q12** | Technical Skills | | | ✓ | |
| **Q13** | Punctuality | | ✓ | | |
| **Q14** | Environment risk assessment | | | ✓ | |
| **Q15** | Follow Sop's for safety and sustainability of society | | | | ✓ |

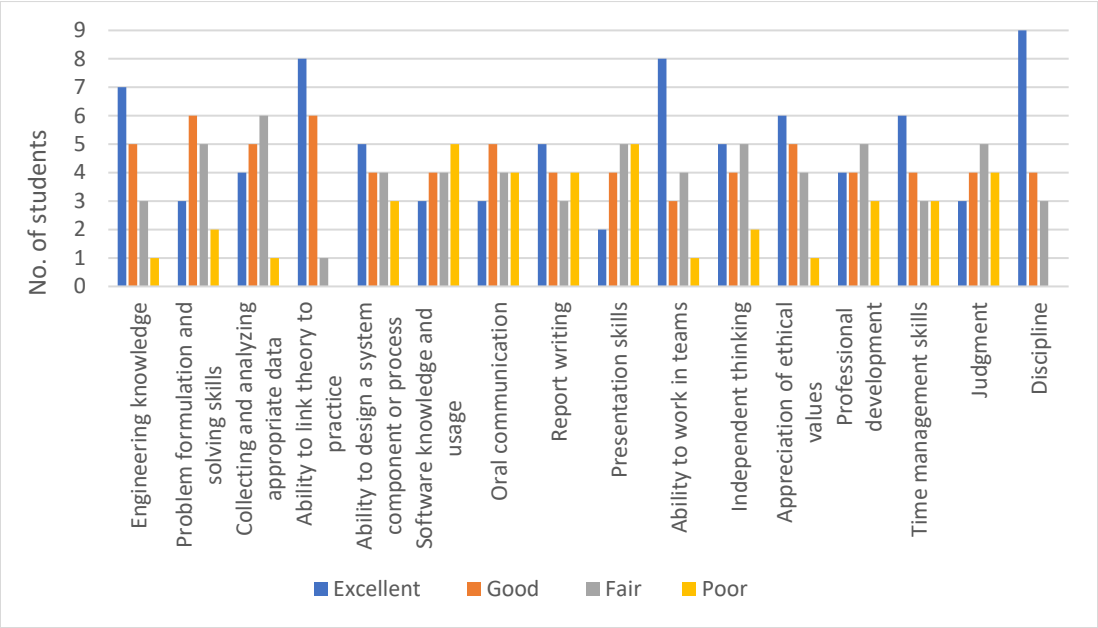


**Figure 4: Alumni feedback results**

## 5. PROGRAM LEARNING OUTCOMES

Program Learning Outcomes (PLOs) are the learning outcomes or the attributes that a graduate must possess after the completion of the degree and utilize them in professional life. PLOs should be written in a way that the PEOs must be reflected in the PLOs. Twelve graduate attributes designed by Washington Accord also given in the PEC accreditation manual 2014 are adopted to define the Program Learning Outcomes (PLOs) for the Electrical Engineering Program shown in table 3. The mapping of the PLOs to the PEOs is shown in Table 4. Figure 6 shows the frequency of the achievement of PLOs by the under-study students' batch. The frequency of the achievement of PLO 2 is higher while the PLO 9 was achieved 3 times only. The consolidated results at the end of the 8th semester were evaluated by averaging the results in PLOs throughout the degree program. If the average of each PLO was less than the KPI (40 %), The PLO was failed, and the student was asked to pass that particular PLO through the CLO. The process is shown in Figure 7. The 2nd criterion of the PEC accreditation manual is to assess the attainment of PLOs, mapping of CLOs to the PLOs, and mapping of PLOs to the PEOs.

