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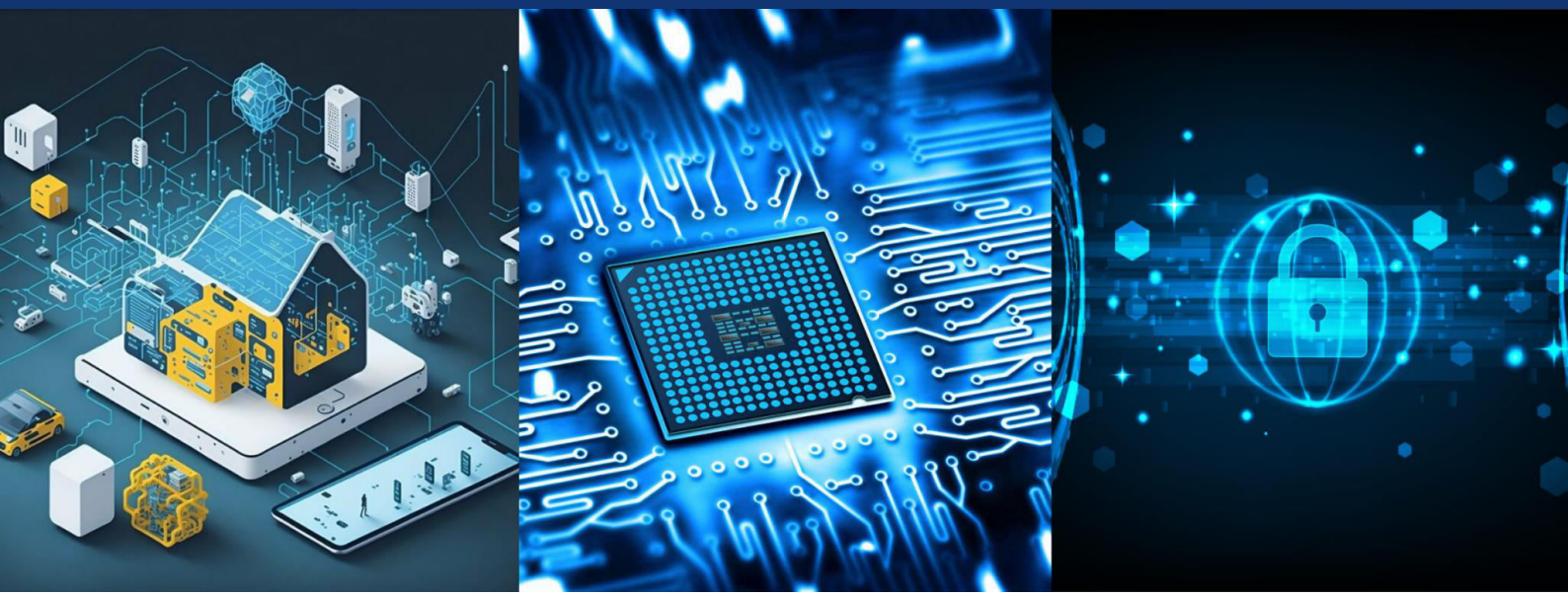

