



Design and Implementation of a Web Platform for Unified Outcome-Based Education Data Management

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Abstract. Outcome-Based Education (OBE) has become core standard for modern education. Higher education institutions have slowly shifted from traditional content-based learning approach to which that is concentrated on student learning experience. OBE focuses on what students are expected to show at the end of a course and on completion of degree program. However, OBE in practical is still difficult to implement in many institutions due to heavy manual process, the use of spreadsheets for data management which scatters data across multiple files and also calculations are often repeated, causing inconsistencies and errors.

This paper presents a unified web-based framework for OBE management that supports a batch-centric academic model. The system enables structured definition of Program Outcomes (POs), Program Specific Outcomes (PSOs), Course Outcomes (COs), CO-PO/PSO mapping, direct and indirect assessment process and Final CO attainment calculation. Each course offering is treated as a batch, allowing semester-wise OBE activities while maintaining complete academic data over multiple years. Centralized storage of data supports long-term academic planning and data-driven decision making. The system provides role-based access for department heads and faculty, replacing scattered spreadsheet-based workflow with unified platform and reduce manual workload and calculation errors.

Keywords: Outcome-Based Education (OBE), Management, CO Attainment, Centralized, Web-system, Unified system.

1 Introduction

Outcome-Based Education has become important in higher education these days. Instead of traditional approach where teachers focus on syllabus completion and

final exams, OBE puts students at center and measure what students actually learn and what they can do at end of a course, through clear outcomes. Shifting from traditional to learner-centric and result-based approach. This approach focuses on measurable skills and align academic work with how industry or work-places required in real-life. Even if OBE provides many benefits, its management and implementation remains challenging, mainly in institutions which still follows traditional spreadsheet based-workflow. OBE is now widely used in engineering, computing and other professional programs [1]. William Spady, who introduced “design-down” method where end outcomes for the graduates are defined first [2] and then teaching strategies and assessment. These outcomes are not just about knowledge but they also cover technical skills, professional attributes and moral values. The importance of OBE framework boosted after getting supported by the United Nations Sustainable Development Goal 4 (SDG 4) which promotes quality education as a universal right [3]. For this reason, OBE has become important part of the path to achieve international academic recognition in modern education. By focusing on specific outcomes, teachers can give more effective and relevant learning experience to their students. In India, OBE gained importance after the country became a signatory to the Washington Accord in 2014 [4]. This made engineering institutions to adopt outcome-based assessment for accreditation by bodies like NBA and NAAC [5]. This made institutions to define Program Specific outcomes (PSOs) and Course Outcomes (COs) then connecting them through measurable assessment and attainment. This adds heavy administrative and analytical workload on the faculty. Even with stronger regulatory support, most of the institutions still use spreadsheet-based workflow [6]. Faculty members repeat tasks like CO-PO/PSO mapping, calculating attainment, score aggregation, correcting formulas and report generation. Studies shows that way leads to mistakes, inconsistencies and consume too much of time. There have been instances where accreditation preparation has taken up approx. 16,000 faculty hours for a single audit cycle. This shifts faculty focus away from teaching and mentoring [7]. Manual workflow also lacks in transparency and objectivity to be able to conduct a proper Continuous Quality Improvement (CQI) [8] which results decrease faculty participation and increase resistance towards OBE adoption [9]. Over the years, as more institutions walk the path toward achieving accreditation grading, the accreditation requirements grown more complex, increasing need of structured and centralized documentation, remote audits, accurate outcome tracking and proper management for growing academic data. This exposes the limitations of traditional workflow. Modern education need system which will help reducing human error and improve efficiency and consistency in outcome evaluation [10]. Centralized platforms enable standardized assessment process, consistent calculations and secure data isolation during each academic cycle, meeting accreditation standards [8]. This paper introduces a web-based Out-come-based Education Management System (OBEMS) to solve these problems. The system aims reduce the gap between how outcome are defined and the how they are implemented in practices [10]. The system uses a curriculum-version-centric architecture with batch-based ex-

ecution ensure systematic data management, traceability and consistency across years. Moreover, it also includes CO-PO and CO-PSO mapping, configurable assessments and standardized attainment calculations. The main contribution of this research leads to the design and implementation of scalable OBEMS that replaces scattered spreadsheet-based process, reduces faculty workload and administrative overhead. The system improves accuracy and usability by providing a centralized and unified approach to OBE management.

