

Scrutinizing Outcome Assessment of Outcome-based Education using Q-OBE in Engineering Education

Sania Bhatti¹, Mariam Memon², Areej Fatemah Meghji³



Abstract

Educational institutions constantly strive to meet accreditation requirements which demand continuous improvement in the quality of education. As a consequence, there has been an active shift in strategizing pedagogical processes towards an outcome-based approach of learning. To effectively implement the Outcome Based Education (OBE) framework in Pakistan, universities need to ensure that the OBE system is fully understandable to the faculty members and students; confirm the implementation of the OBE system according to the guidelines set forth by the Pakistan Engineering Council (PEC); and acquire the accreditation of engineering programs, formalized through the Washington Accord and governed by the PEC. A key challenge in implementing OBE is in its assessment process. Education programs have to compute students' attainment of learning outcomes as measured by multiple courses offered within each program. Q-OBE was implemented to automate the process of assessment and to produce detailed reporting of each student's aggregated outcomes in a visually effective format. Q-OBE takes the assessment marks as the input and accurately tracks how well the students attain the intended learning outcomes in terms of both Course Learning Outcomes (CLOs) and Program Learning Outcomes (PLOs). This study reports on the implementation of Q-OBE in engineering education. The main aim is to show how Q-OBE, a GUI-based software, automates calculating students' outcomes incorporating both CLOs and PLOs achievements. An attempt has also been made to make explicit the OBE implementation via well-documented and reliable procedures across the institutions.

Keywords: *Outcome Based Education (OBE), Assessment and Evaluation, Automation System, Course Learning Outcome (CLO), Program Learning Outcome (PLO)*

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1. Introduction

The basic motivation behind the transformation of various engineering programs at Mehran University of Engineering and Technology (MUET), Pakistan, according to the Outcome-based Education (OBE) system (Bansal, Bansal, & Dalrymple, 2015; Lui & Shum, 2012; Premalatha, 2019; Wong & Cheung, 2011) was the decision taken by the Pakistan Engineering Council (PEC) to make Pakistan a member of the Washington Accord (Business Standard, 2017). The work in this regard started in mid-2015. The department of Software Engineering at MUET also commenced its journey toward OBE in 2016. The faculty developed the Course Learning Outcomes (CLOs) for each course and mapping of their respective courses with the twelve standard Program Learning Outcomes (PLOs) provided by the Pakistan Engineering Council (PEC) in its 2014 accreditation manual (PEC Accreditation Manual Pakistan, 2014).

The implementation of the OBE framework in Pakistan has introduced numerous major educational obligations for universities. Three of these are: i) to make sure that the OBE system is fully understandable to faculty members and students, ii) to confirm the implementation of the OBE system according to PEC guidelines, and iii) to acquire the accreditation of engineering programs, formalized through the Washington Accord and governed by the PEC.

One key challenge in implementing OBE is in its assessment process, where the education programs have to compute students' attainment of learning outcomes as measured from multiple courses offered within each program (Chan, Wang, & Arbai, 2022; Luzan, Titova, Kurok, & Mosia, 2021). Thus, to automate the assessment process (Mohamed-Kassim & Kamaruddin, 2017; Othman & Abdullah, 2019), the university implements Q-OBE (<https://qualityobe.com/>). Q-OBE is a learning management system (LMS) with a Graphical User Interface (GUI). The GUI is an interface specifically designed to provide a user-friendly mechanism of interacting with a software. Q-OBE allows educational institutes to sustain, refine, and enhance the quality of education using the OBE framework. It is used to produce detailed reporting of each student's aggregated outcomes in a visually effective format. These requirements necessitate faculty and institution to carefully document their teaching and learning processes guided by the PEC in its Accreditation Manual of 2014 (PEC Accreditation Manual Pakistan, 2014).

Q-OBE takes the assessment marks as the input and accurately tracks how well students attain the intended learning outcomes in terms of both CLOs and PLOs. The key performance indicators (KPI) for PLO attainment are set by the university. PLO attainment is dependent on direct and indirect assessment methods. Indirect assessment is carried out using graduating survey, which is

collected at the time of graduation. The direct individual assessment measures the attainment via CLOs and 50% CLOs mapped to certain PLO should be achieved.

Table 1 shows the data input at the course level in the Q-OBE.

Table 1

Sample calculation of learning outcomes of a student in a course

| CLO | PLO | CLO Weight * credit | Assessment Methods | | | | | Marks obtained in CLO |
|-------|------|---------------------|--------------------|------------|-----------------------------------|-------------|-------------|-----------------------|
| | | | Midterm Marks | Test Marks | Problem-based learning assignment | Final marks | Exam | |
| CLO1 | PLO1 | 0.25 x 3 = 0.75 | 16/20= 0.8 | 3/5= 0.6 | | | | 19/25= 0.76 |
| CLO2 | PLO4 | 0.34 x 3 =1.02 | | 4/5= 0.8 | 4/5=0.8 | | 20/24= 0.83 | 28/34= 0.82 |
| CLO3 | PLO3 | 0.41 x 3 =1.23 | | | 4/5=0.8 | | 30/36= 0.83 | 34/41=0.83 |
| Total | | 3 | Weighted Average | | | | | 81% |

Table 1 illustrates the calculations of outcomes attainment for one student in a course as derived from four assessment methods. These calculations document the mapping of assessment methods with the subject-specific CLOs, and the PLOs of the program (Ovinis, Karuppanan, Sulaiman, Melor, Paiz, & Urquia, 2018). When the calculation is scaled up by the addition of CLOs of all the subjects of the program then complications are ascended.