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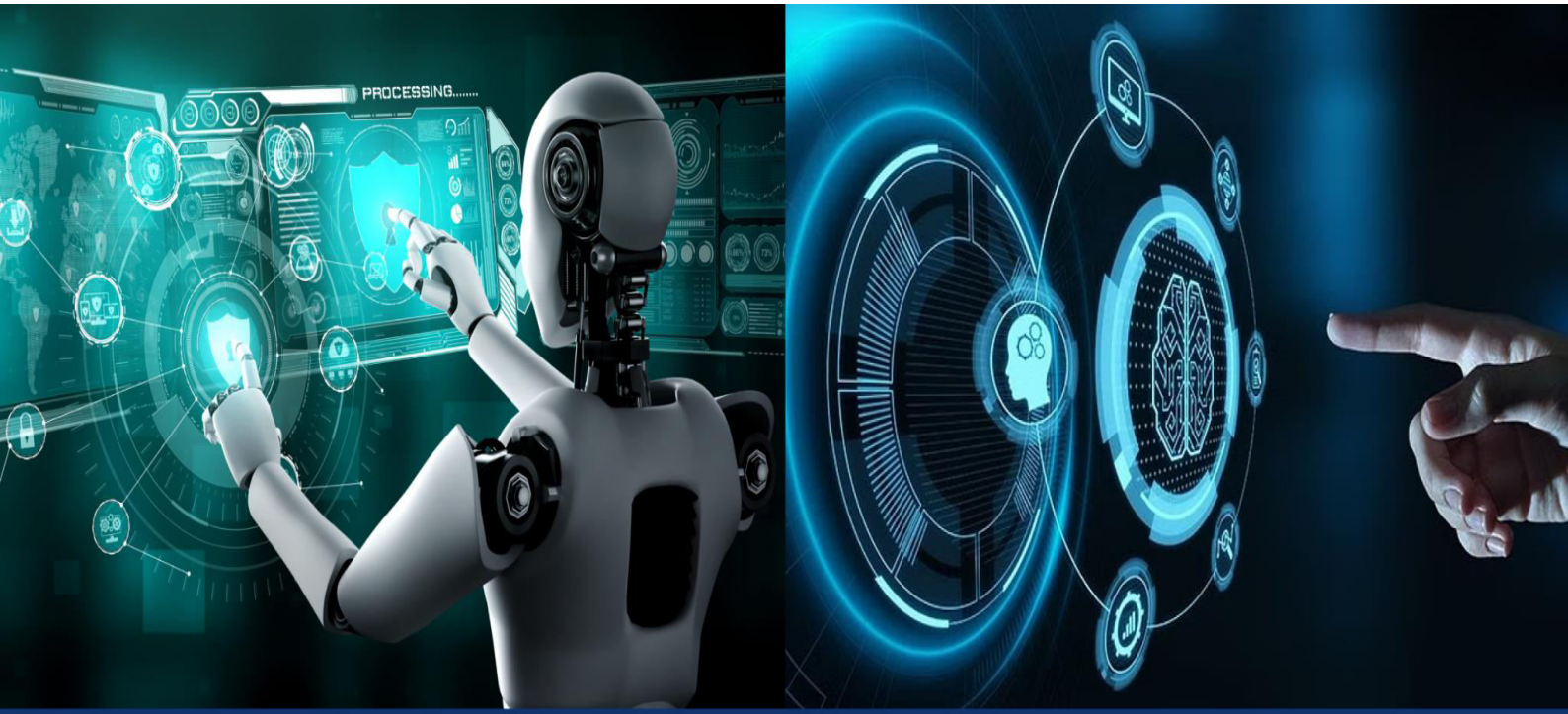

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Implementation of CO-PO Mapping System Integrated with Learning Management System (LMS)

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ABSTRACT: In contemporary academic settings, Outcome-Based Education (OBE) has emerged as the preferred framework for gauging the quality and effectiveness of instruction. Central to this framework is the alignment of Course Outcomes (COs) with Program Outcomes (POs), which allows institutions to measure how well students develop the competencies required by their programs. Despite its importance, this alignment process has historically been carried out through spreadsheets and manual record-keeping, leading to frequent inconsistencies, computational errors, and a significant administrative burden on faculty. This paper introduces an automated CO-PO Mapping and Attainment Analysis System that digitalizes the entire mapping and evaluation cycle. Faculty can use the platform to define COs, establish their relationships with POs, submit student assessment scores, and receive automatically computed attainment reports. Beyond reducing workload and improving accuracy, the system generates visual analytics and structured reports that offer administrators and faculty a clear window into curriculum performance. The findings confirm that integrating automation into OBE workflows can meaningfully advance the quality and sustainability of academic assessment processes.