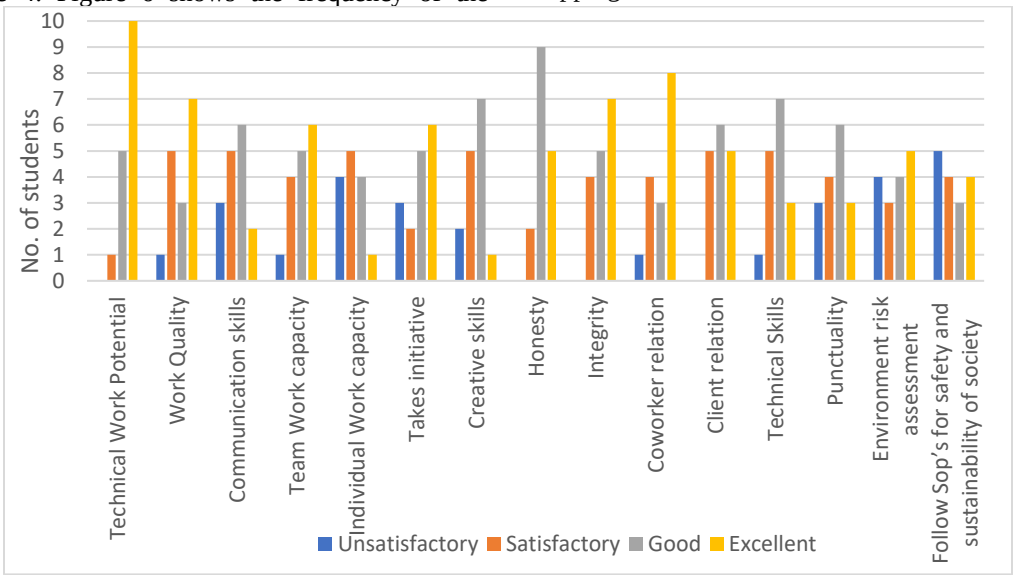


**Figure 5: Employer Feedback results**

**Table 3: Program Learning Outcomes**

| | | |
|---|---|---|
| 1 | **Engineering Knowledge** | Ability to apply basic engineering, mathematical and scientific knowledge to devise a way for Solving Complex Engineering Problems (CEP). |
| 2 | **Problem Analysis** | An ability to understand the available literature for CEP analysis developing substantiated conclusions through first mathematical principle, engineering science, and natural science. |
| 3 | **Design and Development of Solutions** | An ability to select appropriate components, processes, techniques or methods to develop systems through designing solutions for CEP keeping in view of public health, safety, cultural, environmental and any other societal considerations. |
| 4 | **Investigation** | An ability to investigate CEP in a systematical way through literature survey, experiments, analysis, interpretation and synthesis to extract valid conclusions. |
| 5 | **Modern Tool Usage** | An ability to develop, choose and apply appropriate algorithms, available resources, and advanced IT tools, prediction and modeling must be a part of complex engineering activities, with proper knowledge of the limitations. |
| 6 | **The Engineer and Society** | An ability to inculcate the societal needs and issues, such as health, legality, cultural and safety, into their professional Engineering practices while looking to solve the CEP. |
| 7 | **Environment and Sustainability** | An ability to apprehend the impact of devised solutions on society and the environment with profound knowledge and obligation of sustainable development. |
| 8 | **Ethics** | An ability to demonstrate ethical values with the commitment to be professionally ethical, responsible and to follow standards of engineering practice. |
| 9 | **Individual and Team Work** | An ability to prove to be equally effective as an individual as well as working in a team, on multidirectional/multidimensional and /or multidisciplinary settings. |
| 10 | **Communication** | Ability to develop effective oral and writing communication skills with the engineering community along with society at large to document, design, present, comprehend instruct and receive the problems and solutions related to complex engineering practices. |
| 11 | **Project Management** | An ability to demonstrate management skills through applying principles of engineering as being a part of and/or leading a team. Hence, managing projects in a transdisciplinary framework. |
| 12 | **Lifelong Learning** | An ability to acknowledge and pursue the significance of lifelong learning under the light of innovation and technological advancements. |