2 Research and Related Work

Early attempts of Outcome-Based Education were mainly for the completion of paperwork required for accreditation and not for continues academic improvement. Initial OBE practices very heavily depends on manual data collection and tools based on spreadsheets for mapping the course outcomes to program out-comes (CO-PO), aggregating assessment and calculating attainment levels [4]. These methods provide basic outcome tracking but they were very slow, time consuming, prone to errors and not scalable. Accreditation preparation using manual spreadsheet-based approach was reported to spent more than a million dollars, collected more than a ton of data and exhausted more than 16,000 hours of preparation time. Since they employ manual CQI processes, assessment and evaluation data is often deficient and lacks the rigor and quality required by a student-centered authentic OBE model to attain the required standards of holistic learning [8]. To solve these problems and limitations, many accreditations focused software platforms were developed and introduced that could automatically perform pro-gram level assessments and reporting. Tools like ACAT and EvalTool® were specifically developed to assist in the collection of data and evaluation of out-comes required for ABET [11]. EvalTool® employs the Faculty Course Assessment Report (FCAR) and EAMU performance vector methodology to evaluate student success across learning domains [8]. Similarly other tools like OBE-ANAS and MyCOPO were developed to simplify Individual Program Out-come achievement analysis and structured academic report [1]. These systems reduce some amount of manual workload of documentation and reporting but they primarily focused on post assessment analysis and offers limited support for continuous outcome tracking. Recent web-based OBE systems use modern MVC frameworks, Laravel and MERN-stack architecture to create better accessible, scalable and centralized data storage with role-based access control [6] [10]. But majority of systems only handle specific tasks like attainment calculations or report generation, also they depend on manual data entry, limiting transparency and cross-year comparison. The implemented system overcomes these gaps through a centralize, batch-centric framework that allows for structured management of Course Outcomes, CO-PO/PSO Mapping, assessment and attainment results while still maintaining historical records for institutional monitoring, comparing progress across years.

3 Methodology

3.1 Overview

The Outcome-Based Education Management System (OBEMS) follows a centralized and batch-centric approach to simplify OBE management and minimum dependency on spreadsheet based academic workflows. The methodology focuses on constant structured handling of Course Outcomes (COs), assessment records, attainment calculation, and historical academic data within unified platform. The system supports Program Outcome (POs), Program Specific Outcome (PSOs), CO-PO/PSO mapping, direct and indirect assessment and automated final CO attainment.

Each course instance is maintained independently in form of academic batch, which provides semesters-wise isolation

3.2 Batch-Centric Workflow

System uses batch-centric approach, where each course instance is represented as an independent and sperate academic batch. A batch holds all academic information related to specific semester and select course, including Course Outcomes (COs) definition, mappings for that semester, assessment records, attainment results and student data. Isolating help in organizing and preventing overlap between historical and current data. Storing of historical data will help for departmental monitoring, curriculum analysis and to compare data and progress across multiple academic cycles. Fig.1 shows overall batch-centric workflow and organization of academic data.

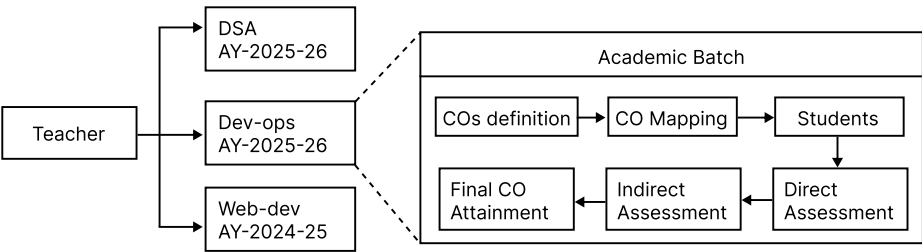


Fig. 1. Batch-centric workflow showing semester-wise isolation

3.3 Role based Access

System uses Role-Based Access Control (RBAC) to maintain secure and controlled academic operations:

- **Head of Department (HOD):** Manage Courses (create new, delete, update), define department level Program Specific Outcome (PSOs), inserting or updating Program Outcomes (POs) and monitor batches.
- **Faculty:** Select course and create batch, define batch-specific Course Outcomes (Cos), CO-PO/PSO mapping, assessment management, final CO attainment.

