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Enhancing Mechanical Engineering Education: Leveraging Industrial Visits to Address Curriculum Gaps

[1]Pankaj R. Beldar*, [2]Dr. Prashant B.Kushare
[1,2] Department of Mechanical Engineering, K.K.Wagh Institute of Engineering Education and research,
Savitribai Phule Pune University,
[1]prbeldar@kkwagh.edu.in,
[2]pbkushare@kkwagh.edu.in

Abstract : Industrial visits are essential for bridging the gap between theoretical classroom learning and practical application in mechanical engineering education. This study explores how such visits address curriculum gaps and improve learning outcomes by incorporating industry feedback, Program Outcome (PO) assessments, and aligning visit outcomes with Program Specific Outcomes (PSO). Feedback from industry stakeholders and students facilitated continuous improvement, providing insights into the practical application of theories. PO attainment calculations offered a quantitative evaluation of the visits' educational impact. Detailed visit reports served as assessment tools, reinforcing students' understanding of theoretical concepts through hands-on experiences. This approach enhances theoretical learning and helps achieve educational objectives, creating a more comprehensive and practical learning environment for mechanical engineering students.

Pankaj R. Beldar
Department of Mechanical Engineering,
K.K.Wagh Institute of Engineering Education and research,
Savitribai Phule Pune University,
prbeldar@kkwagh.edu.in,

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1. Introduction

The theoretical groundwork laid within the confines of classrooms forms the bedrock of engineering education, yet its application in the real world often remains obscured without practical exposure.(Al-Atabi et al., 2013a) This research paper aims to highlight the pivotal role of industrial visits in augmenting engineering education, particularly in disciplines encompassing the design of chiller plants, turbines, power plants, cooling stations, vibration testing, and balancing. It delves into the drawbacks of solely relying on theoretical knowledge, underscores the importance of industrial visits, and elucidates the pathways through which these visits can facilitate the attainment of Program Outcomes (POs). The complexities inherent in disciplines like chiller plant design, turbine functionality, power generation, and precision engineering techniques cannot be comprehensively understood through textbooks and lectures alone.(Soon et al., 2017a) The drawbacks of a theoretical-only approach become apparent when students face challenges in conceptualizing the practical applications of thermodynamics, fluid mechanics, or mechanical vibrations in real-world engineering scenarios. This void between theoretical understanding and its practical implications often impedes a holistic comprehension of engineering principles. The design of chiller plants represents a fundamental aspect of HVAC systems crucial in various industries. By visiting manufacturing facilities or operational sites, students gain first-hand exposure to the intricacies of chiller plant components, such as compressors, evaporators, and controls. This practical exposure allows them to comprehend the principles behind the design, operation, and maintenance of these systems, fostering a deeper understanding beyond theoretical concepts learned in lectures. Similarly, exploring turbines and power plants during industrial visits enables students to witness the immense scale and complexity of these installations. Observing turbine operations, power generation processes, and plant control systems enhances their understanding of thermodynamics, fluid mechanics, and energy conversion principles in a real-world context. Moreover, exposure to cooling stations offers insights into advanced cooling techniques and technologies, supplementing theoretical knowledge in heat transfer and thermal management. Vibration testing and balancing, crucial practices in engineering for ensuring machinery reliability and performance, are best comprehended through practical exposure. Industrial visits to testing facilities or manufacturing units specializing in vibration analysis provide students with hands-on experience in conducting tests, interpreting data, and understanding the significance of balancing techniques in maintaining machinery integrity.(Markom et al., 2011) Industrial visits stand as indispensable bridges between theoretical learning and practical application. They offer students immersive experiences, allowing them to witness first-hand the implementation of theoretical concepts in operational environments. For instance, visiting power plants or turbine facilities provides a tangible connection between classroom teachings and the colossal machinery driving power generation. Similarly, exploring chiller plant installations or vibration testing laboratories enables students to grasp the intricate workings of these systems beyond theoretical abstractions. The significance of these industrial visits lies not only in supplementing theoretical knowledge but also in aligning with educational objectives.(González-Peña et al., 2021) By integrating these visits into the curriculum, engineering programs can directly address specific Program Outcomes (POs) and Program Specific Outcomes (PSOs). For instance, witnessing the operation and maintenance of chiller plants or conducting vibration tests facilitates the attainment of outcomes related to practical skills, problem-solving abilities, and comprehension of industry standards. In conclusion, the integration of industrial visits is indispensable for a well-rounded engineering education. These visits not only rectify the drawbacks of solely theoretical learning but also serve as catalysts for achieving educational objectives. By immersing students in practical settings, industrial visits not only enhance comprehension but also pave the way for the attainment of desired Program Outcomes, ensuring that engineering graduates are equipped with both theoretical knowledge and practical skills essential for success in the field. The transition from Excel to Python programming for PO/PSO attainment computation and feedback analysis has yielded a substantial reduction in manual labor, significantly streamlining our processes within industrial visit assessments. Python's capabilities have allowed for more efficient and scalable computations, mitigating the time-consuming nature of these tasks previously performed in Excel.In addition, the integration of sentiment analysis techniques has provided invaluable insights, enabling us to generate comprehensive recommendations for refining our visit planning strategies. This data-driven approach, derived from sentiment analysis outputs, has empowered us to optimize our planning methodologies for enhanced visit experiences. Furthermore, a strategic decision has been made to defer visits to industries with limited feedback to a later stage. This deliberate action allows us to allocate resources more efficiently, focusing on refining our engagement strategies before revisiting these industries for a more comprehensive assessment.

