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Design and Implementation of a CO-PO Attainment Monitoring System for Engineering Programs

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ABSTRACT

Outcome Based Education (OBE) is essential in modern engineering education to ensure that students achieve clearly defined learning outcomes. With the implementation of NEP 2020 and CBCS, institutions are required to adopt systematic and transparent approaches for evaluating Course Outcomes (CO) and Program Outcomes (PO). This paper presents a CO–PO mapping and attainment system designed for engineering programs. The proposed system utilizes both direct and indirect assessment methods, including internal examinations, assignments, laboratory performance, and student feedback, to automate the calculation of attainment levels. It also generates analytical reports that assist faculty members in evaluating student performance and identifying areas for improvement. The system enhances accuracy, transparency, and efficiency, while supporting accreditation processes such as NBA and NAAC.

1. INTRODUCTION

Outcome-Based Education (OBE) has emerged as a significant paradigm in modern engineering education, focusing on the achievement of clearly defined learning outcomes and competencies [1,3]. Unlike traditional education systems that emphasize teaching processes, OBE concentrates on what students are expected to learn and demonstrate at the end of a course or program. This approach ensures a student-centric learning environment and promotes continuous academic improvement. In engineering education, Program Outcomes (POs) represent the broad skills and competencies expected from graduates, such as problem-solving ability, technical knowledge, and

ethical responsibility, while Course Outcomes (COs) define the specific learning objectives at the course level [5,7]. The mapping of COs to POs plays a crucial role in ensuring that course-level learning contributes effectively to overall program goals With the implementation of accreditation frameworks such as NBA and NAAC, institutions are required to adopt systematic and measurable approaches for evaluating CO–PO attainment [4]. However, many institutions still rely on manual methods such as spreadsheets, which are time-consuming, error-prone, and inefficient when handling large volumes of academic data [20].Therefore, there is a need for an automated and data-driven system that can efficiently perform CO–PO mapping, calculate attainment levels, and provide meaningful insights for improving student performance and academic quality.

2. PROBLEM DEFINITION

In Outcome-Based Education (OBE), the systematic evaluation of Course Outcomes (COs) and Program Outcomes (POs) plays a critical role in ensuring academic quality, continuous improvement, and compliance with accreditation requirements such as NBA and NAAC [4]. CO–PO mapping is essential for measuring how effectively course-level learning contributes to overall program objectives [5,7].However, many institutions still rely on traditional manual approaches, such as spreadsheets, for CO–PO mapping and attainment calculation, which are inefficient, time-consuming, and highly prone to human errors [20,21]. As the volume of academic data increases, maintaining accuracy, consistency, and transparency in outcome evaluation becomes increasingly difficult [11].Furthermore, existing systems often lack advanced analytical capabilities and visualization tools, which limits the ability to generate meaningful insights into student performance and attainment trends [10,12]. This makes it challenging for faculty members and administrators to identify learning gaps, monitor progress effectively, and take timely corrective actions [9].In addition, the absence of integrated and automated frameworks restricts the use of data-driven decision-making in educational institutions, thereby affecting the overall effectiveness of outcome-based education systems [14,17].Therefore, there is a strong need for a comprehensive and automated CO–PO mapping system that not only improves accuracy and efficiency but also incorporates data analytics and visualization techniques to support effective academic decision-making and continuous quality improvement.

