Evaluating Student Performance in CAD Education: A CAP-Based Analysis of Course Outcomes

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ABSTRACT

Computer-Aided Design (CAD) education plays a vital role in shaping the technical proficiency of engineering and design students. However, assessing student performance in CAD courses often relies heavily on subjective grading and inconsistent evaluation metrics. This study introduces a structured framework using the Course Attainment Parameters (CAP) methodology to evaluate student outcomes in a standardized and objective manner. By aligning course objectives with measurable performance indicators, the CAP-based approach enables a more transparent assessment of individual and collective student progress. Data were collected from students in the October 2024 – February, 2025 cohort, of a public university in Malaysia. The students were enrolled in the third semester's core CAD course, encompassing both theoretical understanding and practical skill development. The analysis involved mapping student performance to predefined Course Outcomes (COs), with each outcome weighted based on its relevance and complexity. The CAP-based assessment revealed strong attainment in affective and psychomotor domains, with over 93% of students achieving satisfactory or higher in CO3 to CO5. However, significant learning gaps were identified in theoretical understanding (CO1) which measured the cognitive competency, where only 57.8% of students met the minimum competency level. CO2 however had an acceptable measurement of 80.4% indicating clearly that this cohort of students are more skilled in the psychomotor and affective domains. This study demonstrates the effectiveness of CAP as a tool for continuous course enhancement and as a feedback mechanism for both instructors and students. The findings support the integration of outcome-based education (OBE) principles to elevate the quality and consistency of CAD education across institutions.

Keywords: Computer-Aided Design (CAD), Course Attainment Parameter (CAP), Course Outcomes, Outcome-Based Education (OBE), Student Attainment.

INTRODUCTION

The rapid evolution of technology in engineering education has led to an increased emphasis on Computer-Aided Design (CAD) as a fundamental component of the curriculum. CAD facilitates the design, analysis, and manufacturing of engineering components, making it an essential skill for future engineers(Shih et al., 2020) . However, effective CAD education requires a balance between theoretical knowledge, practical application, and professional competencies, which are traditionally categorized under cognitive, psychomotor, and affective learning domains (CAP)(Krathwohl, 2002) . Cognitive learning encompasses the understanding of CAD principles and theories, psychomotor learning involves the hands-on application of CAD tools, and affective learning relates to teamwork, communication, and ethical considerations (Anderson & Krathwohl, 2001).

Educational assessment frameworks, such as Bloom's Taxonomy and the Revised Bloom's Taxonomy, emphasize the importance of evaluating students beyond rote memorization and into application, analysis, and creation which provide a structured framework for categorizing learning objectives into cognitive (knowledge-based), psychomotor (skill-based), and affective (attitude-based) domains (Biggs & Tang, 2011). In engineering education, Outcome-Based Education (OBE) further integrates these principles, aligning learning outcomes with industry needs and accreditation requirements (Spady, 1994). Prior studies have demonstrated that a well-structured CAP approach enhances students' ability

to engage with complex problem-solving tasks and apply knowledge in real-world settings (Felder & Brent, 2009). Despite these advancements, achieving high competency levels in all three remains a challenge, particularly in courses requiring both technical proficiency and theoretical understanding (Lohani et al., 2019). In CAD education, students often exhibit stronger psychomotor skills but struggle with the cognitive components, such as theoretical comprehension and problem-solving(Mat Isa et al., 2024) .

Recent research highlights the need for improved instructional strategies to address disparities in CAP-based learning outcomes. Studies indicate that blended learning approaches, incorporating face-to-face lectures, online resources, and hands-on training, significantly improve student engagement and performance in technical courses (Means et al., 2013). Furthermore, interactive assessments, peer collaboration, and project-based learning have been shown to enhance knowledge retention and practical application in CAD courses (Prince & Felder, 2006). Despite these efforts, students often face difficulties in theoretical assessments due to lack of preparation, inadequate study habits, and a preference for hands-on work (Freeman et al., 2014). Additionally, the affective domain, which includes communication and ethical responsibility, requires targeted interventions to ensure students develop professionalism and teamwork skills essential for their careers (Dym et al., 2005).