2. Mechanical Engineering Education

Mechanical engineering education traditionally relies heavily on theoretical instruction imparted within classroom settings. This foundation forms the backbone of an engineer's knowledge, encompassing fundamental principles of physics, mathematics, and engineering sciences. However, this conventional pedagogical approach has inherent limitations that hinder a comprehensive understanding of real-world applications and may lead to significant curriculum gaps. Mechanical engineering programs typically comprise a structured curriculum designed to cover a wide array of subjects, including mechanics, thermodynamics, fluid dynamics, materials science, and manufacturing processes. The educational approach predominantly involves lectures, theoretical problem-solving sessions, and laboratory experiments conducted in controlled environments.

Lectures serve as the primary mode of knowledge dissemination, wherein professors convey theoretical concepts, equations, and principles. These sessions aim to lay a theoretical foundation by explaining fundamental laws and theories pertinent to mechanical engineering disciplines. Laboratory experiments, although valuable, often possess limitations in replicating real-world conditions. While they provide a hands-on understanding of theoretical concepts, these controlled settings may not encapsulate the complexities and challenges encountered in actual industrial scenarios.

Addressing curriculum gaps and aligning them with program outcomes (POs) is a critical aspect of engineering education, as highlighted by several researchers. Vinish et al. (2022) proposed a systematic framework for identifying curriculum gaps, emphasizing the alignment of curriculum with Course Outcomes (COs) and POs through structured mapping and faculty feedback. Similarly, Sumathi et al. (2023) introduced a Curriculum Compliance Improvement Model that bridges the gap between curriculum delivery and program outcomes, incorporating real-time monitoring to ensure compliance. To enhance experiential learning, Kulkarni and Dandge (2024) explored the integration of industrial visits, emphasizing pre-visit planning, defined learning objectives, and post-visit assessments for maximizing educational outcomes.

Assessment of outcomes also plays a significant role, as discussed by Thiruvengadam et al. (2022), who utilized rubrics and statistical analysis to systematically evaluate the attainment of COs and POs in undergraduate engineering programs. Alternate assessment methods have shown promise, with Namratha et al. (2023) demonstrating their efficacy in enhancing outcomes for cryptography and network security courses using tools like peer reviews and project-based evaluations. Furthermore, Suji Prasad et al. (2023) emphasized the integration of co-curricular activities into formal assessment processes, which contributes to achieving program outcomes by fostering holistic skill development.