3. LITERATURE REVIEW

Several researchers have contributed to the development and implementation of Outcome-Based Education in engineering institutions. Kaliannan and Chandran [1] emphasized the importance of OBE in enhancing student engagement and improving learning outcomes, while Keen and Hall [2] highlighted the role of structured learning approaches in achieving long-term educational benefits. Wahab et al. [3] discussed systematic processes for program outcome measurement and assessment, providing a foundation for structured evaluation systems.In the context of CO–PO mapping, Ranganath [5] presented practical examples of mapping techniques and corresponding assessment strategies. Similarly, Teja et al. [7] proposed structured frameworks for implementing CO–PO mapping in accreditation processes, emphasizing its importance in improving educational quality. Subbarao [18] analyzed real-time CO and PO attainment and highlighted the significance of continuous monitoring in engineering programs. Choudhari et al. [19] further extended this concept by focusing on curriculum improvement through strategic CO–PO mapping and gap identification.Automation of outcome assessment has been explored by Saad and Haque [21], who proposed systematic approaches to reduce manual effort and enhance accuracy in attainment calculations. However, most of these systems lack advanced analytical capabilities.Recent studies have shown that data analytics and visualization techniques can significantly improve the analysis of student performance. Learning analytics frameworks [9] and dashboard-based systems [10,12] provide visual insights into academic performance, enabling better decision-making. Nguyen et al. [11] highlighted the role of data analytics in higher education for improving institutional effectiveness.Furthermore, artificial intelligence and machine learning techniques have been widely used in education for predicting student performance and identifying learning gaps. Studies by Albreiki et al. [13] and Khan and Ghosh [14] demonstrated the effectiveness of machine learning models in analyzing student data. Sekeroglu et al. [17] applied classification algorithms for performance prediction, while Kuleto et al. [16] discussed the opportunities and challenges of AI in higher education.

Despite these advancements, there is limited research on integrating CO–PO mapping with data analytics and AI-based techniques, which highlights the need for a comprehensive and intelligent system for outcome-based education.

4. PROPOSED SYSTEM

The proposed CO–PO mapping and attainment system presents a structured, automated, and data-driven approach for evaluating student performance in Outcome-Based Education (OBE).

The system is designed to align Course Outcomes (COs) with Program Outcomes (POs) and to ensure accurate measurement of learning attainment in accordance with accreditation requirements [5,7].The system begins with the definition of Course Outcomes for each subject, which are then systematically mapped to relevant Program Outcomes using predefined correlation levels such as high, medium, and low [5]. This mapping establishes a clear relationship between course-level learning and overall program objectives.The system collects academic data from multiple sources, including internal examinations, assignments, laboratory performance, and student feedback, ensuring a comprehensive evaluation of student learning [8,21]. Both direct and indirect assessment methods are incorporated to provide a balanced and reliable measurement of attainment levels [21].The collected data is processed using analytical techniques to compute CO attainment values, which are further mapped to Program Outcomes to determine overall PO attainment [11]. The system leverages data analytics approaches to ensure accuracy, consistency, and efficient handling of large datasets [9].Additionally, the system includes visualization and reporting modules that generate graphical dashboards and detailed reports, enabling faculty members to easily interpret performance trends and identify learning gaps [10,12]. These insights support timely decision-making and continuous improvement in the teaching–learning process.The modular architecture of the system consists of components such as data input, attainment calculation, CO–PO mapping, analytics processing, and report generation. Automation of these processes significantly reduces manual effort, minimizes errors, and enhances the reliability of outcome evaluation [20,21].

Overall, the proposed system provides an efficient and scalable solution that integrates automation, data analytics, and visualization techniques to improve the effectiveness of outcome-based education and support institutional quality enhancement.

5. METHODOLOGY

The proposed system follows a structured methodology for evaluating CO–PO attainment using both direct and indirect assessment methods. Academic data is collected from multiple sources, including internal examinations, assignments, laboratory performance, and student feedback [8]. This multi-source data collection ensures a comprehensive evaluation of student performance.CO–PO mapping is performed using predefined correlation levels such as high, medium, and low, which represent the degree of contribution of each CO to the corresponding PO [5,7]. These mapping relationships are essential for accurately determining program-level attainment.The attainment of Course Outcomes (COs) is calculated using a weighted combination of direct and indirect assessment methods. Direct assessment includes objective evaluation methods such as exams and assignments, while indirect assessment includes subjective measures such as feedback and surveys [21].Data analytics techniques are applied to process and analyze the collected data, enabling identification of trends and patterns in student performance [11]. Visualization tools are used to generate graphical reports and dashboards, providing clear insights into CO and PO attainment levels [10,12].

