Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2026/v39i3/26082

Enhancing Program Outcome Mapping and Attainment through Integrated Educational Activities

[1]Pankaj Beldar, [2]Dr. Prashant Kushare, [3]Dr. Mahesh Shelar, [4]Dr. Ajinkya Joshi
[1,2,3,4]K.K.Wagh Institute of Engineering Education and Research
[1]prbeldar@kkwagh.edu.in, [2]pbkushare@kkwagh.edu.in, [3]mnshelar@kkwagh.edu.in, [4]as.joshi@kkwagh.edu.in

***Abstract*— This study investigates the influence of integrating diverse educational interventions, including open-ended assignments, expert talks, interdisciplinary workshops and industrial visits, on Program Outcome (PO) mapping and attainment in engineering education. Utilizing past data, the research assesses the efficacy of these initiatives in enhancing student learning experiences and outcomes within the Outcome-Based Education (OBE) framework. Open-ended assignments are examined as mechanisms for cultivating critical thinking and problem-solving skills, while expert talks serve as avenues for bridging theoretical knowledge with real-world applications. Furthermore, interdisciplinary workshops and industrial visits are scrutinized for their contributions to hands-on learning, industry exposure, and teamwork development. The study incorporates two case studies to elucidate the impact of these interventions on PO mapping and attainment, providing valuable insights for curriculum design and educational practice in engineering education. Notably, the analysis reveals that Batch 2 exhibits commendable attainment, underscoring the effectiveness of integrated educational approaches in fostering student success.**

***Keywords*— Outcome-Based Education (OBE), Program Outcome (PO) Mapping, Open-Ended Assignments, Industrial Visits, Student Workshops, Expert Talks.**

***JEET Category*—Case Study.**

I. INTRODUCTION

Outcome-Based Education (OBE) is a student-centric teaching and learning methodology that emphasizes achieving specific outcomes that reflect the skills, knowledge, and attitudes necessary for professional success(Cresencio, 2023). In engineering education, OBE is crucial as it ensures that graduates are not only theoretically proficient but also practically capable of addressing real-world challenges. Effective Program Outcome (PO) mapping and attainment are central to OBE, serving as benchmarks for evaluating educational effectiveness and ensuring continuous improvement.

Program Outcomes (POs) are a set of competencies that engineering students must acquire by the end of their program. These include technical expertise, problem-solving abilities, teamwork, communication skills, and ethical practice. Achieving these outcomes requires a curriculum that goes beyond traditional lectures and exams. This paper explores how integrating diverse educational activities such as open-ended assignments, expert talks, mini projects, industrial visits, and student workshops can significantly enhance PO mapping and attainment(Hu et al., 2023).

Open-Ended Assignments: Open-ended assignments encourage students to think critically and creatively, offering them the opportunity to explore multiple solutions and approaches to a given problem(Brauner et al., 2007). This method helps develop problem-solving skills and deepens their understanding of complex concepts, which are essential for several POs(Sapawi et al., 2023).

Expert Talks: Expert talks by industry professionals and academics provide students with insights into current trends, technological advancements, and best practices in engineering. These sessions bridge the gap between theoretical knowledge and practical application, helping students appreciate the relevance of their studies and stay informed about contemporary issues (Throndsen, 2017).

Mini Projects: Mini projects allow students to apply theoretical knowledge to practical challenges, promoting innovation and technical competence. These projects require students to work collaboratively, manage time effectively, and develop project management skills, which are crucial for their professional development (Tang et al., 2021).

Industrial Visits: Industrial visits offer students firsthand exposure to engineering practices and professional environments. By observing and interacting with professionals in real-world settings, students can better understand industrial processes, professional practices, and the application of classroom knowledge to real-world problems.

Student Workshops: Workshops provide hands-on training in specific skills and tools relevant to the engineering field. These interactive sessions enhance technical competence, teamwork, and communication skills, allowing students to apply their knowledge in a practical context and collaborate effectively

Pankaj Beldar
Mechanical Engineering Department, K.K.Wagh Institute of Engineering Education and Research, Nashik, 422003 .
Savitribai Phule Pune University, India.
prbeldar@kkwagh.edu.in

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

with peers(Fox et al., 2017). Integrating these activities into the engineering curriculum creates a holistic learning environment that not only meets educational standards but also prepares students for the multifaceted challenges of their future careers. By enhancing PO mapping and attainment, these strategies ensure that graduates are well-equipped to contribute effectively to the engineering profession. Enhancing PO mapping means improving the alignment between course-level activities (like assignments, industry visits, or workshops) and program-level outcomes (skills and competencies graduates should achieve), ensuring that the curriculum effectively contributes to students' professional and personal development.

Programme Specific Outcomes (PSO):

1. PSO1: Analysing real-world problems in design, thermal, and manufacturing fields, creating solutions using modern tools.
2. PSO2: Applying professional skills, project management capabilities, and practical experience in mechanical engineering and related areas.

Program Outcomes (POs) and Program Specific Outcomes (PSOs) are metrics used to evaluate the proficiency and readiness of engineering graduates.

Program Outcomes (POs) are specific skills and knowledge areas that all engineering students are expected to achieve by the end of their program. These outcomes ensure that graduates are well-prepared to face complex engineering challenges, apply modern tools, understand ethical and societal responsibilities, work effectively in teams, and commit to lifelong learning, among other competencies(Cresencio, 2023). Program Specific Outcomes (PSOs), on the other hand, are tailored to specific engineering disciplines. They reflect the specialized skills and knowledge that graduates from a particular program, such as mechanical engineering, are expected to possess. These might include the ability to analyse real-life problems in specific engineering fields and apply professional skills and project management abilities relevant to their discipline(Alonzo et al., 2023).

PO and PSO attainment refers to the measurement of how well students have achieved these outcomes. This is typically assessed on a scale from 1 to 3:

- Level 1 (Basic): The student demonstrates basic understanding and limited application of the outcome.
- Level 2 (Proficient): The student demonstrates a good understanding and adequate application of the outcome.
- Level 3 (Advanced): The student demonstrates excellent understanding and effective application of the outcome.

For example, if a batch of students' scores an average of 2.56 on PO1 (Engineering Knowledge) and 2.34 on PO2 (Problem Analysis), it indicates that the students have a proficient to advanced understanding in these areas. Conversely, if the attainment for PO6 (The Engineer and Society) or PO8 (Ethics) is at 1.86 and 1.83 respectively, it may suggest that these areas require more focus and effort to move beyond the basic level.

II. LITERATURE REVIEW

Program Outcomes (POs) are a set of competencies that engineering students must acquire by the end of their program. These include technical expertise, problem-solving abilities, teamwork, communication skills, and ethical practice. Achieving these outcomes requires a curriculum that goes beyond traditional lectures and exams(Pawar et al., 2023). Program Specific Outcomes (PSOs), on the other hand, are tailored to specific engineering disciplines. They reflect the specialized skills and knowledge that graduates from a particular program, such as mechanical engineering, are expected to possess. These might include the ability to analyze real-life problems in specific engineering fields and apply professional skills and project management abilities relevant to their discipline(Hu et al., 2023).