Table 2

Mapping of PLOs with the CLOs using Blooms Taxonomy levels

| Course Title | Learning Domains and Taxonomy Levels | | | | | | | | | |
|--|--------------------------------------|------|------|------|------|------|------|------|------|-------|
| | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 |
| Applied Calculus | | C4 | | | | | | | | |
| Programming Fundamentals | C3 | | | | P3 | | | | | |
| Introduction to Info. & Comm. Technologies | C2, C3 | | | | P3 | | | | | |
| Functional English | | C3 | | | | | | | | C2 |
| Applied Physics | C1, C2 | | | | | | | | | |
| Object Oriented Programming | C2, C3 | | | | P3 | | | | | |
| Professional Practices | C2 | | | | | A3 | | A3 | | |
| Linear Algebra & Analytical Geometry | | C4 | | | | | | | | |
| Pakistan Studies | | | | | | C2 | C2 | | | |
| Islamic Studies | | | | | | C2 | | C2 | | |
| Ethics | | | | | | C2 | | C2 | | |
| Introduction to Software Engineering | C2, C3 | | | | | | | | | |

Table 2 shows the mapping of PLOs with the CLOs using Bloom's Taxonomy levels (Azuma, Coallier, & Garbajosa, 2003; Huitt, 2011) for the subjects of the first year of the software engineering program. After designing the subject-

specific CLOs, these are approved by the statutory bodies of the university before implementation.

Despite the wide transition of multiple universities across Pakistan towards the OBE system by utilizing Q-OBE, not a single study shows the outcome assessment of the OBE system using Q-OBE in engineering institutions in Pakistan.

1.1 Objectives of the Study

The three objectives of this work were to:

1. To demonstrate how the GUI-based software Q-OBE automates the process of calculating students' outcomes incorporating both CLOs and PLOs achievements.
2. To make explicit the OBE implementation via well-documented and reliable procedures across the institutions.
3. To perform an in-depth analysis of CLO and PLO attainment in tabular and graphical form at the course, semester, student, and program level.

1.2 Significance of the Study

OBE presents a paramount reframing of how educators perceive teaching, learning, and assessment. Recently, it has become a de facto standard for student centric education. The implementation of OBE in Pakistan is still in its infancy and the assessment framework is not, as yet, fully understood. This study reports on the implementation of Q-OBE in engineering education with the aim is to show how Q-OBE, a GUI-based software, automates calculating students' outcomes incorporating both CLOs and PLOs achievements. The proper understanding of the implementation of OBE and the assessment procedure available through Q-OBE will help to meet the promise and potential of OBE.

2. Literature Review

Nayak (2019) demonstrates the computation of the CLO attainment based on the marks obtained in sessional tests, assignments, and the final semester exam. Pradhan (2021) highlights the use of OBE to systematically design and restructure curriculum and evaluate the effectiveness of a teaching strategy. The study focused on the assessment strategy of the framework on students of an engineering college. The difficulties faced in the implementation of the OBE framework have also been highlighted.

Focusing on the two courses of Fluid Mechanics and Thermodynamics mapped to the same PLO (engineering knowledge and problem analysis), Chan, Wang and Arbai (2022) attempted to quantify student performance in OBE. Instructors teaching the courses were asked to fill out a questionnaire regarding the 9 students targeted in the research. The authors proposed a dynamic OBE

model that determines OBE matrices by incorporating assessment marks. The necessary calculations for OBE were performed on a software named MIKA which embeds VBA macro functions in Excel.

Mohamed-Kassim and Kamaruddin (2017) automated the OBE assessment process by implementing iCGPA software adopted in Malaysia at the course and program levels. They also highlighted the overall working procedure of iCGPA mathematically and presented the collective attainment of CLOs and PLOs graphically. Further they used Spiderweb to show the PLO attainment of individual students. Jaafar et al. (2008) demonstrated the working of an office automation system used to assist the faculty of the various departments of Universiti Putra Malaysia to monitor the development of the various PLOs. In OBE, as evidence of outcome achievement is needed in order to show that a student has achieved a desired outcome, Bansal, Mishra and Sachdeva (2021) demonstrate the use of an evaluation framework to measure the attainment of a PLO.

Chiang, Zhang and Cheng (2022) have proposed a quality instructional management system that integrates the features of a learning management system and OBEs Continuous Quality Improvement (CQI). The system contains data regarding student assignments, test results, feedback from instructors, attendance details, and course activities. The data in the system can be categorized broadly as student data, instructional methods, and administrative support. Based on the data, the system creates a holistic visual representation of achievements to foster practical administrative decisions through the alignment of PLOs and CLOs whilst reducing the ambiguity caused by the misinterpretation of data links.