The use of data-driven approaches to curriculum improvement is another emerging trend. Bhoi and Thakkar (2022) applied data mining and sentiment analysis to analyze course reviews, offering actionable insights for refining curriculum design. Similarly, Phadke and Kulkarni (2018) used a network model to visualize curriculum overlaps and deficiencies, enabling targeted revisions to address curriculum gaps effectively. Additionally, Patil and Bhadri (2024) advocated for open-ended experiments combined with statistical designs to enhance competencies aligned with POs, promoting critical thinking and innovation among students.

A. Limitations of Solely Theoretical Learning(Al-Atabi et al., 2013b; Fadhli et al., 2017a; Soon et al., 2017b)(Fadhli et al., 2017b)

Despite the significance of theoretical learning, a purely theoretical approach in mechanical engineering education presents several limitations:

- Lack of Practical Application:

Classroom lectures and simulations may not adequately prepare students to apply theoretical knowledge to practical engineering problems faced in real-world scenarios.

- Limited Contextualization:

Theoretical concepts, while essential, may lack context without exposure to real-world applications. This absence of context often leaves students grappling with how theoretical principles translate into tangible engineering solutions.

- Inadequate Problem-Solving Skills:

Relying solely on theoretical learning may restrict students' ability to develop critical problem-solving skills needed to address complex engineering challenges effectively.

- Industry Relevance Gap:

Classroom education might not encompass the latest technological advancements or industry practices, creating a disconnect between academic learning and industry requirements.

3. Dealing With Curriculum Gaps

Dealing with curriculum gaps involves identifying deficiencies in educational programs and addressing them to better prepare students. This process includes assessing current curriculum effectiveness through feedback and evaluations, developing targeted strategies to fill identified gaps, implementing these strategies through curriculum revisions or new initiatives like Industry internships and industry Visits, and continuously monitoring outcomes to ensure improvements in student learning and preparedness for real-world challenges. It aims to enhance educational quality by aligning teaching with industry needs and technological advancements, fostering a more comprehensive learning experience for students.

A. Industrial Visits in Filling Curriculum Gaps

Table 01 show the subject wise curriculum gap in the syllabus of mechanical engineering (2019 Pattern) of Savitribai Phule Pune University, India.

Table 1 :
Subject Wise Curriculum Gap

Year	Subject	Curriculum Gap
First year(FE)	Systems of Mechanical Engineering	Demonstration of Sand Casting
Second Year (SE)	Thermodynamics	On field Boiler Performance Testing
	Applied Thermodynamics	Maintenance of Petrol and Design Engine
	Manufacturing Processes	Demonstration of Sheet Metal Working, Injection Moulding, Welding
	Engineering Materials and Metallurgy	Microstructure Analysis, Furnace working, Demonstration of Powder Metallurgy
Third Year (TE)	Mechatronics	Demonstration of SCADA (Supervisory Control and Data Acquisition)
	Fluid Power &Control Laboratory	Automatic Pneumatic System Design
	Dynamics of Machinery	Demonstration of Whee l Balancing, Vibration Testing for Faulty bearing
Final Year (BE)	Heating Ventilation Air - Conditioning and Refrigeration	Cooling System Design, Chillers Design
	Turbomachinery	Hydro and Steam Power plant automation
	Energy Engineering	Thermal Power plant Efficiency Ca lculation with on field readings

B. First Year:

- Curriculum Gaps: Lack of Sand-Casting Demonstrations in Systems of Mechanical Engineering.

- Industrial Visit Benefit: Visiting foundries offers exposure, aiding in understanding foundational manufacturing processes.

C. Second Year:

- Curriculum Gaps: Absence of Boiler Performance Testing, Maintenance of Engines, Manufacturing Process Demonstrations, and Material Analysis.

- Industrial Visit Benefits: Tours to power plants, automotive workshops, manufacturing units, and metallurgical labs provide hands-on experiences, bridging theoretical knowledge with real world applications.

D. Third Year:

- Curriculum Gaps: Missing SCADA Demonstrations and Automatic Pneumatic System Design.

- Industrial Visit Benefits: Visits to industrial sites and facilities specializing in automation systems offer insights into SCADA operations and pneumatic system design principles.