This way there is consistency in governance while still maintaining operational flexibility.

3.4 Course Outcome Definition

The Course Outcomes (COs) are defined at batch-level as per the syllabus requirement. Each COs is denoted by unique code which is generated using CO number and course code suffix (eg.C1.443, C2.443). Each CO is linked with CO-PO/PSO, assessment modules and final CO attainment calculation.

3.5 CO-PO/PSO Mapping

System allows for structured mapping between Course Outcomes (COs), Program Outcomes (POs) and Program Specific Outcomes (PSOs). Matrix is used to represent correlation strength between Cos and corresponding POs and PSOs. Correlation is represented as:

$$M(CO_i, PO_j) \in \{0, 1, 2, 3\} \quad (1)$$

Where CO_i denotes i^{th} Course Outcome, PO_j denotes j^{th} Program Outcome and $M(CO_i, PO_j)$ shows correlation strength between them. The mapping strength levels are defined as 0: no correlation, 1: low correlation, 2: medium correlation and 3: high correlation.

Mapping is batch-specific, so curriculum changes in a particular year will not affect historical attainment data. This approach supports curriculum-version-isolation.

3.6 Direct Assessment

Direct assessment is calculated using student marks scored in internal and external academic evaluation such as unit tests, prelim exam, insem exam, endsem for each Course outcome CO_i . The system automatically calculate target marks, passing percentage and attainment levels as follows:

$$T_i = \left(\frac{P_i}{100} \right) \times M_i \quad (2)$$

$$R_i = \left(\frac{S_i}{N_i} \right) \times 100 \quad (3)$$

$$A_i = \begin{cases} 0, & R_i < 40 \\ 1, & 40 \leq R_i < 60 \\ 2, & 60 \leq R_i < 66 \\ 3, & R_i \geq 66 \end{cases} \quad (4)$$

Where T_i denotes the target marks, R_i denotes the passing percentage, P_i denotes the target (passing) percentage, M_i denotes max possible marks for CO_i , S_i denotes number of students achieving target marks, N_i denote total number of students and A_i denotes the attainment levels. The automatic calculations maintain consistency and reduced manual error and effort.

3.7 Indirect Assessment

Indirect Assessment is performed through course exit survey. Faculty is required to upload survey response spreadsheet into the system. Upon uploading system automatically calculates average and total responses for each Course Outcome (COs). The processed results are then stored to be used in final CO attainment calculation.

This automated approach help maintaining accuracy, reduces manual effort and maintain consistency.

3.8 Final CO Attainment Calculation

Final CO attainment is calculated by combining internal direct assessment, external assessment and indirect assessment using configurable weight parameters.

$$FACO_i = (w_{int} \times DA_{CO_i}^{int}) + (w_{ext} \times DA_{CO_i}^{ext}) + (w_{ind} \times IA_{CO_i}) \quad (5)$$

where $FACO_i$ denotes final CO attainment value of Course Outcome CO_i , $DA_{CO_i}^{int}$ denotes internal direct assessment attainment level, $DA_{CO_i}^{ext}$ denotes external direct assessment attainment level and IA_{CO_i} denotes indirect assessment. The variables w_{int} , w_{ext} and w_{ind} denotes weights assigned to internal, external and indirect assessment respectively. These adjustable weights allow faculty members to define their own evaluation strategies according to department or institution rules and observe how different weight combination affect attainment results.

Following normalization condition is always validated:

$$w_{int} + w_{ext} + w_{ind} = 1 \quad (6)$$

Final CO attainment values are calculated automatically by fetching required data and stored in database at batch level for future report generation and

analysis. Algorithm. 1 shows how system automatically calculates final course outcome attainment.