A systematic literature review was conducted by Othman and Abdullah (2019) with the goal of determining the potential of graduate analytics in CGPA system. The findings of their research indicated a large gap in the research area and highlighted how these systems can be expanded to improve higher education.

More than thirty universities across Pakistan utilize Q-OBE to implement the OBE system and fulfill the accreditation requirements specified by PEC. However, an examination of the literature showed that there is not a single study showing the outcome assessment of the OBE system using Q-OBE in engineering institutions in Pakistan.

3. Research Methodology

The objectives of the study were achieved by a four-step approach which comprised of:

Step 1: Understanding

The first step of the research comprised of understanding PLO mappings with all CLOs of an engineering degree program and getting familiar with Q-OBE.

Step 2: Calculations

The second step focused on defining the subject-specific calculations of learning outcomes of a student in a course. The details of the calculation procedure have been depicted in section-4.

Step 3: Implementation

Various assessment methods are used in order to calculate student marks. The marks directly influence the achievement level of a CLO which in turn directly influences the level of achievement of a PLO. This step outlined the OBE implementation process in Q-OBE via variables and equations. The variables and equations pertaining to the OBE implementation process in Q-OBE have been defined in section-4.

Step 4: Detailed reporting

Q-OBE can generate the course-wise, semester-wise, student-wise, and program-wise results in a tabular format as well as graphically. This step focused on the visual depiction of the CLO and PLO attainment procedures implemented in Q-OBE. The visual representation of the CLO and PLO attainment procedure have been presented in section-5.

3.1 OBE implementation process in Q-OBE

This study has reported on the implementation of Q-OBE in engineering education. Students' marks are calculated from Assessment Methods (AM), which contribute towards the achievement of CLOs and are shown in terms of equations (1), (2), and (3). The CLO's contribution towards the achievement of PLOs are represented in equation (4), and (5). The aggregated achievement of 12 PLOs in all the courses of the four-year engineering degree program is depicted in equation (6).

Equations (1) to (6) are depicting individual students concerning CLOs and PLOs. Table 3 lists the definitions of all the variables which are used in the equations.

Table 3

Variable Definitions

| Variables | Definition |
|--------------|--|
| I | Used to control CLOs |
| J | Used to control assessment methods |
| K | Used to control PLOs |
| C | Used to control courses |
| TAM | Total marks assigned to assessment method |
| $W_{CLO, i}$ | The weightage assigned to AM in the respective course |
| $Y_{CLO, i}$ | CLO outcome in the respective course of the degree program of individual student |

| | |
|-----------------|--|
| $T_{CLO,i}$ | Total weightage assigned to CLO in the respective course |
| $A_{CLO,i}$ | Aggregate CLO attainment (%) by individual students in a course |
| $Y_{PLO,k}$ | PLO outcome (%) in the respective course of the degree program of individual student |
| $T_{PLO,k}$ | Total PLO attainment Marks in all the courses |
| $A_{PLO,k}$ | Program outcome of each student in terms of PLOs |
| $S_{c,i}$ | Number of students enrolled in a course |
| $S_{CLO,i}$ | The number of students achieved more than 50% in respective CLOs in a course |
| $S_{CLO,i, \%}$ | Percentage of students achieving more than 50% in respective CLOs in a course |
| $S_{PLO,k}$ | The number of students achieved more than 50% in respective PLOs in a course |
| $S_{PLO,k, \%}$ | Percentage of students achieving more than 50% in respective PLOs in a course |
| S_T | Total number of students |
| n_c | Number of courses |

The CLO outcome acquired in each course of the entire degree program is calculated using equation (1). The total weightage assigned to a particular CLO in each course of the entire program is calculated using equation (2).

$$Y_{CLO,i} = \sum_{j=1}^m (W_{CLO,i} AM_j) \quad (1)$$

$$T_{CLO,i} = \sum_{j=1}^m (W_{CLO,i} TAM_j) \quad (2)$$

Aggregate CLO attainment (%) in a course is computed via equation (3).

$$A_{CLO,i} = \frac{Y_{CLO,i}}{T_{CLO,i}} * 100 \quad (3)$$

The PLO outcome (%) acquired in each course of the entire degree program is calculated using equation (4). The total PLO attainment in all the courses is computed using equation (5).

$$Y_{PLO,k} = \sum_{i=1}^n \frac{Y_{CLO,i}}{T_{CLO,i}} * 100 \quad (4)$$

$$T_{PLO,k} = \sum_{c=1}^{n_c} \sum_{i=1}^n T_{CLO,i,c} \quad (5)$$

Aggregate program outcome in terms of PLOs is computed via equation (6).

$$A_{PLO,k} = \sum_{c=1}^{n_c} \frac{Y_{PLO,k}}{T_{PLO,k}} \quad (6)$$

Class-wise student attainment to show 50% KPI achievement in the respective CLOs and PLOs is calculated via equations (7) to (11). 50% KPI achievement of students in the CLOs of a course is calculated through equations (7) and (8).