This study evaluates the effectiveness of a CAD subject's assessment framework by analyzing students' achievements across the cognitive, psychomotor, and affective domains. The findings provide insights into student learning patterns, identify areas for improvement, and propose pedagogical strategies to enhance course outcomes. By leveraging CAP principles, this research aims to contribute to the ongoing discourse on engineering education and offer recommendations for optimizing CAD instruction. The results of this study will be valuable for educators, curriculum designers, and accreditation bodies seeking to refine assessment strategies in technical education (Álvarez Ariza, 2024; Graham, 2018; Terenzini et al., 2001).

METHODOLOGY

This study employed a Course Attainment Parameter (CAP)-based evaluation approach within the framework of Outcome-Based Education (OBE) to assess student performance in the Computer Aided Design (CAD) course, offered at a public university in Malaysia during the Oct 24–Feb 25 academic semester. The objective was to determine the degree of attainment across five predefined Course Outcomes (COs), each mapped to relevant Programme Outcomes (POs) as stipulated by the Engineering Accreditation Council (EAC) Malaysia (Mohd Saim et al., 2021). This study only focuses one cohort of students from one institution.

Course Structure and Participants

The CAD course included both theoretical and practical components aimed at developing cognitive, psychomotor, and affective competencies in CAD. A total of 367 students from multiple sections participated in this study, with all students undergoing the same instructional content, assessments, and evaluation rubrics. Teaching methods included face-to-face and online lectures, practical lab sessions, group discussions, and project-based learning. Assessments were conducted continuously throughout the semester and were distributed across final tests, lab tests, assignments, and mini projects.

Course Outcomes and Assessment Plans

The course learning outcomes and the respective assessment plans are as shown in Table 1 and the continuous assessment scores are shown in Table 2. The course outcomes are mapped to the general engineering degree's program outcomes (POs), learning outcomes (LOs), soft skills and CAP assessments. Upon completion of this course, students are expected to fulfil these course outcomes.

Table 1 : Course Learning Outcomes And The Respective Assessment Plans

Course Learning Outcomes (CO)	Method Of Delivery	Method Of Assessment
CO1: Explain various concepts of Computer Aided Design (CAD), Engineering (CAE) and Manufacturing (CAM) in design, engineering and manufacturing processes	• Face to Face and Online Lecture	• Final Test
CO2: Build the competency in applying the techniques available in CAD in order to construct, develop and draft CAD models	• Face to Face (F2F) and Online Lecture • F2F and Online Practical Lab Sessions	• Lab Assignments • Lab Test • Mini Project Report
CO3: Explain and communicate effectively the design solutions for engineering problems and design systems, components or processes that take into consideration public health, safety, cultural, societal and environmental consideration	• F2F and Online Lecture • F2F Class Room Discussion	• Presentations for the Mini Project
CO4: Organize and report work independently as well as in a group during the project implementation	• Group Discussion • Problem Based Learning	• Mini Project Report
CO5: Adhere to ethical principles and commit to professional ethics and responsibilities and norms of engineering practice	• F2F and Online Lecture • Class Room Discussion	• Mini Project Report

Table 2: Continuous Assessment (100%)

Assessment Components	CO Addressed	Weightage
TESTS		**50%**
1. Final Test	CO1	30%
2. Lab Test	CO2	20%
MINI PROJECT AND ASSIGNMENTS		**50%**
3. Lab Assignments	CO2	10%
4. Mini Project	CO2, CO4,CO5	15%, 10%, 5%
5. Presentation	CO3	10%

Course Outcome (CO) Achievement Grading

The marks on each course outcome are grouped following the categories listed in Table 3 before the frequency is counted.