Open-ended assignments (Brauner et al., 2007) are a vital tool in OBE as they encourage students to think critically and creatively. These assignments offer students the opportunity to explore multiple solutions and approaches to a given problem. Research shows that open-ended assignments help develop problem-solving skills and deepen understanding of complex concepts, which are essential for achieving several POs, such as PO1 (Engineering Knowledge) and PO2 (Problem Analysis)(Katageri et al., 2023),(Ingaleshwar & Jamadar, 2019).

Expert talks by industry professionals and academics provide students with insights into current trends, technological advancements, and best practices in engineering. These sessions bridge the gap between theoretical knowledge and practical application. For instance, expert talks can enhance PO3 (Design/Development of Solutions) and PO4 (Conduct Investigations of Complex Problems) by providing real-world examples and experiences that help students appreciate the relevance of their studies and stay informed about contemporary issues(Solomon, 2023). Interdisciplinary workshops allow students to apply theoretical knowledge to practical challenges, promoting innovation and technical competence(Hu et al., 2023),(Khot et al., 2020). These projects require students to work collaboratively, manage time effectively, and develop project management skills, which are crucial for their professional development. Such projects are particularly effective in improving PO5 (Modern Tool Usage) and PO11 (Project Management and Finance) (Klippert et al., 2020). Industrial visits offer students firsthand exposure to engineering practices and professional environments (Sapawi et al., 2023). By observing and interacting with professionals in real-world settings, students can better understand industrial processes, professional practices, and the application of classroom knowledge to real-world problems. Industrial visits are instrumental in enhancing PO6 (The Engineer and Society) and PO7 (Environment and Sustainability). Workshops (Klippert et al., 2020) provide hands-on training in specific skills and tools relevant to the engineering field. These interactive sessions enhance technical competence, teamwork, and communication skills (Fox et al., 2017). Workshops help students apply their knowledge in a practical context and collaborate effectively with peers, thereby improving PO9 (Individual and Team Work) and PO10 (Communication).

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

III. CASE STUDY

The Mechanical Engineering Department at an engineering college affiliated with Savitribai Phule University conducted a comprehensive study to enhance Program Outcome (PO) mapping and attainment through the integration of various educational activities. This case study investigates the implementation and impact of these activities over two consecutive batches spanning four academic years: A.Y. 2018-19 to 2021-22 (Batch 1) and A.Y. 2019-20 to 2022-23 (Batch 2). Fig.1. Shows the Methodology adopted for this research.

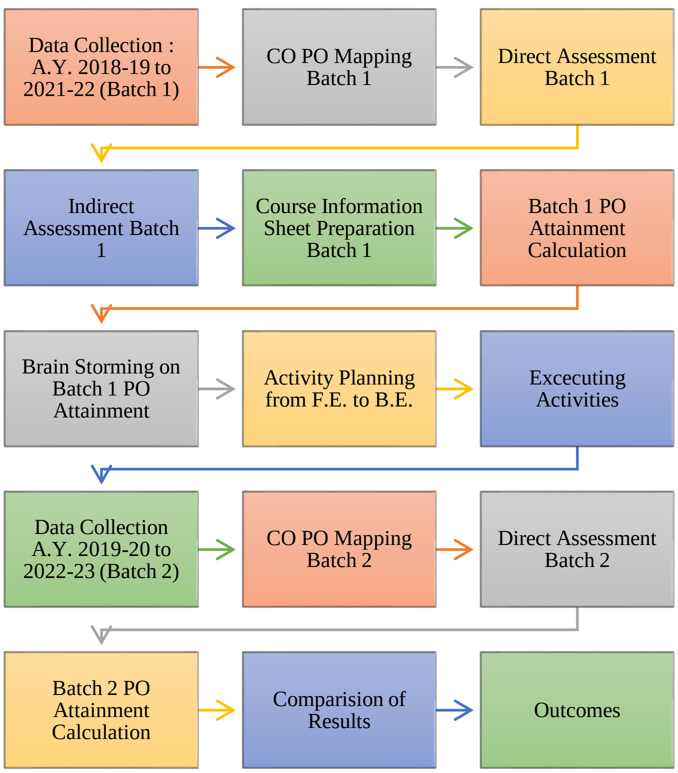

Fig. 1. Methodology

In Batch 1, spanning the academic years 2018-2019 and 2021-2022, student performance across various Program Outcomes (PO) and Program Specific Outcomes (PSO) was measured and recorded. The Average PO Mapping of all subjects from first year to last year is shown in fig. 2

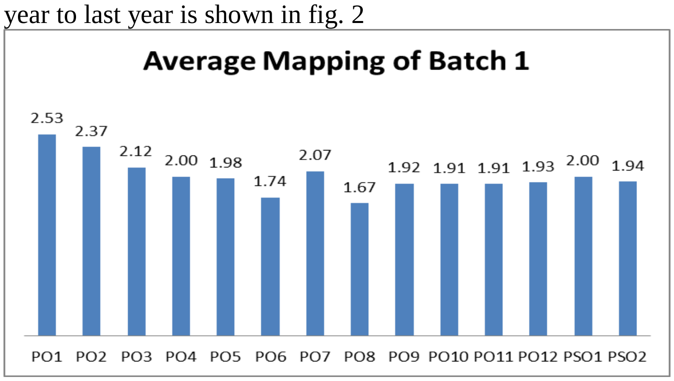

Fig. 2. Average Mapping of Batch 1

After mapping the correlation levels for all courses, an average value is calculated for each Program Outcome (PO) across all the courses. The average is computed by converting the correlation levels into numerical values (1 for slight, 2 for moderate, and 3 for substantial) and then taking the mean for each PO.

For example, the average for PO1 is calculated by adding all the values in the PO1 column for all courses and dividing by the total number of courses. This gives a numerical summary of how much each PO is addressed across the courses. While satisfactory scores were obtained in areas like design of solutions (PO3) and conducting investigations (PO4), there are opportunities for improvement in PO6 and PO8, emphasizing the engineer's societal role and ethical principles. POs related to teamwork, communication, project management, and lifelong learning show moderate proficiency, indicating areas for enhancement. Conversely, PSOs demonstrated strong performance overall, suggesting students possess necessary skills in mechanical engineering problem-solving and professional abilities. This comprehensive assessment enables educators to implement targeted interventions; ensuring students receive a well-rounded education and are adequately prepared for future career success. The assessment revealed varying levels of attainment across the defined outcomes. Fig. 3 shows PO Attainment of Batch 1

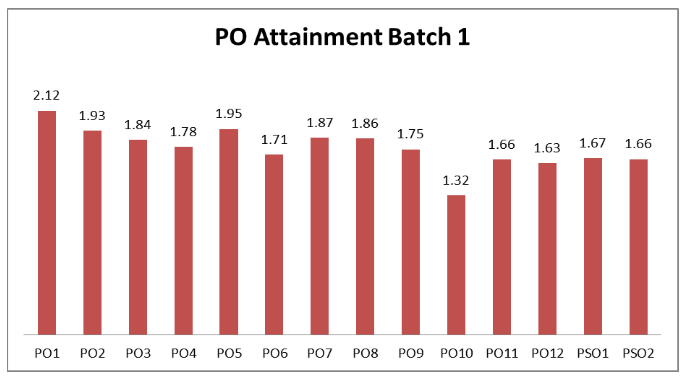

Fig. 3. PO Attainment of Batch 1

To calculate the Total PO Attainment for Batch 1, the formula involves the combination of direct and indirect PO attainment values. Here's how to calculate it:

1. Direct PO Attainment (80% weight): For each PO, the direct attainment value is the average score of all subjects' attainment to that PO.
2. Indirect PO Attainment (20% weight): The indirect attainment is usually taken from the Program Exit Survey, Alumni feedback, and Industrial visit feedback. It is provided as a set of values for each PO.
3. Total PO Attainment (100% weight): To calculate the total PO attainment, combine the direct and indirect attainments using their respective weights:

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

Total PO Attainment = (Direct PO Attainment × 0.80) + (Indirect PO Attainment × 0.20)

The Total PO Attainment is then calculated for each PO, resulting in a score that reflects both direct and indirect contributions.