The number of students who achieved more than 50% in respective CLOs in a course is computed via equation (7) and percentages are computed using equation (8).

$$S_{CLO,i} = \sum_{i=1}^n (S_{C,i}), \quad A_{CLO,i} > 50 \% \quad (7)$$

$$S_{CLO,i,\%} = \frac{S_{CLO,i}}{s_T} * 100 \quad (8)$$

The number of students who achieved more than 50% in respective PLOs in a course is computed via equation (9) and percentages are computed using equation (10).

$$S_{PLO,k} = \sum_{j=1}^m (S_{C,j}), \quad Y_{PLO,k} > 50\% \quad (9)$$

$$S_{PLO,k,\%} = \frac{S_{PLO,k}}{s_T} * 100 \quad (10)$$

The aggregate PLO attainment of students in all the courses is calculated via equation (11).

$$S_C = \sum_{c=1}^{n_c} \frac{S_{PLO,k,\%}}{n_c} \quad (11)$$

To increase the understandability of Q-OBE, the mapping between the results of Q-OBE with equations is given in Table 4.

Table 4

Mapping between results of Q-OBE with the defined equations

| Results | Defined Equations |
|--|-------------------|
| CLO(%) of each student | (1), (2), (3) |
| PLO (%) of each student | (4) |
| Total PLO attainment of each student | (5), (6) |
| CLO attainment graph/ attainment of CLOs | KPI (7), (8) |
| PLO attainment graph | (9), (10) |
| KPI attainment of PLOs | (11) |

Figure 1
CLO attainment procedure implemented in Q-OBE

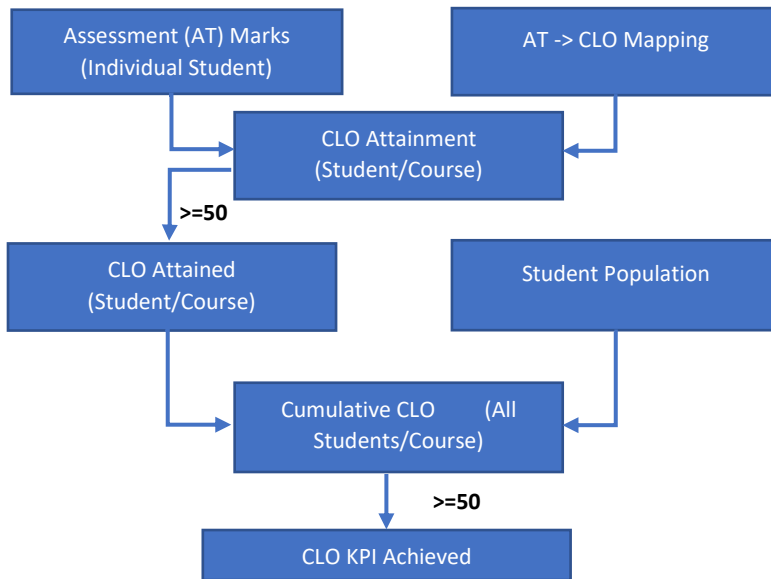


Figure 1 depicts the CLO attainment procedure implemented in Q-OBE. CLO attainment for each student is calculated based on the mapping of the Assessment Methods (AMs) (Mid Term Exam, Final Exam, Project, Tests, Assignments, etc.) to particular CLOs and the assessment marks assigned to them. An individual student is successful in achieving a particular CLO only and only if the assessment marks obtained by him are greater than or equal to 50% of the total marks assigned to that CLO through all the mapped AMs. Furthermore, if more than 50% of the student population effectively attains a particular CLO then the Key Performance Indicator for that respective CLO is also said to be achieved.