**Table 4: PLOs mapping to PEOs**

| Program Learning Outcomes | PEO1 | PEO2 | PEO3 | PEO4 |
|---|---|---|---|---|
| **PLO1** | ✓ | | | |
| **PLO2** | | ✓ | | |
| **PLO3** | | ✓ | | |
| **PLO4** | | ✓ | | |
| **PLO5** | | ✓ | | |
| **PLO6** | | | | ✓ |
| **PLO7** | | | | ✓ |
| **PLO8** | | | | ✓ |
| **PLO9** | | | ✓ | |
| **PLO10** | | | ✓ | |
| **PLO11** | | | ✓ | |
| **PLO12** | | ✓ | | |

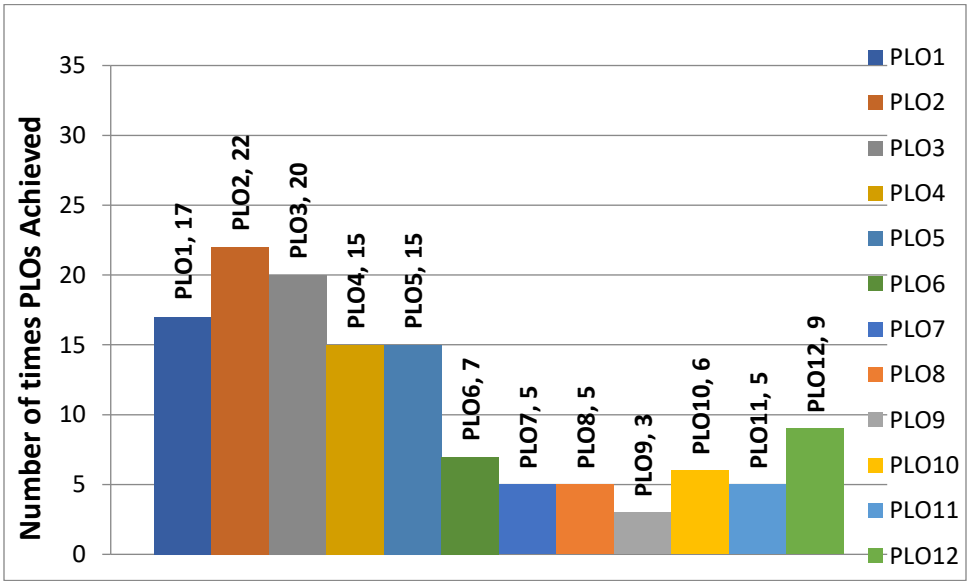


**Figure 6: Frequency of PLOs attainment**

## 6. COURSE LEARNING OUTCOMES

Course learning outcomes were defined using the standard format: action verb from the Bloom Taxonomy, object, and condition. The instructor of each course was asked to define at least four CLOs for the theory courses and two for the lab courses covering the complete contents of the course. Action verb was chosen from the Bloom taxonomy: theory subjects were covered in the cognitive domain, lab courses in the psychomotor domain and the allied courses in the affective domain. Each CLO was mapped to a PLO. Table 5 shows the Bloom Taxonomy levels used in defining the CLOs.

Each PLO was evaluated through a CLO and a CLO was evaluated through a direct and indirect assessment. In indirect assessment, student feedback, alumni feedback, and employer feedback were used while for direct assessment each CLO was evaluated at least in three assessment activities like quiz, assignment, mid-term exam, and final term exam, project work, and lab performance. Assessment tools, assessment criteria, and frequency of data collection in a semester are detailed in Table 6. Key Performance Indicator (KPI) to pass a CLO was set 40 % for each CLO. The revision process of the CLOs is shown in Figure 7. After the announcement of the results, the batch advisor sought the faculty review of each student and communicated the OBE committee about the CLO failing/passing students and delivered the results to the CQI committee through the head of the department. The CQI committee analyzed the results and decided whether the students passing a CLO was greater than or less than the KPI and took the corrective actions. If more than 40 % (KPI) students were failing a CLO, the CQI conveyed the concerned instructor to redefine that CLO by redesigning its complexity, redefining the emphases level, redefining the KPI or reviewing the contents of that course. A sample of the CLOs declaration, mapping of CLOs to the PLO, and CLOs assessment activities are given in ANNEXURE 1. ANNEXURE 2 shows the sample of the CLOs evaluation of the students. The 3rd criterion of the PEC accreditation manual is the assessment of course contents and the level of achievement of PLOs through the assessment of CLOs by using different assessment methods (direct/indirect). Course contents also include the lab works, Final year Project and the internship programs.

