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A Data-Driven Approach to Student's Attainment

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1. Abstract

This paper presents a system to simplify the calculation of Course Outcomes (COs) and their mapping to Program Outcomes (POs) for educational institutions. Course Outcomes (COs) are specific learning goals set for a course, while Program Outcomes (POs) are broader skills students should achieve by graduation. The system allows course instructors to efficiently input and analyze student performance data across multiple assessments. It supports both direct assessment tools like CIE-1 (Midterm 1), CIE-2 (Midterm 2), and SEE (Semester End Exam), and indirect assessment tools like CES (Course End Survey).The platform automates CO attainment calculation using predefined formulas. It ensures a fair and consistent evaluation by using fixed weightage factors and by mapping test questions to their respective COs, which are then linked to POs.

Additionally, the system provides data visualization tools, such as graphs and charts, to make analysis easier. Course instructors can set exam question patterns, enter marks, monitor real-time results, and export detailed reports. The system also generates batch-wise attainment summaries and enables comparisons between different student batches.

Keywords: Course Outcomes (COs), Program Outcomes (POs), Student Performance, Assessments, Mapping, Data Visualization

2. Introduction

Assessing student performance based on Course Outcomes (COs) and Program Outcomes (POs) plays a crucial role in evaluating learning effectiveness. Traditionally, course instructors relied on Excel sheet tools to calculate CO attainment values, which required manually entry of student marks, applying formulas, and maintaining multiple spreadsheets for different exams. While this method worked, it had several limitations, such as difficulty in tracking trends over time, comparing attainment across different batches, and generating meaningful visual insights.

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This web-based system allows course instructors to enter student marks and automatically calculate CO attainment from the predefined CO's mapping to specific question and further using the co attainment values to calculate the co-po attainment from predefined co-op mapping. A structured mapping of COs with POs is established, categorizing the relationship into strong, moderate, and weak correlations. This classification helps in understanding the extent to which a particular course outcome contributes to the achievement of broader program objectives. The system includes visualization with graphs and charts, enabling instructors to compare current and past student performance effectively.

The ability to compare student performance across different batches helps instructors determine the effectiveness of instructional strategies and refine their teaching approach accordingly. It also helps course instructors understand performance trends, and make data-driven decisions for refining the curriculum. By providing clear insights into attainment trends, the system helps course instructors evaluate overall progress and make informed decisions for curriculum improvement like helping course instructors focus on improving learning outcomes.

3. Literature Survey

The process of calculating and analyzing Course Outcomes (COs) and their mapping to Program Outcomes (POs) has been widely studied. Various methodologies and frameworks have been proposed to improve assessment accuracy and ensure alignment with broader educational goals. This survey provides an overview of existing research on CO-PO attainment methods, the role of data visualization in educational assessment, and how technology enhances academic performance tracking.

Despite advancements in CO-PO assessment systems, several challenges remain. Ensuring data accuracy and integrity is crucial, as errors in data entry or incorrect mappings can lead to misleading results (Rani et al., 2018) [1]. Additionally, the effective adoption of such systems requires proper training for faculty members to ensure accurate mapping of COs to POs and meaningful analysis of student performance. Without a structured approach, institutions may struggle to derive actionable insights from the data.

Different approaches have been explored for measuring CO-PO attainment in higher education. Bloom's Taxonomy (1956) categorizes learning outcomes into cognitive, affective, and psychomotor domains, providing a foundation for CO assessment. Researchers emphasize the importance of constructive alignment, ensuring that assessments directly evaluate the intended learning outcomes and that COs contribute meaningfully to POs. Studies have also explored how CO-PO mappings help institutions align their curriculum with accreditation standards such as NBA (National Board of Accreditation) guidelines (Lavanya & Murthy, 2022) [4].

Several research studies have highlighted the advantages of using automated tools for CO-PO calculations. Kumar et al. (2019) proposed an AI-based framework that uses machine learning algorithms to analyze student performance and predict CO and PO attainment levels [1]. Similarly, a web-based system has been developed to provide real-time feedback to educators based on student assessment data, improving instructional strategies and curriculum design (Afreza, 2022) [3].