Figure 2
PLO attainment procedure implemented in Q-OBE

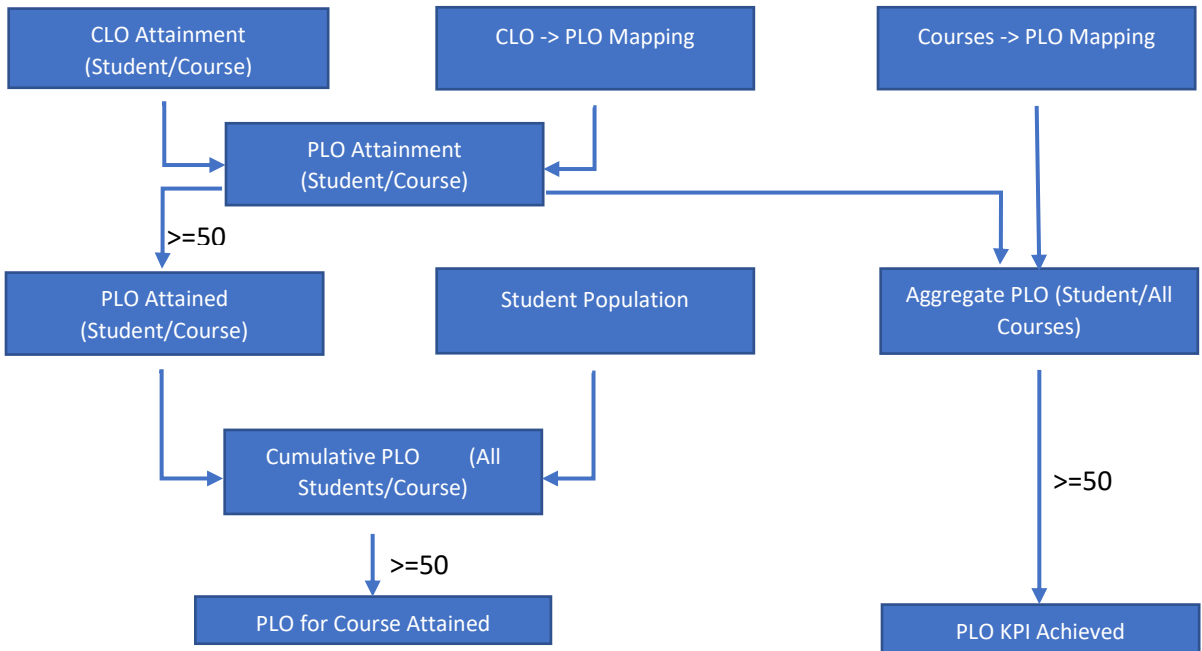


Figure 2 portrays the PLO attainment procedure implemented in Q-OBE. In Q-OBE, each CLO in a course is mapped to a specific PLO, and as already discussed each student has a CLO attainment score in every course. Based on that score and the mapping of those CLOs to PLOs, a PLO attainment percentage is computed for each student. If that percentage is greater than or equal to 50% then PLO has been successfully attained by the student in that course. Moreover, if 50% of the students enrolled have attained the PLO, then the PLO requirement for that course is also said to be achieved. The process, however, does not end here, the 12 PLOs are mapped to different CLOs in every course so the aggregate PLO attainment for each PLO is measured based on the cumulative PLO attainment score of all the courses that have that specific PLO mapped to itself. If this score is higher than or equal to 50, the Key Performance Indicator for that certain PLO is accomplished as well.

4. Results and Discussion

The chairman of the department plays the role of the admin at the departmental level. He is responsible to assign classrooms to the respective faculty members as well as map CLOs with courses and PLOs with CLOs. Figure

3 indicates all the activities controllable by the chairman. The faculty members can enroll students, add activities and add tentative teaching plans in the classrooms assigned to them by the chairman as shown in figure 4.

Figure 3

Chairman/Department Admin Activity Diagram

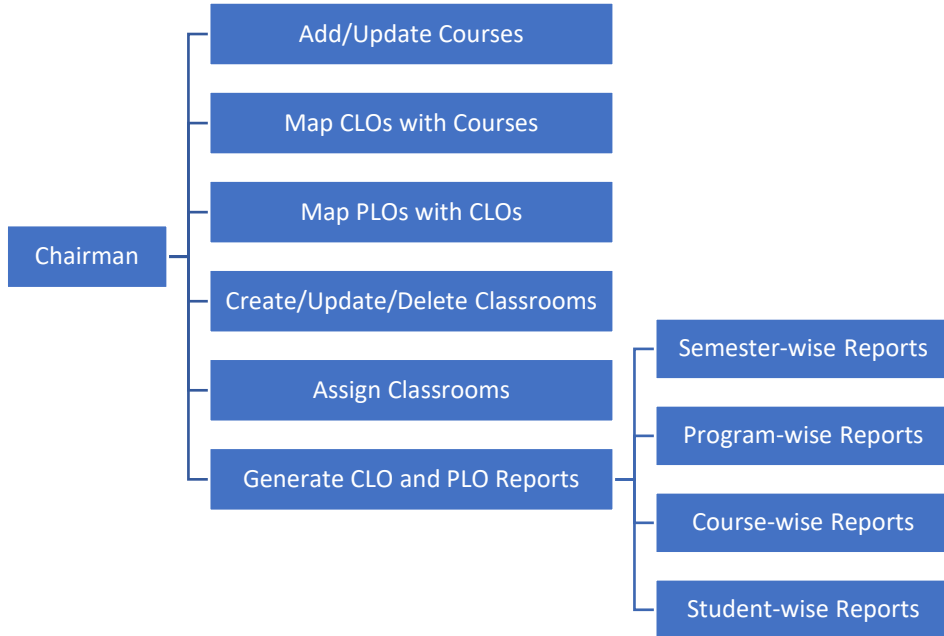
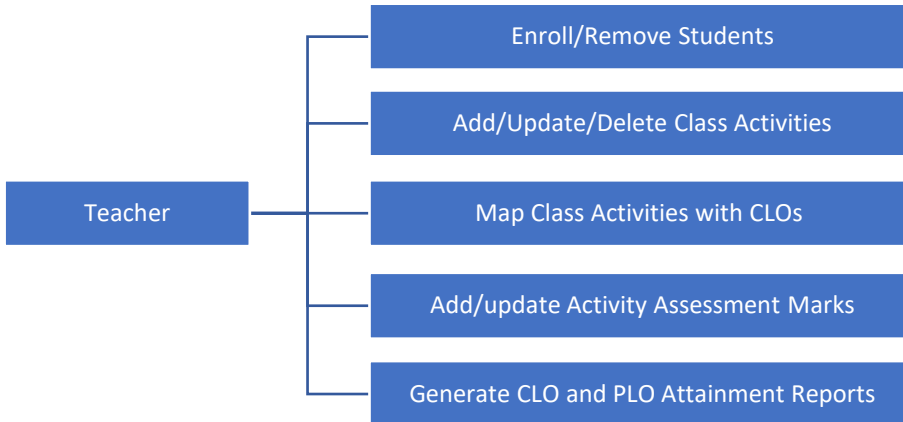


Figure 4
Teacher Activity diagram



Q-OBE can generate the course-wise, semester-wise, student-wise, and program-wise results in tabular format as well as graphically. At the course level, the CLO attainment computed via different assessment methods using (1) for an individual student is shown in figure 5.