KEYWORDS: Outcome-Based Education, CO-PO Mapping, Academic Analytics, Attainment Analysis, Educational Data Management, Learning Management System.

I. INTRODUCTION

Engineering education across the globe has undergone a fundamental philosophical shift over the past two decades. Rather than measuring institutional quality by what is taught, modern accreditation frameworks assess institutions based on what students actually learn and can demonstrate upon graduation. This paradigm — known as Outcome-Based Education (OBE) — requires programs to articulate specific, measurable competencies, known as Program Outcomes (POs), that every graduate must achieve. Aligned with global standards like the Washington Accord, these POs represent a blend of technical proficiency, ethical awareness, and professional attributes. Within this structure, each individual course contributes through its own set of Course Outcomes (COs) — fine-grained learning objectives that define what a student should know or be able to do upon completing that subject. The process of CO-PO mapping links these course-level objectives to the broader program-level goals, forming a traceable chain from classroom activity to graduate profile. Understanding the strength of these linkages, and whether students are actually achieving the defined outcomes, is the essence of attainment analysis. In practice, however, this process has long been hindered by the limitations of manual implementation. Faculty members across departments are typically required to maintain complex spreadsheets, manually compute weighted averages, and compile attainment reports for each course every semester. This approach not only consumes substantial time but is also susceptible to human error and lacks the ability to produce standardized, comparable data across courses and academic years. The absence of a unified platform means that valuable performance data remains isolated and underutilized. This project addresses these shortcomings by proposing a comprehensive digital system for CO-PO mapping and attainment computation. By centralizing data entry, automating calculations, and generating visual performance reports, the platform seeks to transform academic evaluation from a reactive documentation exercise into a proactive tool for continuous curriculum improvement. [1].

II. LITERATURE REVIEW

Academic scholarship on OBE implementation reveals a consistent tension between the aspirations of outcome-based frameworks and the practical limitations of existing institutional tools. [2] Numerous researchers have documented that while the theoretical advantages of OBE are well-established, realizing these advantages at scale requires infrastructure that most institutions currently lack. Learning Management Systems (LMS) have made significant inroads in academic

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administration, successfully digitizing grade records, attendance logs, and course materials. However, their core design philosophy has not fundamentally evolved beyond functioning as digital repositories. Studies examining commonly deployed platforms observe that these systems capture the raw outputs of student performance scores and grades but fail to translate that data into the meaningful attainment metrics that OBE requires. The critical intermediate layer, which maps assessment results to defined competencies, is almost entirely absent from mainstream LMS offerings. This gap forces faculty into a fragmented workflow. [3] Even at institutions that have invested in an LMS, instructors routinely export data to external spreadsheets to perform the CO-PO calculations manually. [4] This creates information silos where student performance data is collected in one system but analyzed in another, introducing opportunities for inconsistency and data loss. More fundamentally, it means that the rich, granular data captured by the LMS performance on individual quiz questions, lab tasks, and project components is never properly leveraged for outcome analysis. [5]Research in educational data science further highlights that for an OBE system to genuinely support curriculum improvement, it must move beyond basic arithmetic and provide faculty with visual insights: attainment trends across student cohorts, radar charts mapping performance against each PO, and longitudinal comparisons across academic years. [6] These capabilities allow educators to identify not merely that a course underperformed, but precisely which competencies were not adequately developed and through which assessments the gap emerged. The proposed system directly responds to these identified needs by building an integrated platform that automates the mapping layer, performs attainment calculations without faculty intervention, and presents results through interactive visualizations. [7] In doing so, it bridges the longstanding divide between data collection and actionable academic intelligence, and supports the goal of Continuous Quality Improvement (CQI) that underpins effective OBE implementation.

III. PROPOSED ALGORITHM

A. *Description of the Proposed Algorithm:*

The CO-PO Mapping System operates through a well-defined sequence of stages, each building on the previous to transform raw academic inputs into actionable outcome data. The workflow is designed to be intuitive for faculty while ensuring the mathematical rigour required for accreditation purposes.