Data visualization plays a crucial role in understanding CO-PO attainment trends. Research shows that graphical representations—such as bar charts, line graphs, and heatmaps—help educators and administrators identify strengths and weaknesses in student learning (Singh et al., 2023) [2]. Many modern educational platforms integrate dashboards with real-time analytics, enabling institutions to monitor how well students are meeting COs and achieving POs. This facilitates data-driven decision-making and continuous improvement in teaching methodologies.

Furthermore, several case studies and methodologies have contributed to refining CO-PO attainment analysis. Rajagopal Reddy et al. (2023) [5] analyzed program quality assessment through CO-PO mapping, emphasizing the need for structured evaluation models. Rajak (2023) [6] investigated how CO-PO assessment contributes to postgraduate program evaluation, demonstrating the need for continuous tracking of student performance. Nayak (2023) [8] studied the impact of CO attainment on undergraduate engineering education, proposing a structured framework for evaluating knowledge acquisition.

Agrawal et al. (2023) [9] developed an assessment methodology for Tier-I institutes in India, highlighting predefined weightage-based calculations for mapping COs to POs. Mawandiya et al. (2023) [10] proposed a comprehensive evaluation model integrating predefined weights and continuous monitoring across all semesters. These studies emphasize that CO-PO mappings should be conducted periodically to ensure consistency and effectiveness in academic assessment.

By integrating technology and data visualization, CO-PO assessment systems can be enhanced, providing institutions with deeper insights into student learning and helping them improve educational outcomes. The combination of structured methodologies, automated processing, and real-time analytics ensures that student performance is accurately assessed, contributing to better academic planning and curriculum development.

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4. Experimental Setup and Implementation

The methodology for this project involves several key phases, including system design, data input, processing, and result analysis. The following steps outline the structured approach to achieving the project objectives:

4.1. System Design and Development

The system is designed as a **web-based platform** with **React JSX** for the front end and **Node.js with Express.js** for the backend. **MongoDB** is used for efficient data storage and retrieval. To ensure secure access, authentication mechanisms are implemented, allowing **course instructors** to manage data entry and assessment configurations. The system efficiently processes and organizes data to support accurate CO and PO calculations.

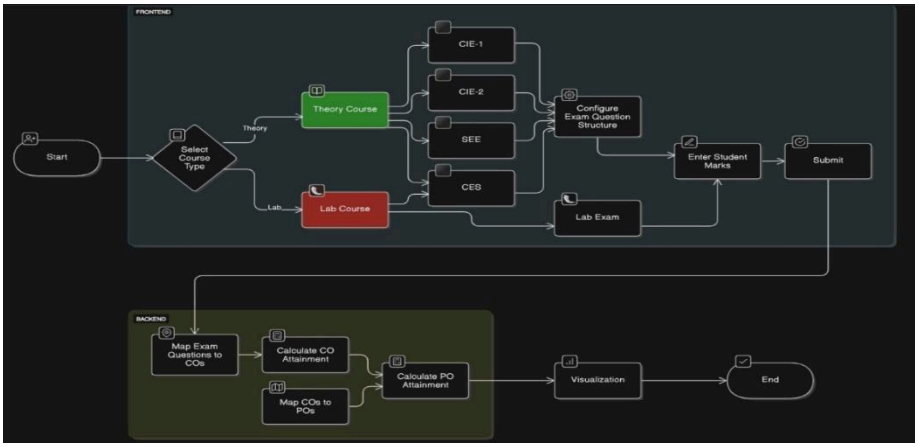

Fig.1 Work Flow of Student Attainment Website

4.2. Data Collection and Input

Course instructors can input student marks based on the course type. For **theory courses**, the assessments are categorized into:

- **Direct Attainment:** CIE-1 (Mid-1), CIE-2 (Mid-2), and SEE (Semester End Exam)
- **Indirect Attainment:** CES (Course End Survey)

For **lab courses**, assessments include:

- **Direct Attainment:** Lab Exam
- **Indirect Attainment:** CES (Course End Survey)

The system provides a structured method for configuring exams by specifying **sub-questions** and their respective **maximum marks.** Validation mechanisms ensure that entered values for marks and maximum marks are accurate and complete.