The total weightage assigned to a particular CLO in each course is calculated using equation (2) and is depicted in figure 6. The aggregate CLO attainment percentage in individual courses obtained via (3) is revealed in figure 7. Figures 5 and 7 are examples of course-wise results. Chan, Wang, and Arbai (2022) used MIKA software and portrayed the course-wise results of an engineering program in detail. However, the CLO and PLO attainment of students in just two subjects was focused in their study.

Figure 5
CLO attainment for individual student

| CLO | CLO-1 | | CLO-2 | | | | | CLO-3 | | | | |
|------------------|----------|----------|-------------------------|------------------|---------------------------|--------------------------------|-------------------------|--------------|--------------|--------------|--------------|--------------|
| | Mid Term | Mid Term | PBL Assignment | PBL Assignment | PBL Assignment | PBL Assignment | PBL Assignment | Final Exam 1 | Final Exam 1 | Final Exam 1 | Final Exam 1 | Final Exam 1 |
| Activity | | | R5: Analysis of results | R4: Completeness | R3: Mathematical Accuracy | R2: Organization and structure | R1: Problem Recognition | Q1 | Q2 | Q3 | Q4 | Q5 |
| % Weight | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| MARKS | 10 | 10 | 2 | 2 | 2 | 2 | 2 | 12 | 12 | 12 | 12 | 12 |
| Registration No. | | | | | | | | | | | | |
| ID1 | 9.00 | 9.00 | 2.00 | 1.50 | 2.00 | 2.00 | 2.00 | 10.00 | 11.00 | 12.00 | 12.00 | 9.00 |
| ID2 | 5.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.00 | 10.00 | 11.00 | 9.00 | 0.00 |
| ID3 | 9.00 | 10.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 11.00 | 11.00 | 12.00 | 11.00 | 9.00 |
| ID4 | 9.00 | 8.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 9.00 | 8.00 | 12.00 | 9.00 | 8.00 |
| ID5 | 6.00 | 6.00 | 2.00 | 1.00 | 2.00 | 2.00 | 2.00 | 10.00 | 5.00 | 9.00 | 9.00 | 8.00 |
| ID6 | 10.00 | 9.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 7.00 | 11.00 | 12.00 | 12.00 | 2.00 |
| ID7 | 8.00 | 9.00 | 2.00 | 1.00 | 2.00 | 2.00 | 2.00 | 9.00 | 8.00 | 12.00 | 8.00 | 11.00 |

Figure 6
Total CLO Marks in individual courses

| CLO-1 | | | | CLO-2 | | | |
|-----------------------------|-------------|---------------|-------------------|-----------------------------|-------------|---------------|-------------------|
| | | Actual Weight | Normalized Weight | | | Actual Weight | Normalized Weight |
| Mid Term / Sessional Exam 1 | Q2 | 10.00 | 33.33 | Mid Term / Sessional Exam 1 | Q1 | 10.00 | 25 |
| Final Exam 1 | Q1 | 12.00 | 33.33 | Final Exam 1 | Q3 | 12.00 | 25 |
| Final Exam 1 | Q2 | 12.00 | 33.34 | Final Exam 1 | Q4 | 12.00 | 25 |
| Total | Even Weight | 34 | 100 | Final Exam 1 | Q5 | 12.00 | 25 |
| | | | | Total | Even Weight | 46 | 100 |

Figure 7

Aggregate CLO attainment percentage of each student in individual courses

| CLO | | CLO-1 | | CLO-2 | | CLO-3 | |
|------------------|----------------|----------------|--------------|----------------|--------------|----------------|--------------|
| Activity | | Weighted Total | CLO Acheived | Weighted Total | CLO Acheived | Weighted Total | CLO Acheived |
| % Weight | | | | | | | |
| | | KPI 50% | | KPI 50% | | KPI 50% | |
| Registration No. | Name | | | | | | |
| ID1 | Muhammad Usama | 84.76 | Y | 80.42 | Y | 70.00 | Y |
| ID2 | Husnain Ali | 90.48 | Y | 63.33 | Y | 70.00 | Y |
| ID3 | Ali Raza | 84.76 | Y | 85.83 | Y | 70.00 | Y |
| ID4 | Muhammad Bilal | 79.52 | Y | 73.33 | Y | 60.00 | Y |
| ID5 | Hira | 87.14 | Y | 83.33 | Y | 80.00 | Y |
| ID6 | Ambar | 92.38 | Y | 86.46 | Y | 80.00 | Y |
| ID7 | Aashir Ali | 90.48 | Y | 82.71 | Y | 60.00 | Y |

The PLO outcome (%) acquired by each student in individual courses of the entire degree program calculated using equation (4) is shown in figure 8. The total PLO attainment in all the courses by each student computed using equations (5) and (6) is portrayed in figure 9. Mohamed-Kassim and Kamaruddin, (2017) automated the OBE assessment process by implementing iCGPA software adopted in Malaysia at the course and program levels. They also highlight the working procedure of iCGPA mathematically and presented the collective attainment of CLOs and PLOs graphically. Further they used Spiderweb to show the PLO attainment of individual students, however, in this study it is depicted in tabular format.