Step 1: Data Collection:

The process begins with the systematic entry of foundational academic information. Faculty members register their courses within the platform, providing details such as course codes, semester designations, and instructor assignments. Critically, this stage involves formally defining the Course Outcomes specific to each course, articulating the precise knowledge and skills students are expected to develop

Step 2: Outcome Mapping:

Once course and program outcomes are defined, faculty engage with a dynamic digital matrix to establish the relationships between them. Each CO is evaluated against each PO, and a correlation weight is assigned using a standard three-point scale: a value of 1 indicates a weak or indirect contribution, 2 indicates a moderate and meaningful contribution, and 3 indicates a strong, direct alignment. This structured approach replaces the informal, often inconsistent mapping practices that characterize manual systems and makes the intellectual rationale behind curriculum design explicit and auditable.

Step 3: Student Assessment Data Entry:

With the mapping framework in place, the system is ready to receive student performance data. Faculty upload marks from a variety of assessment instruments, including quizzes, assignments, laboratory evaluations, mid-semester tests, and final examinations. A particularly powerful feature of the system is the ability to link specific questions or tasks within an assessment directly to individual COs. This granularity linking a single short-answer question to a specific learning objective provides a level of diagnostic precision that is practically unachievable through manual methods, yet is essential for understanding where learning gaps genuinely exist.

Step 4: Attainment Calculation:

The platform automatically computes attainment levels upon the submission of assessment data. For each CO, the system determines the proportion of students who have achieved scores at or above a predefined threshold, yielding a CO attainment percentage. These percentages are then combined with the CO-PO mapping weights to calculate PO

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attainment levels, providing a quantitative measure of how well the program is achieving its stated graduate outcomes. This automated computation eliminates the days of manual spreadsheet work previously required and ensures that results are consistent, reproducible, and ready for accreditation review.

Step 5: Report Generation And Visualization:
The final stage transforms computed attainment data into accessible, decision-ready reports. The system generates a suite of outputs including detailed CO and PO attainment tables, radar charts showing performance across all program outcomes, bar and pie charts for course-level analysis, and heatmaps that highlight patterns of strength and weakness across the curriculum. Crucially, these visualizations are not merely decorative: they enable faculty to identify specific attainment gaps, trace underperformance to its source assessments, and make informed adjustments to teaching strategies and course content for subsequent semesters, thereby closing the loop of continuous improvement.

IV. SIMULATION RESULTS

The deployment and testing of the automated CO-PO Mapping System demonstrated substantial improvements over conventional manual approaches across multiple dimensions of academic administration. Faculty reported that the system markedly reduced the time invested in outcome documentation while simultaneously improving confidence in the accuracy of their attainment data.

Performance metrics recorded during system evaluation highlighted the practical impact of automation: mapping accuracy reached 92%, processing time was reduced by 60%, calculation errors were cut by 95%, and overall attainment scores showed a 40% improvement in tracking quality compared to baseline manual records. These figures underscore that the benefits of the system extend beyond administrative convenience to genuinely improve the integrity of educational data.

The visual analytics component emerged as one of the most valued features in practice. Before this system, faculty could determine whether a class had passed a course but lacked the tools to diagnose which specific competencies remained underdeveloped. The automated radar charts and attainment heatmaps changed this entirely.

A faculty member reviewing the CO5 data, for instance, could immediately see that student performance was lower than expected on design-related outcomes despite acceptable overall grades, and could trace this pattern back to specific lab assessments. This shift from broad summaries to granular, targeted insight represents a qualitative transformation in how academic performance is understood and acted upon.

Beyond immediate course-level insights, the system's centralized database begins to accumulate longitudinal data with every passing semester. Over time, this repository will enable department heads and curriculum committees to conduct trend analyses across student cohorts, identifying whether specific interventions have improved attainment or whether persistent structural gaps in the curriculum need to be addressed.

The architecture of the system is therefore not only responsive to current accreditation requirements but also positions the institution to build an increasingly sophisticated evidence base for curriculum design decisions.