4.3. Mapping of Course Outcomes (COs)

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A **predefined mapping** of exam questions to their respective COs ensures accurate assessment. Each question is linked to a specific CO, allowing automated calculations. Additionally, weightage is assigned to different assessment types, ensuring that final performance calculations accurately represent student achievement across all exams.

4.4. Calculation of CO Attainment

The system performs **backend calculations** to determine **CO attainment** by analyzing student performance for each CO-mapped question across different assessments. Predefined thresholds and grading criteria are used to evaluate CO achievement levels. The calculated data is **stored and processed** in a structured database to enable efficient computations.

4.4.1 Formulaes

$$\text{Threshold} = \text{Max Marks of Each Question} \times 0.6$$

No. of Students Scored Above Threshold = Count of students who scored ≥ **threshold**

$$\text{Question Percentage} = \left(\frac{\text{No. of Students Scored Above Threshold}}{\text{No. of Students Answered the Question}}\right) \times 100$$

No. of Students Answered the Question = Count of students with marks >-1

$$CO\% = \frac{\sum(\text{Question Percentage of Questions Mapped to CO})}{\text{No. of Questions Mapped to CO}}$$

$$\text{Final CO Percentage} = \frac{(0.7 \times SEE) + (0.25 \times CIE) + (0.5 \times CES)}{100}$$

4.5. Mapping of Program Outcomes (POs) to COs

Since there are 12 predefined POs, each CO may or may not map to all POs. This mapping is based on predefined weight values. The PO attainment is calculated using the following formula:

$$PO_{attainment} = \left(\frac{CO_{percentage} \times PO_{predefined\_weight}}{\sum PO_{predefined\_weights}}\right)$$

The PO attainment calculation considers assessments across the eight-semester academic cycle. The average of all COs mapped to a PO contributes 90% of the total PO attainment score, while the remaining 10% is derived from a final student survey, ensuring a comprehensive evaluation of program outcomes.

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4.6. Data Visualization and Reports

The system integrates graphical representations to illustrate student performance across different assessments. Using charts and graphs, instructors can visually analyze trends in Course Outcome (CO) and Program Outcome (PO) attainment, making it easier to interpret large sets of data.

A real-time dashboard is provided for course instructors to continuously monitor CO and PO attainment for each course. The dashboard dynamically updates with student performance data, offering instant insights into whether learning objectives are being met. By visualizing direct attainment (CIE-1, CIE-2, SEE) and indirect attainment (CES) for both theory and lab courses, instructors can assess student learning more comprehensively.

The system also generates detailed reports summarizing CO and PO attainment across different batches. These reports allow course instructors to track progress over multiple academic years, facilitating long-term assessment of curriculum effectiveness. With structured data visualization and reporting, the system provides an efficient and transparent approach to evaluating student learning and academic achievement.