Figure 8

The PLO % acquired in the individual courses by each student

| PLO | | SE-PLO-1 | | SE-PLO-5 | |
|------------------|----------------|----------------|--------------|----------------|--------------|
| Activity | | Weighted Total | PLO Acheived | Weighted Total | PLO Acheived |
| Assigned CLO | | | | | |
| % Weight | | KPI 50% | | KPI 50% | |
| Registration No. | Name | | | | |
| ID1 | Muhammad Usama | 83.31 | Y | 70.00 | Y |
| ID2 | Husnain Ali | 81.43 | Y | 70.00 | Y |
| ID3 | Ali Raza | 85.12 | Y | 70.00 | Y |
| ID4 | Muhammad Bilal | 77.46 | Y | 60.00 | Y |
| ID5 | Hira | 85.87 | Y | 80.00 | Y |
| ID6 | Ambar | 90.41 | Y | 80.00 | Y |
| ID7 | Aashir Ali | 87.89 | Y | 60.00 | Y |

Figure 9
 Total PLO attainment of an individual student of all courses

| Registration No. | SE-PLO-1 | SE-PLO-10 | SE-PLO-11 | SE-PLO-12 | SE-PLO-2 | SE-PLO-3 | SE-PLO-4 | SE-PLO-5 | SE-PLO-6 | SE-PLO-7 | SE-PLO-8 | SE-PLO-9 |
|------------------|----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|
| ID1 | 71.96 | 87.32 | 33.33 | 85.83 | 65.41 | 77.6 | 81.3 | 70.57 | 90 | 59.58 | 90 | 88.54 |
| ID2 | 93.59 | 94.79 | 95.42 | 87.86 | 94.74 | 95 | 94.63 | 91.53 | 87.69 | 92.83 | 89.57 | 89.72 |
| ID3 | 90.48 | 91.18 | 88.33 | 83.95 | 92.88 | 92.62 | 89.07 | 90.94 | 87.59 | 89.68 | 84.57 | 91.11 |
| ID4 | 91.87 | 89.56 | 90.83 | 87.15 | 91.45 | 92.48 | 88.7 | 92.56 | 88.43 | 87.81 | 85 | 81.56 |
| ID5 | 89.99 | 91.85 | 89.17 | 89.32 | 90.38 | 93.17 | 88.89 | 90.51 | 88.06 | 88.15 | 88.21 | 88.78 |
| ID6 | 72.64 | 46.67 | 75.42 | 64.9 | 55.05 | 31.17 | 43.33 | 59.93 | 68.15 | 55.89 | 67.53 | 30 |
| ID7 | 89.66 | 94.86 | 85.42 | 87.19 | 87.79 | 90.75 | 89.63 | 88.38 | 78.8 | 86.27 | 87.35 | 90 |

The number of students who achieved more than 50% in respective CLOs in a course is computed via equation (7) and percentages are computed using equation (8). Figure 10 is obtained using (7) and (8). This is an example of a semester-wise result.

Figure 10
 Course-wise CLO Attainment

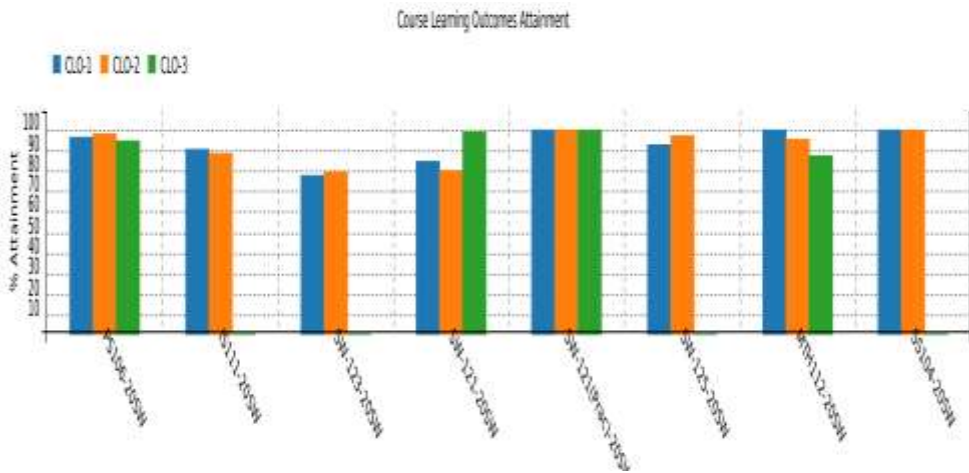


Figure 11 illustrates an example of students' collective attainment of outcomes for one of the courses in the case study in terms of PLOs. Column 3 of the table is obtained using (9) and the graph is generated via (10). The aggregate PLO attainment of students in all the courses, which is calculated via equation (11), is displayed in figure 12. This figure shows a program-wise result. These graphs provide quick statistics on students' overall performance in the course; such information is valuable to guide educators to improve the course. These statistics are intended to be included in the performance report cards of each

student so that they are well informed about their academic progress, not just in terms of the overall CGPA, but also on their development towards specific PLOs and skillsets designed by the program. This information could also be valuable in the CQI process of the program (e.g., by increasing or decreasing the assessment emphases on certain PLOs). In comparison to previous studies (Mohamed-Kassim & Kamaruddin, 2017; Pradhan, 2021; Chan, Wang, & Arbai, 2022), this study has provided detailed results obtained from Q-OBE.