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Table 3: Category of marks for CO analysis

Category	Marks	Scale (1-5)
Very Poor	0 – 29%	0.00- 1.49
Poor	30 – 49%	1.50 – 2.49
Satisfactory	50 – 59%	2.50 – 2.99
Good	60 – 79%	3.00 – 3.99
Excellent	80 – 100%	4.00 – 5.00

RESULTS AND DISUSSION

CO1 Achievement

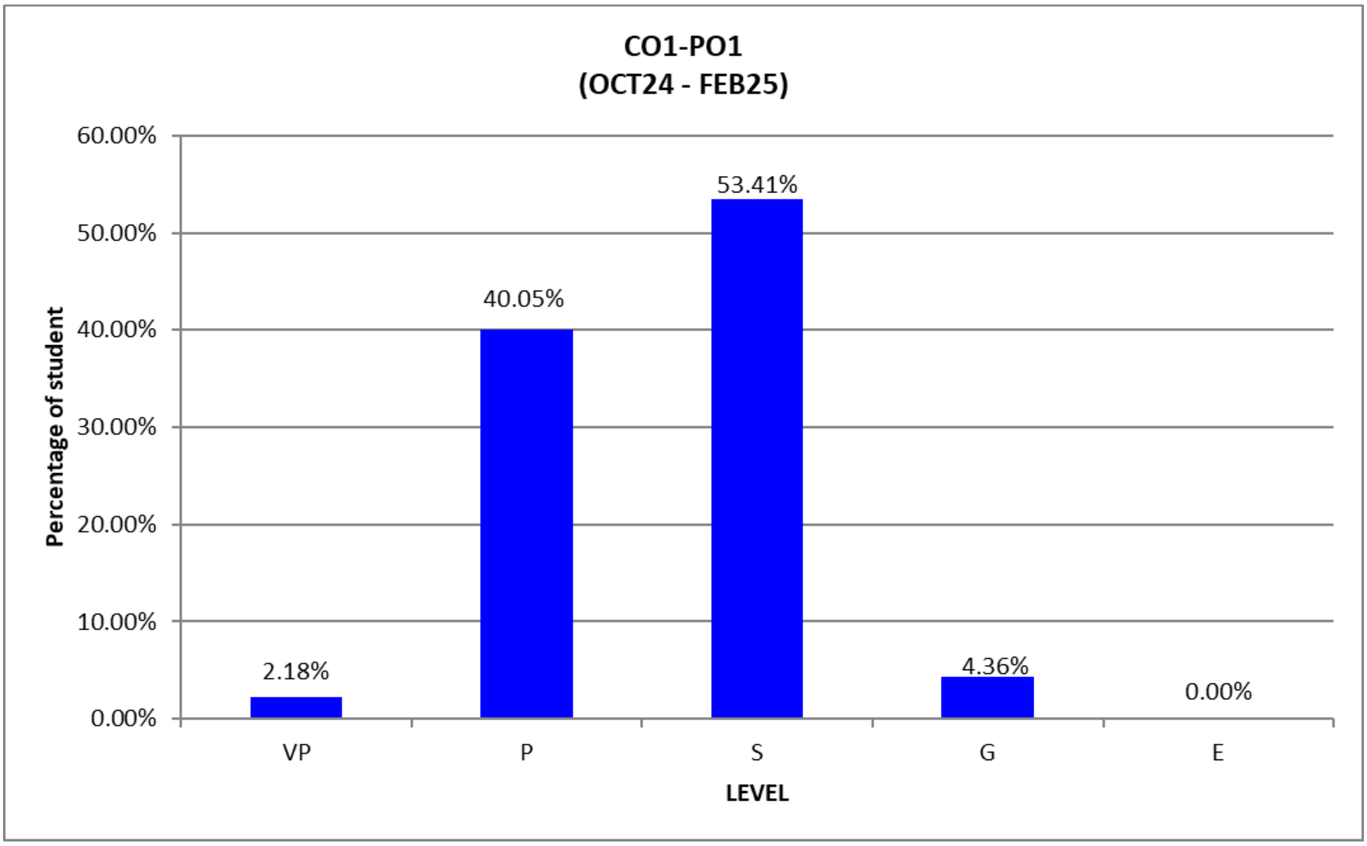

Figure 1: CO1 Achievement

The student performance of CO1 as shown in Fig 1. reveals a concerning distribution, with 2.18% scoring *Very Poor*, 40.05% *Poor*, 53.41% *Satisfactory*, and only 4.36% achieving *Good*, resulting in an average mark of 44.9%. This indicates that fewer than half of the students have adequately grasped the theoretical concepts related to CAD, CAM, and CAE. Despite targeted interventions such as tutorial-style question practice mirroring assessment formats and continuous academic support via WhatsApp groups for doubt clarification, the outcomes remain below expectations. Notably, a significant proportion of poorly performing students did not attempt several questions, suggesting insufficient preparation. The results fall short of the 50% threshold and fail to meet the KPI target of 75% achievement for the course outcome, highlighting the persistent challenge of enhancing student engagement and performance in theoretical assessments compared to psychomotor or affective evaluations.