**Table 5: Bloom Taxonomy domains for CLO formulation**

| Cognitive domain | Psychomotor domain | Affective domain |
|---|---|---|
| Knowledge (C1) | Perception (P1) | Receiving phenomena (A1) |
| Comprehension (C2) | Set (P2) | Responding phenomena (A2) |
| Application (C3) | Guided response (P3) | Valuing (A3) |
| Analysis (C4) | Mechanism (P4) | Organizing values (A4) |
| Synthesis (C5) | Complex overt response (P5) | Internalizing value (A5) |
| Evaluation (C6) | Adaptation (P6) | |
| | Origination (P7) | |

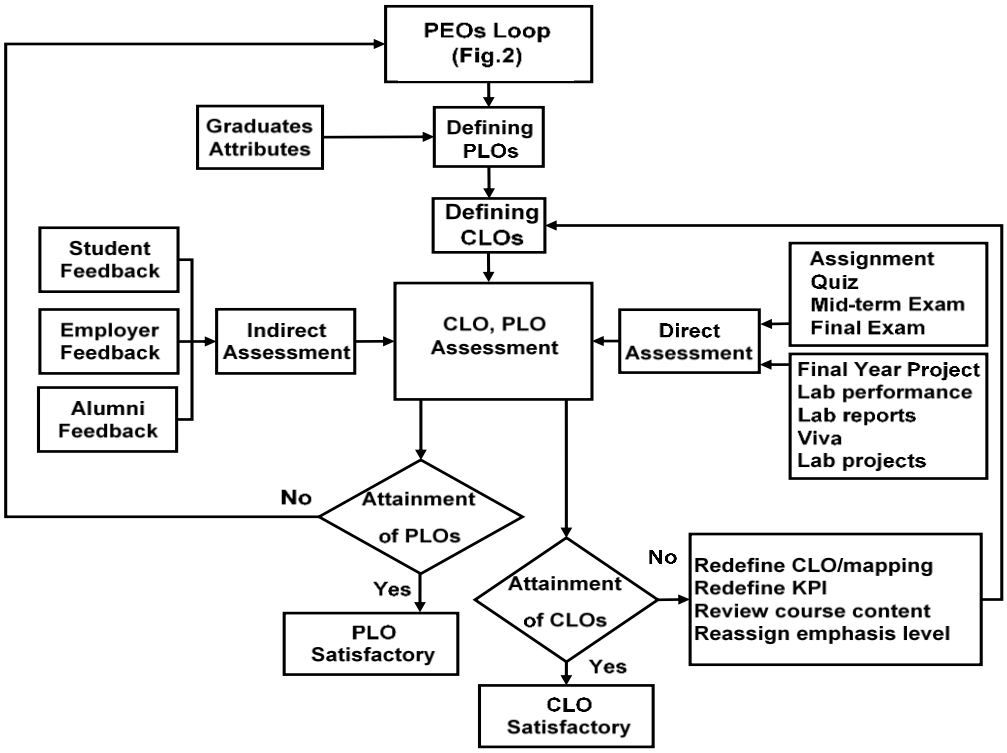


**Figure 7: Process for defining and assessment of PLOs and CLOs**

**Table 6: CLOs assessment tools and process**

| Type of Assessment tool | Assessment tool | Assessment criteria | Evaluation frequency | Responsible entity |
|---|---|---|---|---|
| **Direct** | Assignment | Marks | Twice a semester | Course instructor |
| | Quiz | Marks | Twice a semester | Course instructor |
| | Mid-term exam | Marks | Once apiece semester | Departmental BoE |
| | Final Exam | Marks | Once apiece semester | Institutional BoE |
| | Final Year Project | Marks in grade (Rubrics) | Once per 4 year | Internal supervisor, internal evaluator, and an external co-supervisor from industry or academia |
| | Lab performance | Marks in grade (Rubrics) | 14-16 times per semester | Lab instructor |
| | Lab report | Marks in grade (Rubrics) | 14-16 times per semester | Lab instructor |
| | Lab project | Marks in grade (Rubrics) | Once apiece semester | Lab and course instructor |
| **Indirect** | Students' feedback | Level of satisfaction | Once apiece semester | QEC |
| | Employer feedback | Level of achievement | Once apiece semester | QEC |
| | Alumni feedback | Level of achievement | Once per year | QEC |
| | Faculty feedback | Level of achievement | Once per year | QEC |

## 7. RUBRICS

The rubrics are meant to assess the learning goals of the graduates in professional judgment. Instead of a grade-based examination, rubrics evaluate the knowledge, skills, and attitude of the learners in a systematic way. The students consider the rubrics as a source to prepare their work in a logical way to be assessed to a required standard. Under the OBE system, various rubrics were formed for Final Year Projects (FYP) presentation, FYP demonstration, FYP report, class presentations, complex engineering problems, and lab works.