Figure 11

Students' collective attainment in terms of PLOs

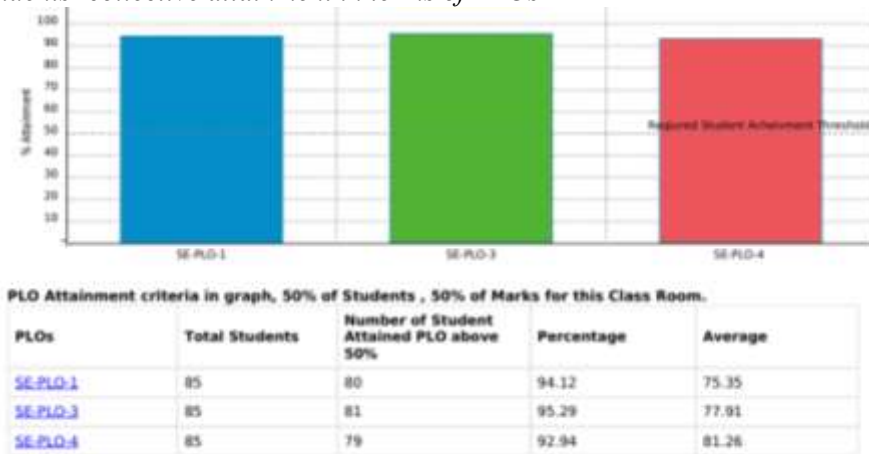
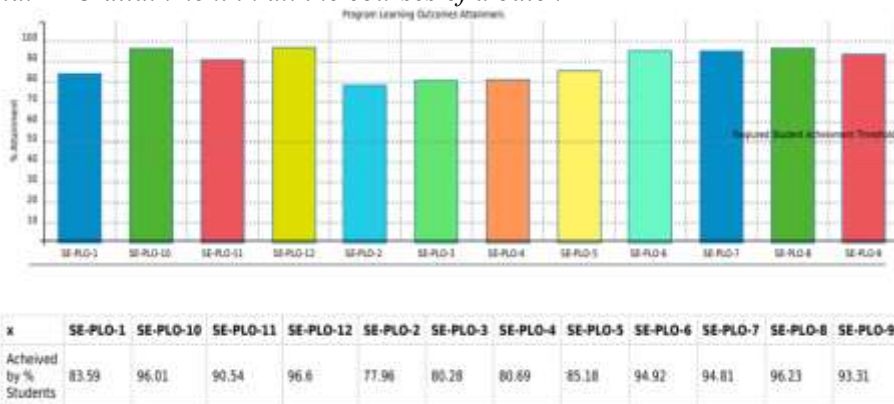


Figure 12

Total PLO attainment in all the courses of a batch



5. Conclusions

In order to meet accreditation requirements, educational institutions are embracing an OBE based approach. Educational institutions are constantly striving to improve the quality of education and emphasizing on an outcome based approach of learning. It has been recognized that the skills and knowledge attained by an individual learner play a key role in the professional life of the individual and shape how the individual will overcome formative challenges in life.

Rigorous assessment is a vital component and a major strength of OBE. It ascertains that a learner has acquired the intended skills, knowledge, and competences. Outcome assessment identifies, collects, analyzes, and finally reports data that can be used to appraise learner achievement in terms of learner outcome or course outcome across multiple courses offered within each program. This process is correlated to an educational institutions mission and is a time consuming, data intensive process which comes across as a major challenge in implementing OBE.

Q-OBE is implemented to automate the assessment process. It produces detailed reports of each student's aggregated outcomes in a visually effective format allowing institutes to monitor the development of their program outcomes across various departments. The Q-OBE takes the assessment marks as the input and accurately tracks how well the students attain the intended learning outcomes in terms of both CLOs and PLOs.

This study demonstrates how Q-OBE, a GUI-based software, automates the process of calculating students' outcomes incorporating both CLOs and PLOs achievements. The aim of this study was to make explicit the implementation of OBE via well-documented and reliable procedures across the institutions. This study presents a detailed depiction of the CLO and PLO attainment procedure implemented in Q-OBE. This study also shows the achievement of 50% KPI for the set PLOs.

6. Recommendations

The central mode of assessment in OBE facilitates a clear trail of evidence on which decisions regarding student competence can be based. At the same time, this also demands more resources and a high standard of assessment. Explicit standards need to be specified for assessment with OBE. This study depicts the implementation of OBE within the bounds of the Washington Accord. A similar study can be conducted for an implementation within the bounds of the Sydney Accord.

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