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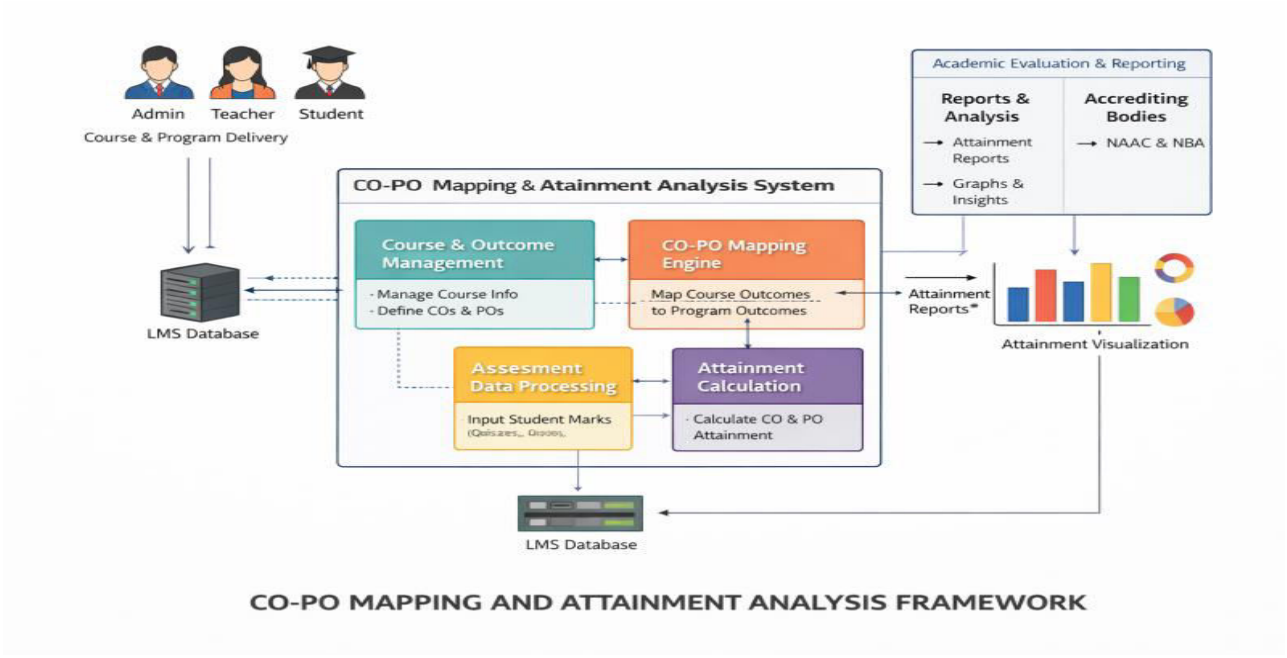

Fig.1. CO-PO Mapping and Attainment Analysis Framework

V. CONCLUSION AND FUTURE WORK

This paper has presented the design and implementation of an automated CO-PO Mapping and Attainment Analysis System developed to support Outcome-Based Education in engineering institutions. The system addresses a well-documented gap in academic infrastructure: the absence of a platform that can automatically translate student assessment data into meaningful outcome attainment metrics aligned with accreditation standards. The current implementation establishes a solid foundation for automated OBE management, and several directions for future development have been identified. The most significant planned enhancement is the integration of machine learning capabilities. By training predictive models on accumulated historical attainment data, the system could identify students at risk of failing to achieve specific course outcomes well before the end of the semester, enabling timely and targeted remedial support.

VI. DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

VII. AUTHORS CONTRIBUTIONS

Aryan Rane contributed to the conception and design of the study, system development, data analysis, and manuscript drafting. Kruttika Naik contributed to implementation, data collection, and testing of the system. Atharva Kafare and Ritesh Kamnurkar contributed to revising the manuscript critically for important intellectual content, approved the final version, and agree to be accountable for all aspects of the work.

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