### 7.1. Final year project

In FYP presentation, along with two internal evaluators, an external evaluator from industry or academia were invited. Other faculty members from the department were also requested to attend. Each evaluator: project supervisor, co-supervisor, two internal evaluators, and an external evaluator were provided rubrics for FYP presentation, FYP report and FYP evaluation. In rubrics, four scales were given on the Likert scale against the attributes. Unsatisfactory presented marks 0, developing (1-2), satisfactory (3-4), and exemplary (5). The data collected from the filled rubrics were analyzed using SPSS software. Twelve CLOs were defined for the FYP and each was mapped to a PLO and these CLOs were evaluated in FYP attributes. Figure 8, Figure 9, and Figure 10 present the results of the FYP presentation, FYP report, and FYP evaluation respectively.

### 7.2. Complex engineering problem

Complex Engineering Problem (CEP) was assigned to the students in each semester. It was conveyed to the instructors that CEP did not mean a difficult problem to be solved. In fact, the complexity level was increased from the first semester to the eight semesters. Eight attributes named depth of analysis required, range of conflicting requirements, Depth of knowledge required, the familiarity of issues, the extent of applicable codes, Extent of stakeholder involvement and level of conflicting requirements, consequences, and interdependence were evaluated in each CEP. It was on the instructor to evaluate any of the above-stated attributes in CEP. Other than the course CLOs, four separate CLOs were defined for the CEP. According to the Washington Accord, complex engineering problems are problems that: Involve wide-ranging or conflicting technical, engineering and other issues, have no obvious solution and require abstract thinking and originality in analysis to formulate suitable models.