CO2 Achievement

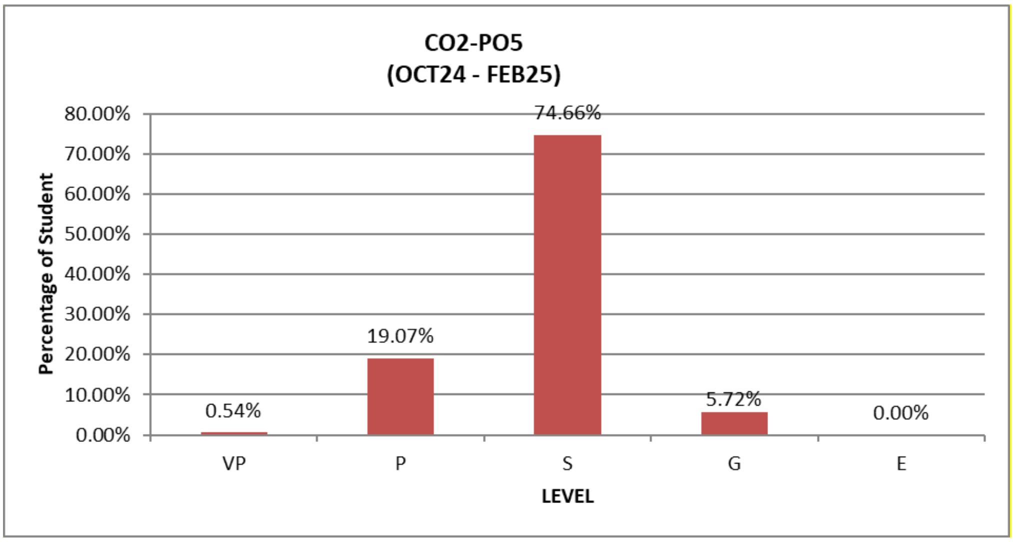

Figure 2: CO2 achievement

The student performance in CO2 illustrated in Fig 2. demonstrates a predominantly *Satisfactory* level (74.66%), with 5.72% achieving *Good*, while 19.07% scored *Poor* and only 0.45% *Very Poor*, yielding an average mark of 57.5%. This suggests that most students have developed foundational competency in applying CAD techniques to model development, indicating reasonable success in practical skill acquisition. However, the low percentage of *Good* performers and the persistence of underperforming students highlight areas for improvement. A critical concern is the lack of engagement among some students, evidenced by neglected assignments, inconsistent lab participation, and failure to contribute to group projects, despite extensive support, including personalized reminders, hands-on guidance, and supplementary video tutorials tailored to the syllabus. The underutilization of these resources raises questions about student motivation and self-directed learning habits. While the overall outcome is acceptable, the lackadaisical attitude of a subset of learners must be addressed through stricter accountability measures or alternative engagement strategies to ensure more consistent participation and skill mastery.