A. Brain Storming

After analysing the attainment results from Batch 1, several strategies were devised to enhance the attainment of Program Outcomes (POs). Brainstorming sessions were conducted from the first year to gather insights and ideas from educators, industry professionals, and students. These sessions provided a platform for collaborative decision-making and generated innovative strategies to improve educational outcomes.

One of the key strategies identified was to increase the frequency and quality of industrial visits. By exposing students to real-world engineering environments, these visits provide valuable insights into industry practices, technological advancements, and practical applications of theoretical concepts. Additionally, expert talks by industry professionals were prioritized to provide students with first-hand knowledge and experiences relevant to their field of study. These talks serve to bridge the gap between theoretical learning and practical implementation, enhancing students' understanding and appreciation of engineering principles. Interdisciplinary workshops were also planned to foster collaboration and creativity among students from different disciplines. These workshops offer opportunities for students to apply their knowledge and skills to solve complex, interdisciplinary problems, thereby enhancing their problem-solving abilities and critical thinking skills. Furthermore, a concerted effort was made to incorporate more open-ended assignments into the curriculum. These assignments encourage students to explore topics in depth, think critically, and apply their knowledge to real-world scenarios, By mapping more POs with Course Outcomes (COs) through open-ended assignments, students have the opportunity to demonstrate their proficiency in a wider range of competencies, thereby enhancing overall attainment. Additionally, all course outcomes were redefined to ensure alignment with program objectives and to provide clear expectations for student learning. This process involved revisiting and refining the learning outcomes of individual courses to better reflect the knowledge, skills, and competencies students are expected to acquire.

Overall, these strategies aim to create a more dynamic and experiential learning environment that empowers students to achieve higher levels of attainment in Program Outcomes. By integrating industry experiences, expert insights, interdisciplinary collaboration, open-ended assignments, and refined course outcomes, educators can effectively prepare students for success in their academic and professional pursuits.

B. Industrial Visits

Mapping Program Outcomes (POs) with industrial visits can be a strategic approach to enhance students' understanding and proficiency in various aspects of engineering. Through 32 visits for batch 1 from F.E. to B.E in various large as well as small scale industries, we have mapped all POs with Industrial Visits. The same mapping is also included in subject CO- PO mapping Matrix.

For example:

Course Outcomes of course Dynamics of Machineries are-

1. APPLY balancing technique for static and dynamic balancing of multi cylinder inline and radial engines.
2. DETERMINE the gyroscopic couple or effect for stabilization of Ship, Airplane and Four wheeler vehicles.
3. EXAMINE natural frequency for single DOF un-damped & damped free vibratory systems.
4. CATEGORIZE the response of forced vibrations due to harmonic excitation, base excitation and excitation due to unbalance forces.
5. EVALUATE natural frequencies, mode shapes for 2 DOF un-damped free longitudinal and torsional vibratory systems.
6. DESCRIBE noise and vibration measuring instruments for industrial / real life applications and COMPARE the conditions of mechanical systems.

CO –PO Matrix of course Dynamics of Machineries is as follow without and with Industrial Visits. Fig. 4 shows the CO –PO Matrix of course Dynamics of Machineries with and without Industrial Visits

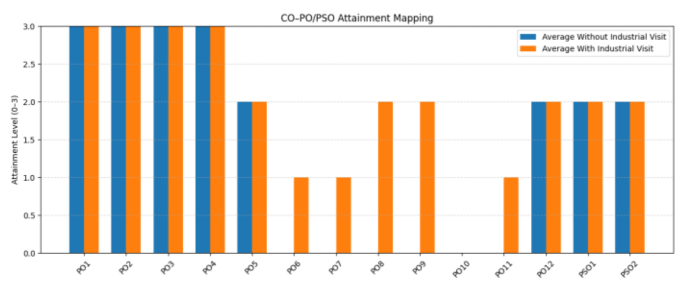

Fig. 4. CO –PO Matrix of course Dynamics of Machineries with and without Industrial Visits

Enhanced Attainment: Industrial visits appear to positively impact the attainment of specific POs, particularly those related to design, problem-solving, ethical considerations, project management, and lifelong learning (PO3, PO4, PO6, PO7, PO8, PO11, PO12).

Areas for Improvement: The decrease in attainment scores for PO5, PO6, PO7, PO8, and PO11 suggests that while industrial visits contribute to certain aspects of learning, they may not fully address other POs. This highlights the need for additional interventions or enhancements in these areas to ensure comprehensive skill development.

Strategic Mapping: The mapping of industrial visits to specific POs indicates areas where these visits are most beneficial. Educators can use this information to tailor industrial visit programs to focus on strengthening particular competencies aligned with these POs.

In summary, while industrial visits contribute positively to the attainment of certain POs, there are opportunities to further optimize their effectiveness and ensure holistic skill development across all desired outcomes. Adjustments in program design, curriculum integration, and assessment strategies can help maximize the impact of industrial visits on

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

student learning and attainment. Table I shows the PO wise Industrial Visit Activities for batch 2.

TABLE I
PO WISE INDUSTRIAL VISIT ACTIVITIES

Program Outcome	Industrial Visit Activities
PO1	Visit manufacturing facilities, research labs, engineering firms to observe real-world engineering applications.
PO2	Analyse engineering challenges encountered in industry settings, observe problem-solving methods used by professionals.
PO3	Observe design processes in industrial settings, explore how engineers address safety, sustainability, and societal impact.
PO4	Learn about research methodologies during industrial visits, observe data collection, analysis, and synthesis techniques.
PO5	Explore modern engineering tools and technologies used in industry, observe their applications in real-world scenarios.
PO6	Explore ethical dilemmas and societal implications of engineering projects during industrial visits.
PO7	Visit industrial sites to observe environmental impact assessments, learn about sustainable engineering practices.
PO8	Observe ethical practices in engineering projects during industrial visits, learn about professional codes of conduct.
PO9	Observe teamwork and collaboration in multidisciplinary industrial settings, learn about team dynamics and communication.
PO10	Learn about effective communication practices in engineering projects, observe presentations and report writing.
PO11	Explore project management practices in engineering projects, observe project planning and execution.
PO12	Learn about the importance of lifelong learning in engineering careers, observe how professionals adapt to technological advancements.
PSO1	Analyse real-life problems in mechanical engineering, including design, thermal, and manufacturing, during industrial visits.
PSO2	Apply acquired professional skills, project management abilities, and hands-on experience in mechanical engineering and allied areas.