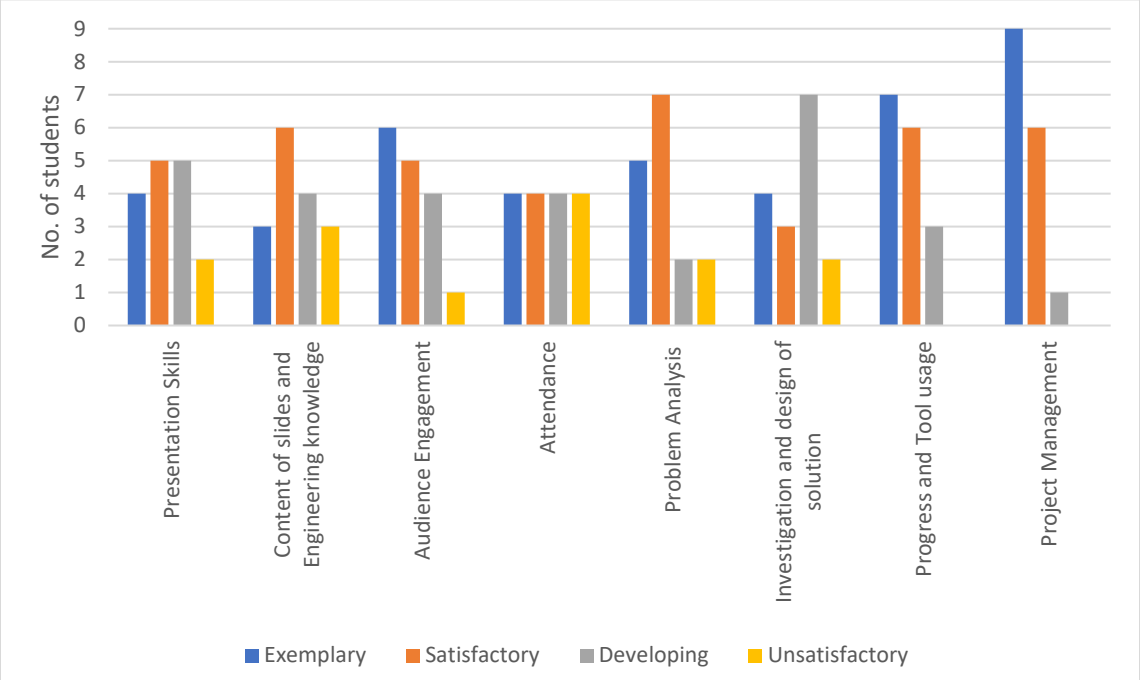


**Figure 8: Results of the FYP presentation evaluation**

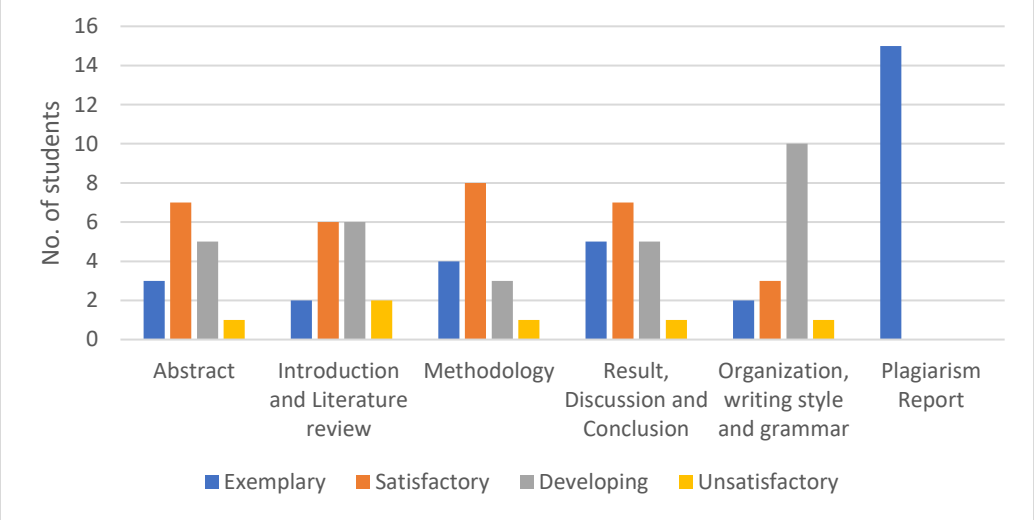


**Figure 9: Results of the FYP report evaluation**

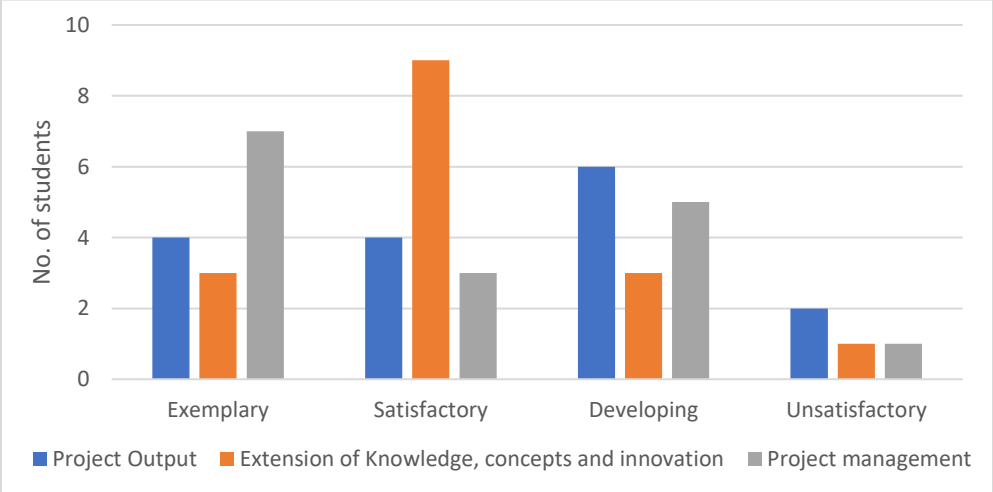


**Figure 10: Results of the FYP demonstration evaluation**

### 7.3. Problem-based learning

Problem-based learning is a pedagogy in which student is a cynosure of the outcomes in which an open-ended lab's statement is provided to the students connected to the previous lab experiment. The problem-based learning as an open-ended lab was implemented in 6th, 7th and 8th semesters. The open-ended lab was evaluated using rubrics. According to Nilson, PBL must provide the opportunity to develop the following skills:

- Teamwork
- Project management and leadership roles
- Communication skills development
- Ability to work independently
- Think, analyze and evaluate critically
- Ability to explain Concepts
- Ability to apply the concepts to solve real-world problems
- Promote self-learning
- Enhancing research skills
- Thinking out of the box to solve across discipline problems.

Open-ended labs are specially targeted to achieve these above-mentioned skills, though not a standard, also, it is not compulsory to achieve all of these yet fair enough to be followed.

### 7.4. Lab works

Four parts of the lab work named lab performance, lab report, viva, and lab projects were evaluated through rubrics. For lab performance, two rubrics for each experiment were defined named the ability to conduct the experiment (0-15) and implementation & results (0-15). Similarly, two rubrics to evaluate the lab report were defined named organization & structure (0-10) and data presentation (0-10). Two rubrics named responsiveness to