Algorithm 1 Final CO attainment calculation

```

1: Begin
2: for each  $CO_i$  do
3:   Calculate target marks:
4:    $T_i = (P_i/100) \times M_i$ 
5:   Calculate passing percentage:
6:    $R_i = (S_i/N_i) \times 100$ 
7:   Assign direct attainment level  $A_i$ 
8:   if  $R_i < 40$  then
9:      $A_i = 0$ 
10:  else if  $40 \leq R_i < 60$  then
11:     $A_i = 1$ 
12:  else if  $60 \leq R_i < 66$  then
13:     $A_i = 2$ 
14:  else
15:     $A_i = 3$ 
16:  end if
17:  Process indirect assessment
18:  Calculate average of survey response:
19:   $IA_{CO_i} = \text{Average}(\text{total response})$ 
20: end for
21: Calculate final CO attainment:
22:  $FA_{CO_i} = (w_{int} \times DA_{CO_i}^{int}) + (w_{ext} \times DA_{CO_i}^{ext}) + (w_{ind} \times IA_{CO_i})$ 
23: Store  $FA_{CO_i}$  in database
24: End

```

The algorithm automates attainment calculation and store it at batch-level, this reduces repetitive manual calculation and improve efficiency and consistency.

3.9 Unified and Centralized

The OBEMS system uses centralized data management model in which all OBE related modules are combined in one platform. Modules such as course definition, mapping, assessments and attainment data for multiple years are stored in single database rather than spread across many spreadsheets and machines.

The centralized approach removes duplicate records and provides uniform attainment and report generation. Since each course instance is maintained separately as a batch, it helps system to store semester-wise academic data. This allows for cross-year batch studies and department or institutional monitoring.

Due to unified workflow, generation of accreditation related documents became easier. Fig.2. shows high level architecture of unified and centralize OBEMS framework.

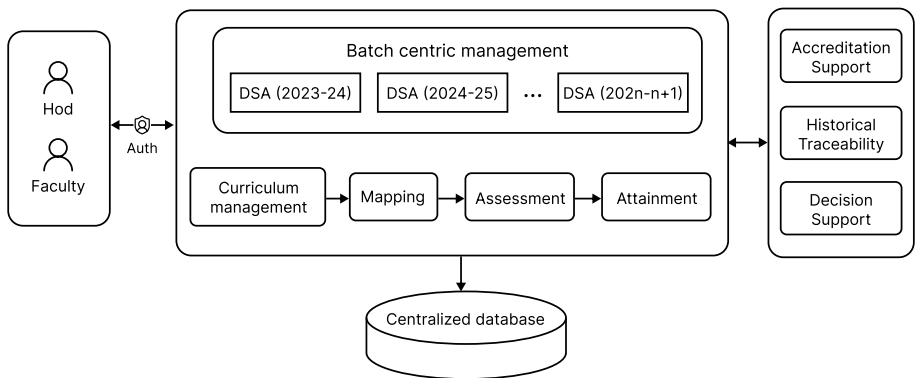


Fig. 2. Unified framework for batch-centric OBE management

4 System Architecture

OBEMS is implemented using modular, scalable, role-based full-stack web architecture. React.js is used for frontend, Next.js API for backend logic and PostgreSQL for centralized data storage. Fig.3. shows the three-layer architecture of system.

- **Presentation layer (Frontend):** Implemented using React.js with Next.js, this layer provides a role-based interface for faculty and Hod. It provides a clean interface for batch management, CO definition, CO-PO-PSO mapping, assessment entry and attainment calculate for faculty and PSO management for HOD.
- **Application Layer (Backend):** Build using Next.js APIs, this layer handles all core business logic, validations, manages workflow and OBEMS calculations. It also deals with security by handling user authentication and access control (RBAC), ensure user can access only authorized data.
- **Data Layer (Database):** The system used PostgreSQL relational database to store user profiles, courses, batches, student records and final Co attainment. The batch-centric schema enables data isolation and multi-year traceability.

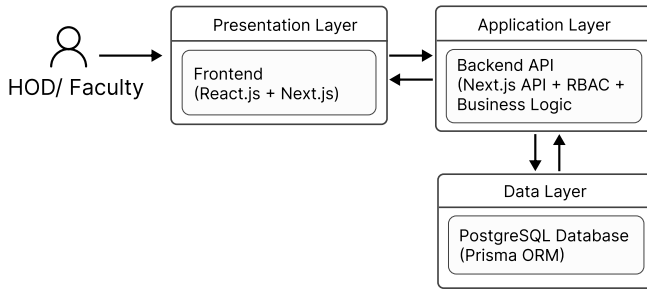


Fig. 3. OBEMS three-layer system architecture

5 Results

The developed Outcome-based Management system was tested in departmental environment to check functionality, workflow clarity and calculation accuracy. This section presents system main features, interfaces and explains how each module helps to implement structured OBE.