C. *Open Ended Assignments*

Open-ended assignments are flexible tasks that encourage students to think critically, solve problems creatively, and apply their knowledge in diverse ways. By allowing students to explore topics freely and develop unique solutions, these assignments support deep learning and the integration of course content. They assess higher-level skills such as critical thinking and communication and can be tailored to align with a wide range of Course Outcomes (COs), maximizing mapping and promoting comprehensive mastery of course material. The impact of open ended assignments on CO PO Mapping is explained below for course Manufacturing Process Table II shows the Course Outcomes (CO) of Manufacturing Processes.

TABLE II
COURSE OUTCOMES (CO) OF MANUFACTURING PROCESSES

Course Outcome (CO)	Description
CO1	Select appropriate moulding, core making, and melting practices for sand casting process. Estimate pouring time and solidification rate. Design riser size and location.
CO2	Understand the mechanism of metal forming techniques. Calculate the load required for flat rolling.
CO3	Demonstrate press working operations. Apply basic principles to design dies and tools for forming and shearing operations.
CO4	Classify and explain different welding processes. Evaluate welding characteristics.
CO5	Differentiate between thermoplastics and thermosetting materials. Explain polymer processing techniques.
CO6	Understand the principles of manufacturing fibre-reinforced composites and metal matrix composites.

Table III shows the sample Open Ended Assignment for course Manufacturing Process.

TABLE III
OPEN ENDED ASSIGNMENT

Manufacturing Processes				
Que. No.	**Assignment Question**	**PO**	**POs**	**CO**
1	Investigate and compare the advantages and limitations of various casting processes used in manufacturing.	PO1	Engineering knowledge	CO1
2	Design a manufacturing process for producing a specific component, considering material properties, tolerances, and cost.	PO3	Design/development of solutions	CO3
3	Analyze the environmental impact of different machining techniques and propose sustainable alternatives.	PO7	Environment and sustainability	CO3
4	Evaluate the ethical implications of using automated manufacturing systems in terms of job displacement and worker safety.	PO8	Ethics	CO4
5	Investigate the use of additive manufacturing in medical device production, considering regulatory requirements and safety.	PO1, PO7, PO8, PO11	Engineering knowledge, Ethics, Environment and sustainability, Project management and finance	CO1, CO3, CO4, CO6

6	Develop a plan for integrating Industry 4.0 technologies, such as IoT and AI, into a traditional manufacturing facility.	PO5, PO11, PO12	Modern tool usage, Project management and finance, Life-long learning	CO2, CO5, CO6
7	Compare traditional subtractive manufacturing with newer subtractive manufacturing methods such as waterjet cutting.	PO1, PO2, PO5	Engineering knowledge, Problem analysis, Modern tool usage	CO1, CO2, CO5
8	Investigate the role of materials science in optimizing heat treatment processes for improving material properties.	PO1, PO4, PO7	Engineering knowledge, Conduct investigations of complex problems, Environment and sustainability	CO1, CO3, CO5
9	Design an experiment to analyze the effect of process parameters on the surface finish of machined components.	PO2, PO4, PO5	Problem analysis, Conduct investigations of complex problems, Modern tool usage	CO2, CO3, CO5
10	Create a case study on a successful implementation of lean manufacturing principles in a real-world industrial setting.	PO5, PO9, PO10	Project management and finance, Individual and team work, Communication	CO2, CO4, CO5

Table IV shows the Question wise CO- PO Mapping of Open ended Assignment

TABLE IV
QUESTION WISE CO- PO MAPPING OF OPEN ENDED ASSIGNMENT

Que No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3											
2			3									
3							2					
4								2				
5	3						3	2		3		3
6					2						2	2
7	2	2			2							
8	2			3			3					
9		3		3	3							
10					3				2	2		3
Average	2.50	2.50	3.00	3.00	2.50		2.67	2.00	2.00	2.50	2.00	2.67

Table V shows the sample CO- PO Mapping of Manufacturing Processes with Open ended Assignment

TABLE V
CO- PO MAPPING OF MANUFACTURING PROCESSES WITH OPEN ENDED ASSIGNMENT

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3									
CO2	2	3	1									
CO3	2	2	3									
CO4	1	1	1									
CO5	1	1	1									
CO6	3	2	2									
Average	2.00	1.83	1.83									
Open Ended Assignment	2.50	2.50	3.00	3.00	2.50		2.67	2.00	2.00	2.50	2.00	2.67
Total Mapping	2.25	2.17	2.42	3.00	2.50		2.67	2.00	2.00	2.50	2.00	2.67

Table 06 shows the sample PO wise Open-ended Assignment Activities

TABLE VI
PO WISE OPEN-ENDED ASSIGNMENT ACTIVITIES

PO	Open-ended Assignment Activities
PO1	Design a project applying engineering knowledge to solve complex problems.
PO2	Develop a research paper analysing complex engineering problems, reaching substantiated conclusions.
PO3	Design innovative solutions for engineering challenges, considering safety, sustainability, and societal impact.
PO4	Conduct independent research projects, including designing experiments and analysing data.
PO5	Utilize modern engineering and IT tools in assignments to solve engineering activities.
PO6	Explore ethical dilemmas and societal implications of engineering projects in written reflections or case studies.
PO7	Address environmental sustainability in engineering solutions through project-based assignments.
PO8	Reflect on ethical principles in engineering practice through written reflections or case analyses.
PO9	Engage in teamwork and collaboration through group-based assignments, demonstrating effective communication.
PO10	Communicate complex engineering activities effectively through written reports, presentations, or instructions.
PO11	Develop project management plans for multidisciplinary engineering projects in assignment scenarios.
PO12	Engage in lifelong learning through assignments that encourage independent research and exploration.
PSO1	Analyze real-life problems in mechanical engineering and develop appropriate solutions using modern tools.
PSO2	Apply acquired professional skills and project management abilities in mechanical engineering and allied areas.

D. Expert Talks

Mapping all Program Outcomes (POs) and Program Specific Outcomes (PSOs) through 45 (F.E. 05, S.E. 13, T.E. 12, B.E. 15)expert talks is a commendable achievement. By organizing a diverse range of expert talks covering various aspects of engineering practice and knowledge, we ensure that students receive comprehensive exposure to the skills and competencies required in their field. These expert talks serve as valuable learning experiences, providing students with practical insights, real-world examples, and opportunities for engagement with industry professionals. Table VII shows the sample Expert Talk Name & Elaboration out of 45 conducted expert talks.