CO3 Achievement

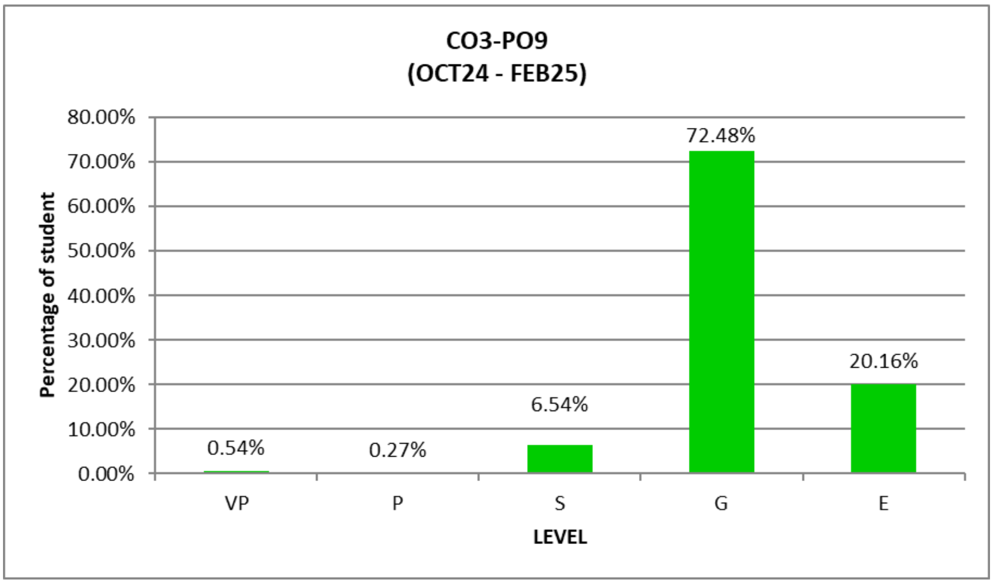

Figure 3: CO3 Achievement

The assessment of CO3 shown in Fig 3. reveals strong student performance, with 72.48% achieving *Good* and 20.16% attaining *Excellent*, while only 6.54% scored *Satisfactory*, resulting in an average

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mark of 78.6%**.** This indicates that the majority of students can effectively structure and present their project outcomes in a professional manner, reflecting well-developed communication and organizational skills. However, despite the high overall achievement, some shortcomings persist such as absenteeism during presentations and failure to adhere to assessment rubrics**,** which contributed to lower grades for certain individuals and groups. These issues suggest a need for stricter enforcement of attendance policies and clearer reinforcement of rubric expectations to ensure consistency in performance. Additionally, while presentation skills are generally proficient**,** further refinement could be achieved through targeted workshops on public speaking, slide design, and technical delivery to elevate the quality to an even higher standard. This outcome demonstrates success in student competency but also highlights opportunities for enhanced instructional scaffolding to minimize variability in performance.

CO4 Achievement

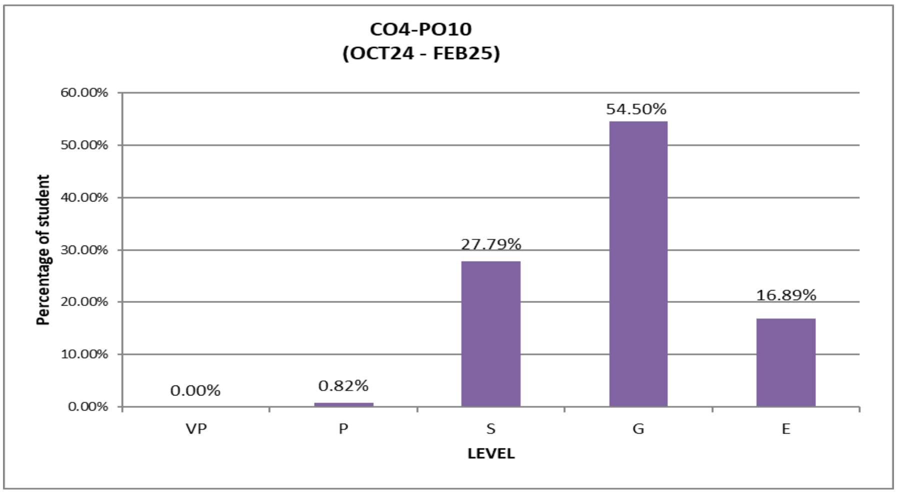

Figure 4: CO4 Achievement

Fig 4. reveals the assessment of CO4 where majority of students perform at a Good (54.50%) or Excellent (16.89%) level, while 27.79% achieve a Satisfactory rating and only 0.82% fall into the Poor category, with an average score of 72.7%**.** This indicates that most students demonstrate satisfactory to strong competency in independently organizing work, both individually and collaboratively. Despite being provided with sample reports and structured templates, some students still failed to comply with the prescribed rubrics, reflecting either misinterpretation of expectations or insufficient engagement with the provided resources. While overall report-writing skills are acceptable, reinforcing rubric comprehension through additional exemplars, targeted feedback, or peer-review exercises could further enhance performance. Addressing these gaps may help stabilize or improve future outcomes, ensuring more uniform excellence across submissions.