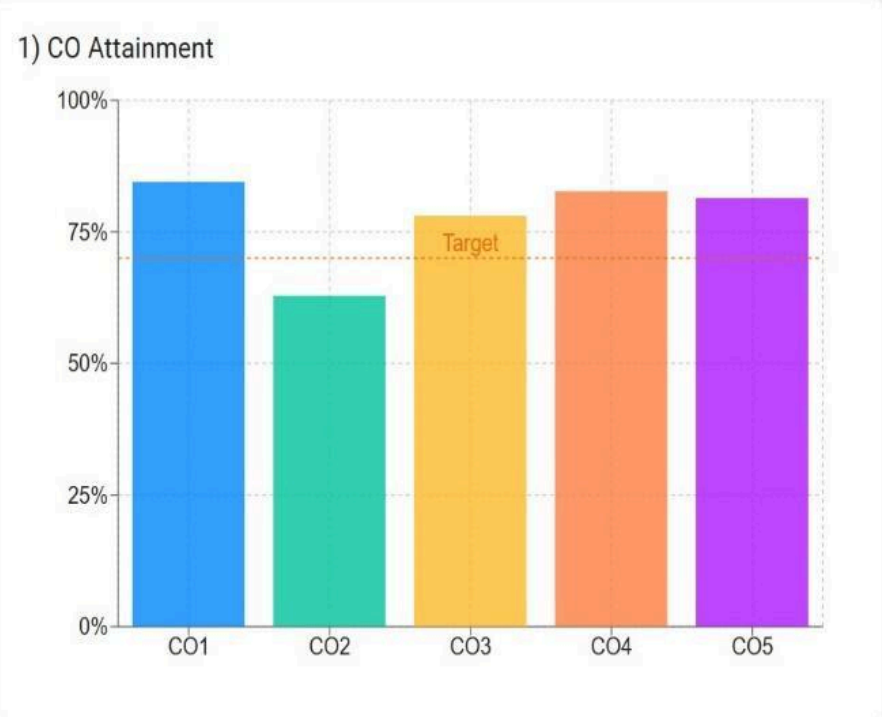

Fig.2 Sample CO Attainment Graph for a particular course

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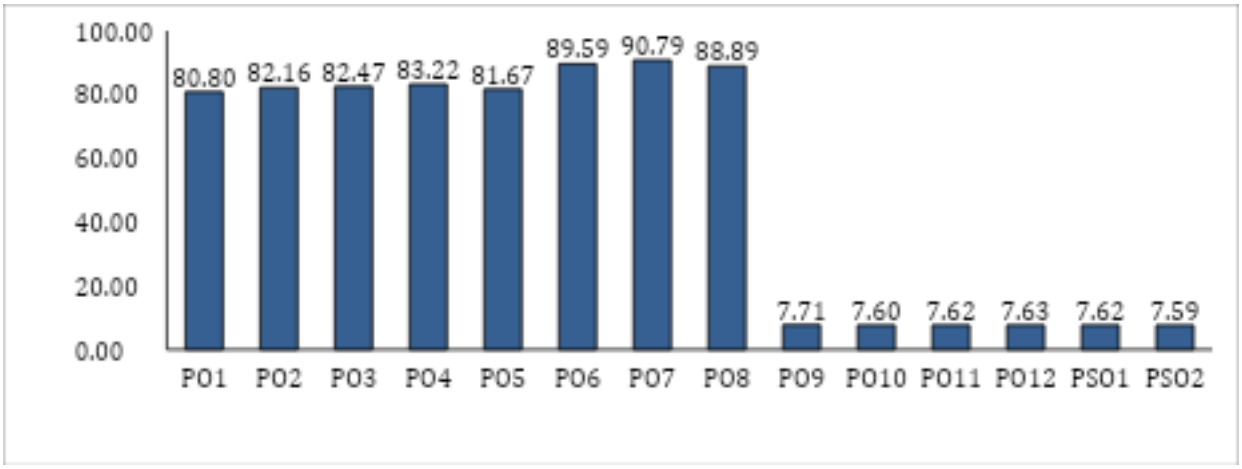

Fig.3 Sample CO-PO Attainment Graph for an Academic Year

By following this structured methodology, the project ensures an efficient and effective system for calculating and analysing Course Outcomes (COs), ultimately assisting educators in enhancing student learning and course effectiveness.

5. Conclusion

This paper makes it easier to compute Course Outcomes (COs) and Program Outcomes(POs) in Outcome Based Education System. By offering a web-based system, it makes it easier for Course Instructors to input student marks, associate particular question to particular CO's of that exams, and auto-generate reports with visual insights, with options such as real-time dashboards and customizable settings, the system is able to accommodate various academic requirements. Future updates, such as AI-based performance, can further make it more effective. Overall, this project facilitates Outcome-Based Education by making CO-PO evaluating simpler, more precise, and data-driven

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