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

TABLE VII
EXPERT TALK NAME & ELABORATION

Program Outcome	Expert Talk Name & Elaboration
PO1	"Recent Advancements in Engineering Technologies" - Explores latest innovations and breakthroughs in engineering technologies, enhancing understanding of current trends and advancements.
PO2	"Tackling Real-life Engineering Challenges: Strategies and Solutions" - Discusses practical problem-solving approaches, equipping students with skills for identifying and resolving complex engineering problems.
PO3	"Innovative Engineering Designs: Showcasing the Design Process" - Highlights innovative engineering designs and projects, providing insights into the design process from conception to implementation.
PO4	"Research Methodologies in Engineering: Insights from Industry Studies" - Addresses research methodologies and analytical approaches used in engineering research, providing insights from industry studies.
PO5	"Utilizing Modern Engineering Tools and Technologies" - Demonstrates practical applications of modern engineering tools and technologies in solving engineering problems.
PO6	"Engineering Ethics and Societal Responsibilities" - Explores ethical dilemmas and societal responsibilities in engineering practice, promoting ethical awareness and responsibility.
PO7	"Sustainable Engineering Practices: Building a Greener Future" - Discusses sustainable practices and solutions in engineering, emphasizing eco-friendly design and development.
PO8	"Navigating Ethical Dilemmas in Engineering Practice" - Helps students navigate ethical dilemmas in engineering, providing frameworks for making ethically sound decisions.
PO9	"Effective Teamwork in Engineering Projects: Lessons from Industry" - Explores effective teamwork strategies and practices in engineering projects, drawing lessons from industry experiences.
PO10	"Mastering Communication in Engineering: Best Practices" - Shares best practices for effective communication in engineering contexts, empowering students to communicate confidently.
PO11	"Project Management Principles in Engineering: From Budgeting to Resource Allocation" - Covers key aspects of project management in engineering, equipping students with essential project management skills.
PO12	"Embracing Lifelong Learning in Engineering: Opportunities and Challenges" - Discusses importance of lifelong learning and professional development in engineering careers, exploring opportunities and challenges.
PSO1	"Analyzing Real-life Problems in Mechanical Engineering: Strategies and Solutions" - Provides strategies for analyzing real-life problems in mechanical engineering and developing appropriate solutions.
PSO2	"Applying Professional Skills in Mechanical Engineering: Real-world Insights" - Offers real-world insights into applying professional skills and project management abilities in mechanical engineering.

Through these expert talks, students can gain a deeper understanding of engineering concepts, ethical considerations, teamwork dynamics, communication strategies, project management principles, and lifelong learning skills. Each talk is carefully designed to align with specific POs and PSOs, ensuring that the learning objectives of the curriculum are met effectively. Fig. 5 shows the Average Mapping of All Expert Talks for Batch 2

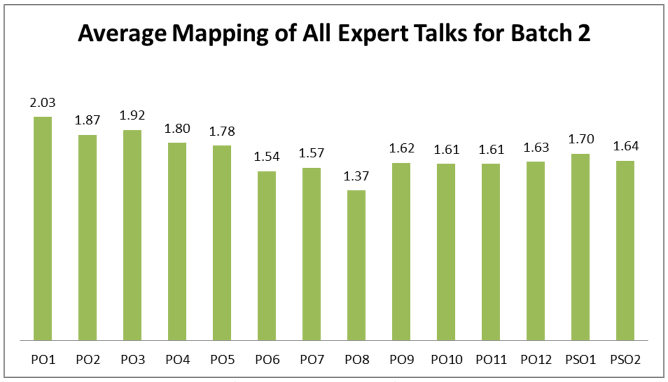

Fig. 5. Average Mapping of All Expert Talks for Batch 2

Furthermore, by mapping all POs and PSOs through expert talks, we create a holistic learning environment that fosters both academic excellence and professional development. Students not only acquire technical knowledge but also develop critical thinking, problem-solving, and communication skills essential for success in their future careers. Overall, leveraging expert talks to map all POs and PSOs demonstrates our commitment to providing students with a well-rounded education that prepares them for the challenges and opportunities of the engineering profession. It reflects our dedication to excellence in teaching and learning, equipping students with the skills and knowledge they need to excel in their chosen field.

E. Interdisciplinary Workshops

Table VIII and IX shows the Interdisciplinary Workshops and its details.

TABLE VIII
INTERDISCIPLINARY WORKSHOPS

PO	Explanation of Interdisciplinary Workshops
PO1	Interdisciplinary workshops provide opportunities for students to collaborate with peers from diverse fields, exposing them to different perspectives and expanding their understanding of engineering fundamentals. Through interdisciplinary projects and activities, students apply their knowledge to solve complex problems that require integration of multiple disciplines.
PO2	In interdisciplinary workshops, students encounter complex challenges that require critical analysis and problem-solving skills. They learn to identify, analyze, and evaluate problems from various angles, incorporating insights from different disciplines to reach substantiated conclusions. This multidisciplinary approach enhances their ability to tackle real-life engineering challenges effectively.

PO3	Collaborative projects in interdisciplinary workshops involve designing solutions for multifaceted problems, integrating considerations for public health, safety, environmental sustainability, and societal impact. Students develop system components or processes that meet specified needs by drawing on their expertise in engineering and insights from other disciplines, fostering creativity and innovation in solution design.
PO4	Interdisciplinary workshops facilitate hands-on exploration and investigation of complex problems that span multiple domains. Students learn research methodologies, design experiments, analyze data, and synthesize information from diverse sources to provide valid conclusions. This experiential learning approach promotes a deeper understanding of research-based knowledge and its application in solving real-world problems.
PO5	Through interdisciplinary workshops, students gain exposure to a wide range of modern engineering tools and technologies used across different disciplines. They learn to create, select, and apply appropriate techniques and resources to address complex engineering activities, gaining practical experience with prediction, modeling, and simulation tools.
PO6	Interdisciplinary workshops foster awareness of societal issues and the engineer's role in addressing them. By collaborating with students from other disciplines, engineering students learn to apply contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to engineering practice. This promotes a holistic understanding of engineering's impact on society and the ethical responsibilities of engineers.
PO7	Interdisciplinary workshops emphasize sustainability principles and environmental considerations in engineering projects. Students explore the environmental impact of engineering solutions and demonstrate knowledge of sustainable development principles through collaborative projects that prioritize environmental stewardship and resource conservation.
PO8	In interdisciplinary workshops, students engage in discussions and activities that promote ethical reasoning and decision-making. They analyze ethical dilemmas, consider diverse perspectives, and develop solutions that align with professional ethics and responsibilities. By collaborating with peers from different backgrounds, students gain insights into the ethical implications of engineering practices and cultivate a sense of ethical awareness and accountability.
PO9	Collaborative projects in interdisciplinary workshops require students to function effectively as individuals and as members of diverse teams. They learn to communicate, collaborate, and lead in multidisciplinary settings, honing their teamwork and leadership skills. Through hands-on experiences and group activities, students develop the interpersonal and collaborative skills essential for success in professional engineering practice.
PO10	Interdisciplinary workshops provide opportunities for students to communicate effectively with diverse audiences. They learn to comprehend complex engineering concepts, write reports, create design documentation, deliver presentations, and communicate instructions clearly and persuasively. By engaging in interdisciplinary projects and discussions, students develop strong communication skills that enable them to convey ideas and information effectively within the engineering community and society at large.
PO11	Collaborative projects in interdisciplinary workshops involve managing resources, coordinating tasks, and meeting project milestones within budget and schedule constraints. Students learn project management principles, including planning, organizing, executing, and controlling project activities. By working on interdisciplinary projects, students gain practical experience in project management and finance, preparing them for leadership roles in multidisciplinary environments.
PO12	Interdisciplinary workshops encourage students to embrace lifelong learning and adaptability in a rapidly changing technological landscape. By engaging in interdisciplinary projects and activities, students develop a mindset of curiosity, exploration, and continuous learning. They recognize the need for independent and lifelong learning to stay abreast of technological advancements and evolve as professionals in their field.
PSO1	Interdisciplinary workshops provide opportunities for students to analyze real-life problems in mechanical engineering from a multidisciplinary perspective. By collaborating with students from other disciplines, mechanical engineering students gain insights into the broader context of engineering challenges and develop strategies for addressing them effectively. Through interdisciplinary projects and activities, students analyze real-life problems and develop appropriate solutions using modern tools and techniques.
PSO2	Collaborative projects in interdisciplinary workshops enable students to apply acquired professional skills and project management abilities in mechanical engineering and allied areas. By working on interdisciplinary projects, mechanical