CO5 Achievement

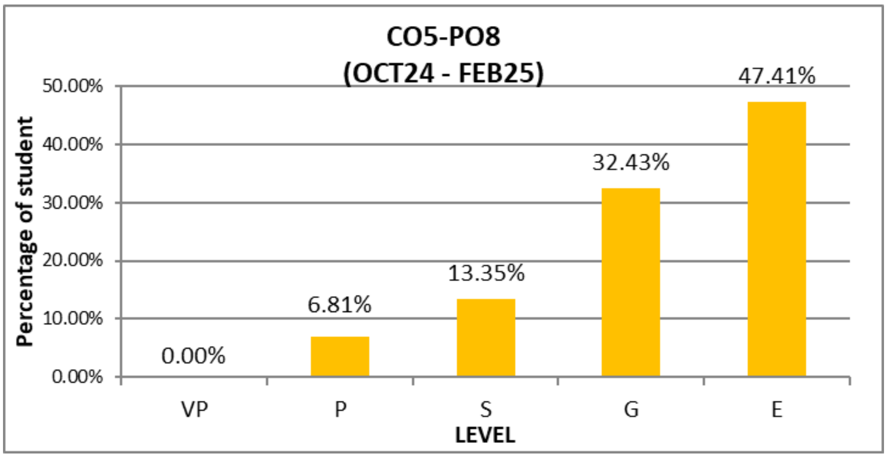

Figure 5: CO5 Achievement

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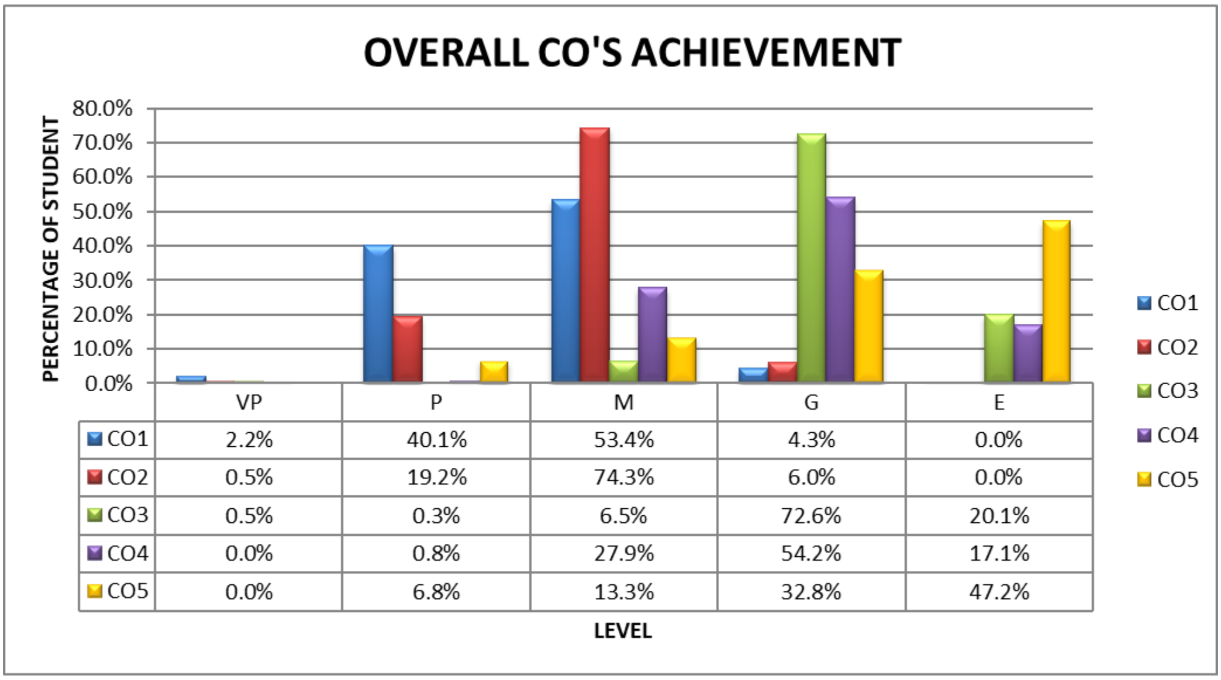
The assessment of CO5 in Fig 5. demonstrates strong student performance, with 47.41% achieving Excellent and 21.43% attaining Good, while 13.35% scored Satisfactory and 6.81% fell into the Very Poor category, yielding an average mark of 81.1%**.** These results suggest that the majority of students successfully apply ethical principles and demonstrate commitment to professional responsibilities and engineering norms**.** However, the presence of a minority (6.81%) performing very poorly along with some students omitting ethical analysis in their design projects indicates gaps in either comprehension, application, or engagement with ethical frameworks. The high average score reflects overall competency, yet the polarized distribution (between Excellent and Very Poor) suggests inconsistent internalization of ethical reasoning. To address this, structured scaffolding such as case-based learning, reflective writing tasks, or mandatory ethics checkpoints in project phases could ensure deeper and more uniform integration of ethical considerations**.** Further investigation into the causes of disengagement among lower-performing students (e.g., lack of awareness, perceived irrelevance) would help tailor interventions effectively.