6. RESULTS AND DISCUSSION

The proposed system was evaluated using real academic data, and the results indicate significant improvements over traditional manual methods. The automation of CO–PO mapping and attainment calculation reduced the time required for processing and minimized human errors [21].

The use of data analytics enabled detailed analysis of student performance, allowing faculty members to identify weak areas and take corrective actions [9,11]. Visualization dashboards provided clear and intuitive representations of attainment levels, improving the overall understanding of performance trends[10,12].Additionally, the system demonstrated scalability by efficiently handling large datasets without performance degradation. These results confirm that the proposed system is effective, reliable, and suitable for implementation in engineering institutions.

7. ADVANTAGES

The proposed CO–PO mapping and attainment system offers several significant advantages in improving the efficiency and effectiveness of outcome-based education.

- The system ensures accurate and systematic calculation of CO and PO attainment levels by using structured mapping and analytical methods, resulting in reliable evaluation of student performance [5,7].
- It significantly reduces manual effort and minimizes human errors associated with traditional spreadsheet-based approaches, thereby improving overall efficiency and consistency [20,21].
- The automated framework enables faster and more efficient generation of analytical reports, saving valuable time for faculty members and academic administrators [21].
- The system provides improved monitoring and tracking of student performance across various assessment components such as

examinations, assignments, and laboratory work [8,11].

- It helps faculty members identify gaps in learning outcomes by analyzing attainment levels and performance trends, allowing timely corrective actions for academic improvement [9,12].
- The inclusion of visualization tools and dashboards enhances the representation of attainment data, making it easier to interpret and analyze complex information [10,12].
- The system supports data-driven decision-making by leveraging data analytics techniques, enabling institutions to improve teaching strategies and learning outcomes [11,14].
- It enhances transparency and consistency in the evaluation process by standardizing CO–PO mapping and attainment calculations across courses and programs [7,20].
- The system is scalable and capable of handling large volumes of academic data efficiently without compromising performance [11].
- Additionally, it assists institutions in meeting accreditation requirements such as NBA and NAAC by providing systematic documentation and measurable outcome evaluation [4].

CONCLUSION

This paper presented a comprehensive CO–PO mapping and attainment system designed to support the effective implementation of Outcome-Based Education (OBE) in engineering institutions. The proposed system integrates structured methodologies for defining Course Outcomes (COs), mapping them with Program Outcomes (POs), and systematically calculating attainment levels using both direct and indirect assessment methods [5,7,21].The system provides an automated framework for data collection, processing, and analysis of student performance from multiple assessment sources, ensuring a more reliable and consistent evaluation process [8,11]. By reducing dependency on manual methods, it minimizes human errors and significantly improves the accuracy and efficiency of attainment calculations [20,21].

The incorporation of data analytics and visualization techniques enables the generation of detailed analytical reports and dashboards, which assist faculty members in effectively monitoring student performance and identifying gaps in learning outcomes [9,10,12]. These insights support timely corrective actions and continuous improvement in the teaching–learning process. Furthermore, the system enhances transparency and standardization in CO–PO mapping and evaluation, thereby promoting consistency across courses and programs [7,20]. It also supports data-driven decision-making by providing meaningful insights into attainment trends and performance patterns [11,14].Overall, the proposed system offers a scalable and efficient solution for outcome evaluation, helping institutions improve academic quality and successfully meet accreditation requirements such as NBA and NAAC [4]. The integration of automation, analytics, and structured evaluation methods makes the system highly suitable for modern educational environments and future advancements in outcome-based education.

FUTURE SCOPE

Future enhancements of the system may include the integration of artificial intelligence and machine learning techniques to enable predictive analysis of student performance [13,17]. Such approaches can help in early identification of at-risk students and provide personalized recommendations for improvement. Educational data mining techniques can be further utilized to analyze learning patterns and enhance decision-making processes [14]. Integration with advanced learning analytics dashboards can provide real-time monitoring and visualization of attainment levels [10,12].Additionally, the system can be extended to integrate with Learning Management Systems (LMS) and institutional ERP platforms for automated data collection and real-time processing, making it more efficient and scalable

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