Through six interdisciplinary workshops, we've provided students with immersive experiences aimed at enriching their understanding and application of engineering principles. The workshop on Drone Technology, for instance, not only delved into cutting-edge advancements in aerospace engineering and robotics but also fostered teamwork and ethical awareness as students collaborated on projects. Similarly, the Advances in Heat Transfer workshop equipped students with insights into thermal engineering while emphasizing sustainability considerations. Creo Modeling for All introduced students to CAD software, honing their design skills and communication abilities. Python for Everyone empowered students with programming skills essential for engineering analysis and data processing. In the Advances in HVAC workshop, students explored energy-efficient HVAC design and worked on collaborative projects to address real-world challenges. Lastly, the Ansys CFD Analysis workshop provided students with hands-on experience in fluid dynamics simulations, enhancing their research skills and preparing them for advanced engineering studies. Overall, these interdisciplinary workshops have been instrumental in fostering holistic learning experiences, aligning with various Program Outcomes and Program Specific Outcomes while preparing students for the dynamic demands of the engineering profession.

TABLE IX
INTERDISCIPLINARY WORKSHOPS

Workshop Topic	Explanation of Workshop
Drone Technology	The workshop on Drone Technology exposes students to cutting-edge advancements in aerospace engineering and robotics. Through hands-on activities and projects, students apply engineering knowledge to design, build, and operate drones. They analyze complex engineering problems related to drone navigation, control systems, and payload delivery, enhancing their problem-solving and design skills (PO2, PO3, PO4). Moreover, students explore the ethical, societal, and environmental implications of drone technology, developing a broader understanding of the engineer's role in society (PO6, PO7, PO8). This workshop also fosters teamwork and communication skills as students collaborate in multidisciplinary teams to complete drone-related projects (PO9, PO10).

Advances in Heat Transfer	The Advances in Heat Transfer workshop delves into the latest developments in thermal engineering and heat transfer phenomena. Through theoretical discussions, computational simulations, and experimental demonstrations, students gain insights into advanced heat transfer concepts and applications. They analyze complex engineering problems involving heat transfer in various systems and devise innovative solutions using modern engineering tools and techniques (PO1, PO2, PO3, PO4, PO5). Additionally, this workshop emphasizes the engineer's responsibility towards environmental sustainability and energy conservation by exploring strategies for efficient heat transfer systems and renewable energy technologies (PO6, PO7).
Creo Modelling for All	Creo Modelling for All workshop introduces students to computer-aided design (CAD) software and its applications in engineering design and product development. Students learn to create 3D models, perform simulations, and generate engineering drawings using Creo parametric software. By engaging in hands-on design projects, students develop proficiency in design and development of solutions for complex engineering problems (PO3). They also gain practical experience in using modern engineering tools and technologies for product design and development (PO5). Moreover, this workshop enhances students' communication skills as they present their design concepts and collaborate with peers to optimize product designs (PO10) .
Python for Everyone	Python for Everyone workshop equips students with programming skills essential for engineering analysis, modeling, and data processing. Students learn Python programming language and its applications in engineering computations, data visualization, and automation tasks. Through coding exercises and projects, students develop problem-solving skills and computational thinking abilities (PO2, PO4). They apply Python programming techniques to analyze real-world engineering problems and develop efficient algorithms (PO1, PO9). Moreover, this workshop enhances students' lifelong learning skills as they gain proficiency in a versatile programming language widely used across various engineering disciplines (PO12).
Advances in HVAC	The Advances in HVAC workshop explores the latest advancements in Heating, Ventilation, and Air Conditioning (HVAC) systems and technologies. Students learn about energy-efficient HVAC design, thermal comfort principles, and indoor air quality management. Through case studies, simulations, and design projects, students analyze complex engineering problems related to HVAC system design, operation, and optimization (PO2, PO3, PO4). They apply engineering knowledge to develop sustainable HVAC solutions that meet environmental and societal needs (PO6, PO7, PO8). Moreover, this workshop fosters teamwork and collaboration skills as students work in multidisciplinary teams to design and evaluate HVAC systems (PO9, PO11).
Ansys CFD Analysis for Research and Projects	The Ansys CFD Analysis for Research and Projects workshop introduces students to Computational Fluid Dynamics (CFD) simulations and their applications in engineering research and projects. Students learn to use Ansys software for fluid flow analysis, heat transfer simulations, and aerodynamic modeling. Through hands-on simulations and projects, students develop proficiency in conducting CFD analyses, interpreting results, and optimizing engineering designs (PO1, PO2, PO3, PO4, PO5). They apply CFD techniques to investigate complex fluid flow phenomena, such as turbulence, heat transfer, and multiphase flow, in various engineering applications (PO10, PSO1). Moreover, this workshop enhances students' research skills and prepares them for advanced engineering studies and research projects (PO12, PSO2).

IV. Results And Discussion

By integrating a diverse range of educational activities such as industrial visits, expert talks, open-ended assignments, and interdisciplinary workshops, we've observed a noticeable enhancement in the average mapping of all courses from the Freshman Engineering (FE) to Bachelor of Engineering (BE) levels. This increase in average mapping signifies a more robust alignment between the curriculum and the intended Program Outcomes (POs) and Program Specific Outcomes (PSOs).Industrial visits offer students invaluable real-world exposure, bridging the gap between theory and practice and allowing them to witness firsthand the application of engineering concepts in various industries. Expert talks bring industry professionals into the classroom, providing insights into current trends, challenges, and best practices in the field. Open-ended assignments encourage critical thinking and creativity, allowing students to explore topics in depth and demonstrate their understanding in innovative ways. Interdisciplinary workshops promote collaboration and integration of knowledge from different disciplines, fostering a holistic approach to problem-solving. Fig. 6 shows the Average Mapping of Batch 2

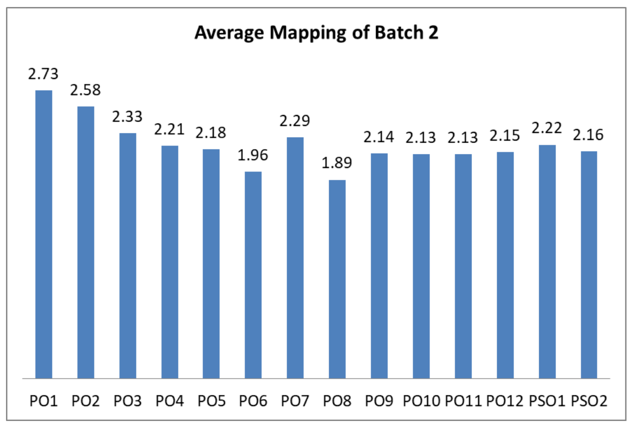

Fig. 6. Average Mapping of Batch 2

As a result of these initiatives, students have shown improved performance in mapping POs and PSOs across all courses. They demonstrate a deeper understanding of engineering principles, enhanced problem-solving skills, improved communication abilities, and a heightened awareness of ethical and societal responsibilities. Ultimately, this leads to an overall improvement in attainment, as students are better equipped to meet the demands of the engineering profession and excel in their future careers. Fig. 7 shows the PO Attainment Batch 2.