Overall CO Achievement



	VP	P	M	G	E
CO1	2.2%	40.1%	53.4%	4.3%	0.0%
CO2	0.5%	19.2%	74.3%	6.0%	0.0%
CO3	0.5%	0.3%	6.5%	72.6%	20.1%
CO4	0.0%	0.8%	27.9%	54.2%	17.1%
CO5	0.0%	6.8%	13.3%	32.8%	47.2%

Fig 6: Overall CO Achievement

The data if Fig 6. reveals significant variation in student achievement across five Course Outcomes (CO1-CO5) from October 2024 to February 2025. CO1 and CO2 show concerning trends, with 40.1% and 19.2% of students respectively in the Poor category, and virtually none achieving Excellent performance. In contrast, CO3 demonstrates outstanding results, with 72.6% Good and 20.1% Excellent achievement, while CO5 leads overall with 47.2% of students in the Excellent range. These disparities suggest that some outcomes (particularly CO1 and CO2) may require instructional refinement, while others (CO3-CO5) represent areas of teaching strength that could inform improvements elsewhere in the curriculum.

The patterns indicate that most students grasp moderate-level concepts but struggle with advanced application in certain outcomes. For CO1, 53.4% reached Moderate but only 4.3% achieved Good, whereas CO4 and CO5 show stronger high-end performance with 54.2% and 32.8% respectively in the Good category. Targeted interventions should focus on elevating Poor performers in CO1-CO2 through additional support or revised teaching methods, while maintaining the successful approaches used for CO3-CO5. The data ultimately highlights opportunities to balance achievement across all outcomes by identifying and addressing the specific challenges impacting CO1 and CO2 performance.

Students Academic Performance (Final Grades)

Final grades are determined based on the sum of all course works marks. Overall, all the 359 students passed the

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course with distribution as shown in Figure 7 and Table 4. The grades for the student are determined based on the grading scale in Table 4.The average mark is 65.43 (B+) the median is 66.0 (B+), and the standard deviation is 7.86.