questions/accuracy (0-10) and depth of subject knowledge (0-10) were defined for the viva. Eleven rubrics named Implementation and completion (0-5), Appearance (0-5), Organization/Structure (0-5), Results and Discussion (0-5), Responsiveness to Questions/Accuracy (0-5), Depth of Subject Knowledge (0-5), Organization (0-5), Confidence (0-5), Responsiveness to Audience (0-5), Share Information (0-5), and Fulfill Team Role's Duties (0-5) were defined to assess the lab projects.

## 8. CONCLUSION

In this paper, the implementation of the outcome-based education system under the Washington accord signatory and the outcomes achieved have been described. The implementation and the assessment process under the OBE system have been clearly explained. The results revealed that the OBE system is completely student-oriented that assesses the learning outcomes of the program in a true sense. The key stakeholders: students, teachers, employers, parents, and the institute are necessary to implement and reform the OBE process. Strengthening the industrial academia linkage, the PEOs were improved through the loop shown in fig considering the suggestions in the alumni feedback, and employer feedback. The intended program learning outcomes were successfully achieved confirming the achievement of the PEOs and the university vision and mission. The presented research would be a guideline for the public and private institutes wishing to implement the OBE system under the Washington accord accreditation of the Pakistan Engineering Council. Batch 16 of the electrical engineering department where the OBE system was implemented as discussed in the paper got level II accreditation of Pakistan Engineering Council.

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