The table X represents the attainment levels of Program Outcomes (POs) and Program Specific Outcomes (PSOs) based on both direct and indirect methods.

- **Direct Attainment**: This is the average of the attainment levels from all subjects across all years of study.
- **Indirect Attainment**: This is based on feedback collected from various stakeholders, including

industrial visits, program exit surveys, alumni, and employers.

- **Total Attainment**: This is the combined value of direct (80%) and indirect (20%) attainment

TABLE X
PO ATTAINMENT OF BATCH 2

Metric	Average PO and PSO Attainment (Direct)	Average PO and PSO Attainment (Indirect)	Total Attainment
PO1	2.45	2.98	2.56
PO2	2.16	2.97	2.33
PO3	1.86	2.98	2.09
PO4	1.82	3	2.05
PO5	1.79	2.98	2.03
PO6	1.59	2.98	1.87
PO7	1.56	2.98	1.84
PO8	1.75	2.98	2
PO9	1.69	2.98	1.95
PO10	1.73	2.98	1.98
PO11	1.6	2.98	1.88
PO12	1.78	2.89	2.01
PSO1	1.73	2.94	1.97
PSO2	1.8	2.94	2.03

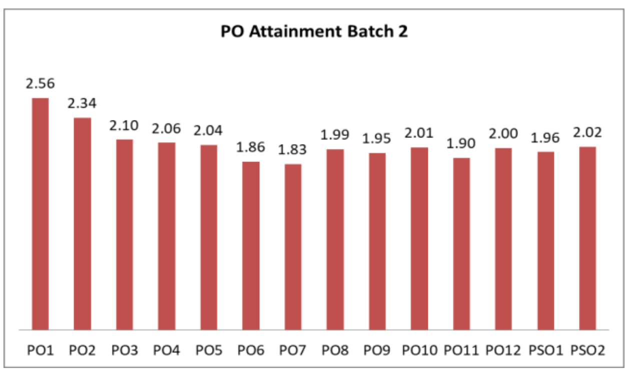

Fig. 7. PO Attainment Batch 2

In the second batch, there has been a notable improvement in the attainment of Program Outcomes (POs) compared to the previous batch. Across various POs, there is an overall upward trend, indicating enhanced performance among students. Particularly noteworthy is the significant improvement in PO1 (Engineering knowledge) and PO2 (Problem analysis), suggesting a stronger grasp of fundamental engineering concepts and analytical skills. While there are slight variations in attainment across different POs, the overall trend reflects positive progress in aligning the curriculum with the intended learning outcomes. Additionally, both Program Specific Outcomes (PSOs) have also seen an improvement, indicating that students are better equipped to analyze real-life problems in mechanical engineering and apply professional skills effectively. Overall, this improvement in PO attainment in the second batch reflects the success of educational interventions and strategies implemented to enhance student learning and development.

Comparing the attainment of Program Outcomes (POs) between Batch 1 and Batch 2 reveals significant improvements in various areas of student performance. Across both batches, there's a general upward trend in PO attainment, indicating progress in students' mastery of engineering competencies. In Batch 2, notable enhancements are observed in PO1 (Engineering knowledge) and PO2 (Problem analysis), reflecting a stronger foundation in core engineering principles and analytical abilities compared to Batch 1. Additionally, there are improvements in PO4 (Conduct investigations of complex problems), PO5 (Modern tool usage), and PO11 (Project management and finance), suggesting advancements in research skills, technological proficiency, and project management capabilities among students. Fig. 8 shows the Comparison of PO Average Mapping of Batch 1 and Batch 2

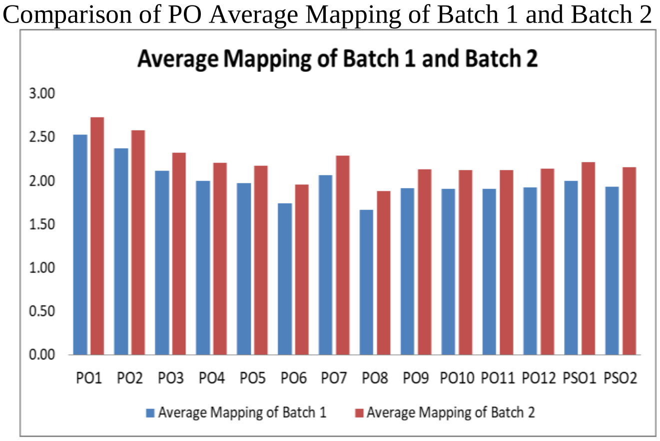

Fig. 8. Comparison of PO Average Mapping of Batch 1 and Batch 2

Fig. 9 shows the Comparison of PO Attainment of Batch 1 and Batch 2

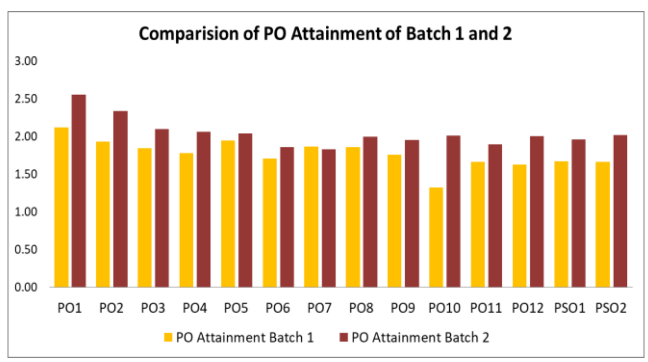

Fig. 9. Comparison of PO Attainment of Batch 1 and Batch 2

In Batch 2, there has been a remarkable improvement in the attainment of Program Outcomes (POs) compared to Batch 1. Across various POs, there's a noticeable upward trend, indicating enhanced performance among students. Particularly significant is the substantial increase in PO1 (Engineering knowledge) and PO2 (Problem analysis), suggesting a stronger grasp of fundamental engineering concepts and analytical skills. While there are slight variations in attainment across different POs, the overall trend reflects positive progress in

Journal of Engineering Education Transformations, Volume 39, No 3, January 2026, ISSN 2349-2473, eISSN 2394-1707

aligning the curriculum with the intended learning outcomes. Additionally, both Program Specific Outcomes (PSOs) have also seen an improvement, indicating that students are better equipped to analyze real-life problems in mechanical engineering and apply professional skills effectively. Overall, this improvement in PO attainment in Batch 2 reflects the success of educational interventions and strategies implemented to enhance student learning and development. Table XI shows the Percentage Increase in POs and PSOs of Batch 1 and Batch 2.