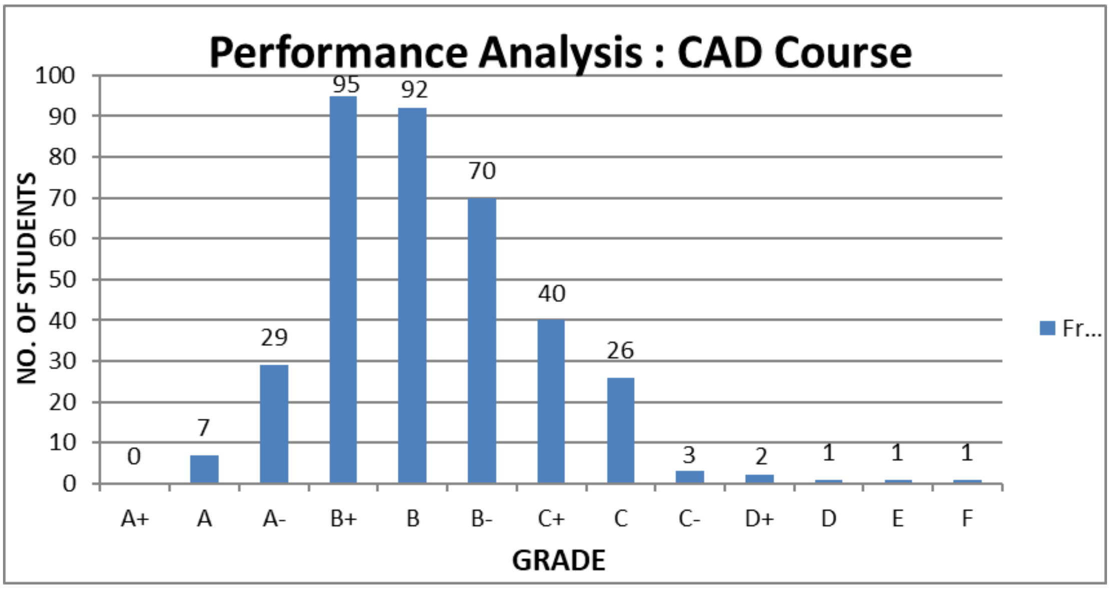

Fig 7: Performance Analysis

Table 4: Summary of students' performance

Mark	Point	Freq.	Grades	% of Grades
90 - 100	4.00	0	A+	0.00
80 - 89	4.00	7	A	1.91
75 - 79	3.67	29	A-	7.90
70 - 74	3.33	95	B+	25.89
65 - 69	3.00	92	B	25.07
60 - 64	2.67	70	B-	19.07
55 - 59	2.33	40	C+	10.90
50 - 54	2.00	26	C	7.08
47 - 49	1.67	3	C-	0.82
44 - 46	1.33	2	D+	0.54
40 - 43	1.00	1	D	0.27
30 - 39	0.67	1	E	0.27
0 - 29	0.00	1	F	0.27
TOTAL:		367		
PASS :		359		97.82
FAIL :		8		2.18

CONCLUSION

Overall, students performed well in this course (average B+). The total number of students evaluated are 367. Summary of CO and PO achievements are as follow:

	% of achievement with satisfactory and above (50 and above)	Number of students with satisfactory & above (50 and above)	% of achievement with poor and below (49 and below)	Number of students with poor or very poor (49 and below)
CO1-PO1	57.77% **KPI Not Achieved**	212	42.23%	147 (Poor), 8 (Very Poor)
CO2-PO5	80.38% **KPI Achieved**	295	19.62%	70(Poor), 2 (Very Poor)
CO3-PO9	99.18% **KPI Achieved**	364	0.82%	1 (Poor), 2 (Very Poor)
CO4-PO10	99.18% **KPI Achieved**	364	0.82%	3 (Poor), 0 (Very Poor)
CO5-PO8	93.19 % **KPI Achieved**	342	6.81%	25 (Poor), 0 (Very Poor)

*KPI Indicator – when 75% or above percentage of students achieve a 50 marks and above scores

This study applied a CAP-based evaluation framework to objectively assess student performance in a CAD course aligned with Outcome-Based Education (OBE) principles. The findings demonstrate that while students exhibited strong performance in communication, collaboration, and ethical responsibility (CO3–CO5), there remain notable deficiencies in theoretical comprehension (CO1) and practical modelling consistency (CO2). The majority of students achieved satisfactory to excellent ratings in the affective and psychomotor domains, confirming the effectiveness of current teaching strategies in fostering soft skills and practical CAD proficiency. However, the underperformance in CO1 highlights persistent challenges in cognitive engagement, especially in mastering fundamental concepts of CAD, CAE, and CAM.

To address these imbalances, future instructional strategies should emphasize active learning, targeted remediation, and scaffolded assessments tailored to the cognitive domain. Enhancing student accountability, providing clearer rubrics, and integrating ethics and theory more explicitly into projects may improve consistency across all learning outcomes. The CAP framework has proven to be a valuable diagnostic and feedback tool, enabling data-driven improvements in course delivery. These insights can support educators in refining pedagogical approaches, improving academic outcomes, and ensuring alignment with accreditation standards, ultimately contributing to the broader goal of elevating CAD education quality at the institutional level.

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