5.1 Batch Management

The batch-centric workflow successfully isolated academic data for each semester by creating course instance as independent academic batch. This dashboard gives faculty a clean, structured and centralized access to batch records. Each batch contains CO definitions, mappings, assessments and attainment. Fig.4. shows the batch management interfaces used by system.

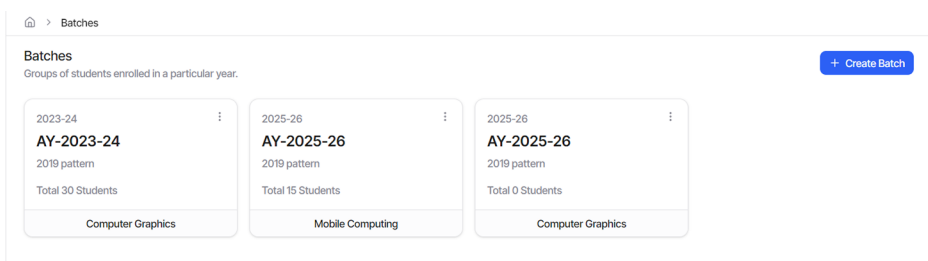


Fig. 4. Batch dashboard showing centralized management of academic batches

Centralized workflow allow faculty to access batch-wise OBE records without searching for multiple folders and machine, which is common in case of manual spreadsheet workflow. This saves lot of time and also helps at the time of accreditation evaluation.

5.2 CO-PO/PSO Mapping Management

The system allows clean and structured way for CO-PO/PSO mapping. Faculty members were easily able to map and manage correlation between Course Outcomes (COs), Program Outcomes (POs) and Program Specific Outcomes (PSOs) according to there requirements. Fig.5 shows the implemented mapping module used by the system of correlation management.

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Batches

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Mapping

Course Outcomes Mapping

Map course outcomes to program outcomes and program specific outcomes.

This table is automatically generated based on POs/PSOs and COs data.

Save changes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PK
C1.453	3	2	2	1	0	1	0	0	0	0	0
C2.453	3	3	2	1	1	0	1	0	1	1	0
C3.453	2	2	3	2	1	0	0	0	1	1	0
C4.453	2	2	2	2	1	1	0	0	1	1	1
C5.453	1	1	1	1	2	2	1	1	2	2	1
C6.453	0	0	0	0	0	1	2	2	2	2	2
Total Sum	11	10	10	7	5	5	3	3	7	7	
Average	2.2	2	2	1.4	1.25	1.25	1.5	1.5	1.4	1.4	1.1

Fig. 5. CO-PO/PSO mapping module showing structured outcome correlation management

Dropdown allows faculty to select correct strength level typical range from 0 (no correlation) to 3 (high correlation). This batch-level mapping help in creating curriculum-version separation.

5.3 Automated Attainment Computation

The developed system automatically processed direct and indirect assessment data to generate final CO attainment. It combines internal, external and indirect assessment components, multiplying with adjustable weights parameters to calculate overall attainment scores. Fig. 6 show implementation of automated attainment modules within the system.

The automated workflow has completely eliminated manual spreadsheet calculation in which faculty needs to manually select internal, external and indirect attainment value from different sheet to calculate final CO attainment. This approach is highly error prone and inconsistent.