TABLE XI
PERCENTAGE INCREASE IN POS AND PSOS OF BATCH 1 AND BATCH 2

PO/PSO	Batch 1	Batch 2	Percentage Increase (%)
PO1	2.12	2.56	20.75
PO2	1.93	2.34	21.24
PO3	1.84	2.1	14.13
PO4	1.78	2.06	15.73
PO5	1.95	2.04	4.62
PO6	1.71	1.86	8.77
PO7	1.87	1.83	-2.14
PO8	1.86	1.99	6.99
PO9	1.75	1.95	11.43
PO10	1.32	2.01	52.27
PO11	1.66	1.9	14.46
PO12	1.63	2	22.7
PSO1	1.67	1.96	17.37
PSO2	1.66	2.02	21.69

Based on the percentage increases observed from Batch 1 to Batch 2 across various Program Outcomes (POs) and Program Specific Outcomes (PSOs), several key inferences can be made:

1. Significant Improvement:
   - PO10 shows the highest increase of 52.27%, indicating substantial progress in communication skills.
   - PO12 also exhibits a considerable improvement of 22.7%, suggesting an enhanced recognition of the need for lifelong learning.
   - PO1 and PO2 have significant improvements, with increases of 20.75% and 21.24% respectively, indicating better application of engineering knowledge and problem analysis.
2. Moderate Improvement:
   - Several outcomes such as PO3 (14.13%), PO4 (15.73%), PO9 (11.43%), PO11 (14.46%), and PSO1 (17.37%) show moderate improvements, reflecting overall enhancements in design and development of solutions, investigations of complex problems, project management, and specific mechanical engineering skills.
3. **Minimal Improvement**:
   - PO5 shows a smaller improvement of 4.62%, which may indicate the need for additional focus on the use of modern tools.
   - PO8's increase of 6.99% also suggests that while there is progress, there is still room for further improvement in understanding societal impacts.
4. **Areas of Concern**:
   - PO7 shows a negative percentage change (-2.14%), indicating a slight decline in performance related to the engineer's role in society. This may require investigation and corrective measures.
5. **Consistent Performance**:
   - Other outcomes such as PO6 (8.77%), PO8 (6.99%), and PO9 (11.43%) have shown consistent but moderate improvements, indicating steady progress but still needing continuous efforts to achieve higher performance.
6. **Overall Positive Trend**:
   - Most POs and PSOs have shown positive improvements, suggesting effective interventions and enhancements in the educational process and learning outcomes.

In summary, while there are notable improvements in many areas, particularly in communication skills and lifelong learning, certain areas such as the engineer's role in society need more attention to ensure comprehensive development across all outcomes. The overall trend is positive, indicating a general enhancement in the capabilities of engineering graduates from Batch 1 to Batch 2.

CONCLUSION

In conclusion, the comparison between Batch 1 and Batch 2 highlights the substantial progress achieved in the attainment of Program Outcomes (POs) and Program Specific Outcomes (PSOs) within the Outcome-Based Education (OBE) framework. The notable improvements observed in Batch 2 underscore the efficacy of educational interventions aimed at enhancing student learning experiences and outcomes. Through the strategic implementation of initiatives such as open-ended assignments, expert talks, mini projects, industrial visits, and student workshops, students have demonstrated a heightened proficiency in essential engineering competencies and a deeper understanding of real-world applications.

The success of Batch 2 in attaining higher PO scores reflects the effectiveness of aligning curriculum objectives with industry demands and fostering a culture of continuous improvement. By providing students with diverse learning opportunities and practical experiences, the OBE framework has empowered them to develop critical thinking skills, problem-solving abilities, and effective communication practices necessary for success in their professional endeavours.

As we move forward, it is imperative to sustain this positive momentum and further enhance the OBE framework through on-going curriculum refinements, innovative teaching methodologies, and collaborative partnerships with industry stakeholders. By continuing to prioritize student-cantered learning approaches and adapt to evolving industry needs, we can ensure that future batches of engineering graduates are well-equipped to address complex challenges and make meaningful contributions to society.

References

Alonzo, D., Bejano, J., & Labad, V. (2023). Alignment between Teachers' Assessment Practices and Principles of Outcomes-Based Education in the Context of Philippine Education Reform. International Journal of Instruction, 16(1). https://doi.org/10.29333/iji.2023.16127a

Brauner, A., Carey, J., Henriksson, M., Sunnerhagen, M., & Ehrenborg, E. (2007). Open-ended assignments and student responsibility. Biochemistry and Molecular Biology Education, 35(3). https://doi.org/10.1002/bmb.49

Cresencio, M. (2023). Outcome-based education in open and distance learning. Journal of Education and E-Learning Research, 10(4). https://doi.org/10.20448/jeelr.v10i4.5043

Fox, S., Fitzgerald, C., Dening, K. H., Irving, K., Kernohan, W. G., Treloar, A., Oliver, D., Guerin, S., & Timmons, S. (2017). Better palliative care for people with a dementia: Summary of interdisciplinary workshop highlighting current gaps and recommendations for future research. In BMC Palliative Care (Vol. 17, Issue 1). https://doi.org/10.1186/s12904-017-0221-0

Hu, A., Mao, X., Fu, C., Wu, M., & Zhou, S. (2023). Engineering Curriculum Reform Based on Outcome-Based Education and Five-Color Psychology Theory. Sustainability (Switzerland), 15(11). https://doi.org/10.3390/su15118915

Ingaleshwar, S. S., & Jamadar, A. M. (2019). Enhancing faculty competencies through engineering exploration & design project course. Journal of Engineering Education Transformations, 33(Special Issue 1). https://doi.org/10.16920/jeet/2019/v33i1/149018

Katageri, B. G., Torse, D. A., Khanai, R., & Pai, K. (2023). The Impact of Implementation and Evaluation of Engineering Exploration Activities in a First-Year Engineering Course. Journal of Engineering Education Transformations, 36(3). https://doi.org/10.16920/jeet/2023/v36i3/23101

Khot, S. B., Jadhav, P. J., & Jadhav, P. M. (2020). Teaching engineering design module from engineering exploration and design project (EEDP) course through hands on activities. Journal of Engineering Education Transformations, 33(Special Issue). https://doi.org/10.16920/jeet/2020/v33i0/150109

Klippert, J., Reuter, M., Conrad, A. K., Wannöffel, M., Schulte, D., Wienbruch, T., & Kuhlenkötter, B. (2020). Learning factory for decent work—An interdisciplinary workshop on MES for worker representatives. Procedia Manufacturing, 45. https://doi.org/10.1016/j.promfg.2020.04.062

Pawar, R., Patil, S., & Kulkarni, S. (2023). Enhancing Product Development Skills of Engineering Students through Diversified Group Activities. Journal of Engineering Education Transformations, 37(1). https://doi.org/10.16920/jeet/2023/v37i1/23128

Sapawi, R., Wahi, R., Anuar, A., Razali, N. T., Hashim, M. H., & Rasit, A. H. (2023). Alternative and Online Assessment in the Context of Outcome Based Education: A Practical Guide. Journal of Advanced Research in Applied Sciences and Engineering Technology, 31(2). https://doi.org/10.37934/araset.31.2.173183

Solomon, G. E. A. (1990). Psychology of Novice and Expert Wine Talk. The American Journal of Psychology, 103(4). https://doi.org/10.2307/1423321

Tang, Y., Brockman, M. L., & Patil, S. (2021). Promoting Privacy Considerations in Real-World Projects in Capstone Courses with Ideation Cards. ACM Transactions on Computing Education, 21(4). https://doi.org/10.1145/3458038

Throndsen, W. (2017). What do experts talk about when they talk about users? Expectations and imagined users in the smart grid. Energy Efficiency, 10(2). https://doi.org/10.1007/s12053-016-9456-5