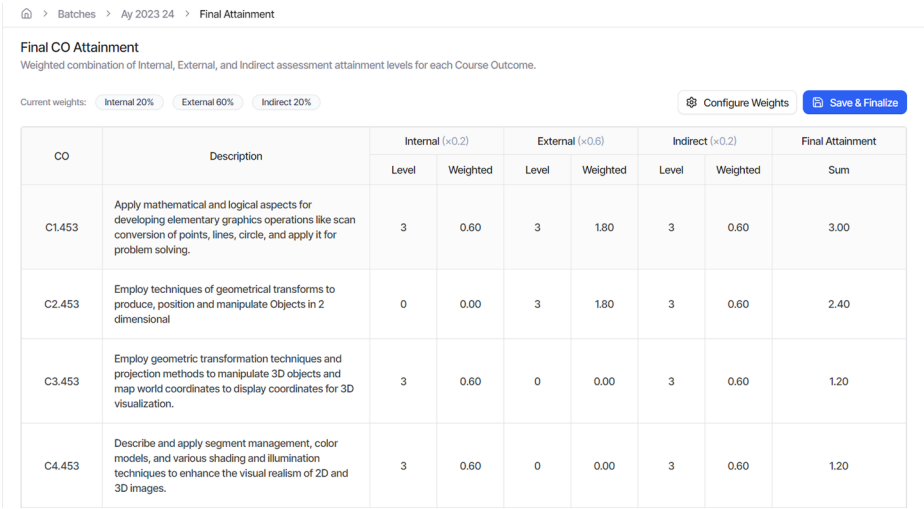


Fig. 6. Automated final CO attainment computation using configurable weight parameters

5.4 OBEMS vs Spreadsheet

Table 1. Comparison between OBEMS and Traditional Spreadsheet-Based OBE workflow

Parameters	Spreadsheet-Based workflow	Proposed OBEMS	Impact
Data Storage	Distributed across multiple excel files	Centralized in a single system	Better data consistency and access
Assessment Entry	Marks entered manually in sheet	Marks uploaded or entered through a guided interface	Faster and less errors
CO Attainment Calculation	Manual formulas and cell-based computation	Automated attainment engine	Save time and reduce calculation errors
Historical Record Maintenance	Difficult to track across semester and batches	Batch-wise historical database maintained	Enable long-term comparisons and analysis

Table 1. (continue)

Parameters	Spreadsheet-Based workflow	Proposed OBEMS	Impact
Standardization	Depends on individual faculty or department spreadsheet format	Common workflow across all faculty	Ensure standardized workflow and uniform reporting
Error Risk	Higher due to formula and entry mistake	Lower due to validation	Improve reliability
Faculty Work-load	High manual effort	Reduced manual work	Improve productivity
Scalability	Becomes difficult with increasing courses and batches	Handles multiple courses and academic cycles	More suitable for institutions

The comparison shows that proposed OBEMS system decreases tedious repetitive manual work required for attainment calculations and provides uniform OBE workflow. Also improved consistency due to centralized data handling and automated calculations.

6 Future Scope

6.1 Multi-Department and Institutional Scalability

The present system is working for single department. A key future extension is to support multiple departments within a common institutional structure. This would allow departments to manage their own PSOs and curriculum framework, while also enabling institution-level monitoring and reporting. Such systems support institutional governance and quality evaluation [12], and meet the need for centralized records for remote and continuous audits.[8].

6.2 Program-Level PO Attainment Computation

The current system calculates the CO attainment at batch level but does not aggregate results across courses for program-level PO attainment. A future module must combine CO-PO mappings across all courses in a semester to compute overall program attainment. This is necessary to show graduate attribute achievement under accreditation standards [4]. It would also complete the OBE lifecycle and allow curriculum-level gap analysis for Continuous Quality Improvement (CQI) [13].

6.3 Automated Accreditation Reporting

The NBA and NAAC accreditation bodies require structured records of CO-PO mappings, attainment summaries and CQI records. Right now, these reports are prepared manually by faculty using data from system outputs. A future reporting module that could generate accreditation ready documents in a standard format would reduce administrative efforts and improve consistency in reports[4].

7 Conclusion

This research introduced a centralized, web-based Outcome-Based Education Management System (OBEMS) build to solve practical issues of OBE implementation. Instead of searching and juggling between multiple spreadsheets. OBEMS combined all required components like Course Outcome, CO-PO-PSO mappings, direct and indirect assessments and final CO attainment calculations within a single platform, this removes need of repeated copying data between different tools. The system supports role-based access control (RBAC), where department heads have clear view and control, while faculty manage batch-level activities with flexibility. The batch-centric approach keeps academic data separated by semester, while maintaining records across multiple years, supporting performance analyze and accreditation requirements. Automated attainment calculation, configurable weighting and structured workflow improved accuracy, reducing manual efforts and ensure consistency across faculty. Tested within a department showed improvement in workflow clarity and structured data organization. All OBE related data stored in one centralized place instead of multiple spreadsheets. Data access and management became simpler and faster for faculty. Overall OBEMS provides an effective method for proper OBE implementation, improving evaluation consistency, efficiency and institutional oversight. while remaining flexible for future developments.

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