E. Final Year:

- Curriculum Gaps: Absence of Demonstrations in Machinery Dynamics, HVAC System Design, Turbomachinery Automation, and On-field Efficiency Calculations.

- Industrial Visit Benefits: Engaging with testing labs, HVAC manufacturers, power plants, and thermal plants equip students with real world exposure to machinery dynamics, HVAC designs, turbomachinery automation, and real-world efficiency calculations.

F. Outcomes of the visit

This cumulative summary underscores the range of curriculum gaps prevalent throughout different academic years in mechanical engineering education. Industrial visits offer a versatile solution by providing students with real world experiences and hands-on exposure, thereby enhancing their understanding of theoretical concepts and preparing them for real-world applications in the field of mechanical engineering.

4. Program Outcomes And Attainments

A. Visit outcomes

Table No. 02 shows the Visit wise Outcomes.

Table 2 :
Visit Wise Outcomes

Name of the Industry	Outcome of the Visit
I1	Describe all elements in the casting process and identify defects in casting (Remember, Analyze)
I2	Identify and explain processes carried out during casting (Remember, Explain)
I3	Explain boiler operation and analyze/calculate boiler efficiency (Explain, Analyze)
I4	Explain the principle of induction hardening, trial and error method of coil designing, and importance of heat atmosphere (Explain)
I5	Describe the process of sand casting (Explain)
I6	Describe the forming processes practically (Explain)
I7	Identify and compare different systems used in engines (Remember, Analyze)
I8	Explain the principle of polymer manufacturing for thermoplastic polymer (Explain)
I9	Explain the principle of polymer manufacturing for thermosetting polymer (Explain)
I10	Describe the working and components of hydraulic and pneumatic operated mechanisms, and automation processes (Describe, Apply)
I11	Explain the use of Coordinate Measuring Machines (CMM) and gauges (Explain)
I11	Explain the use of Coordinate Measuring Machines (CMM) and gauges (Explain)
I12	Demonstrate the procedure for preventive maintenance for a given system (Apply)
I13	Demonstrate the working of PLC-SCADA systems (Apply)
I14	Explain the applications of SCADA systems (Explain)
I15	Describe advanced machining processes (Describe)
I16	Interpret production drawings; explain limits, fits, and tolerances (Interpret, Apply)
I17	Demonstrate the use of CMM and identify different instruments used in industry with Go NoGo gauges and their applications (Apply, Identify)
I18	Identify different instruments used in industry with Go NoGo gauges and their applications (Identify, Explain)
I19	Demonstrate the working of SCADA systems (Apply)
I20	Develop components using advanced manufacturing processes (Create)
I21	Describe modern machining processes and observe parameters of the processes (Describe, Analyze)
I22	Calculate process heat and efficiency of a co-generation plant and identify different power plant instruments (Apply, Identify)
I23	Balance the wheel (Apply)
I24	Describe the construction, working, layout, parameters, components, and environmental impact of a thermal power station (Describe)
I25	Explain co-generation systems (Explain)
I26	Analyze cold storage systems (Analyze)
I27	Balance rotating elements like a wheel (Apply)
I28	Describe the working, components, and applications of air conditioning plants (Describe)

B. Feedback Mechanism:

Following questions were asked through google form for taking visit feedback. PO and PSO Mapping is also included for calculation of PO Attainment. Table No. 03 shows the Industrial Visit Feedback Questionnaires

Table 3 :
Industrial Visit Feedback Questionnaires

Que.	Outcome	POs / PSOs Mapped
Q.1	Are you able to relate technical knowledge gained from visit to curriculum?	PO1
Q.2	Are you able to analyse real life problems & provide solution using knowledge gained from visit?	PO2, PO3, PO4, PSO1
Q.3	Have you understood the applications of modern tools & technologies used in industry and apply the knowledge gained from visit to assess societal issues and safety?	PO5. PO6
Q.4	Have you understood organizational structure, business operation, professional ethics & responsibilities followed in industry and the impact of industry products & services in societal & environmental context?	PO7, PO8, PO9, PO10, PO11, PSO2

Figure 01, 02, 03 and 04 shows the Google form for Industrial Visit Question from 01 to 04.

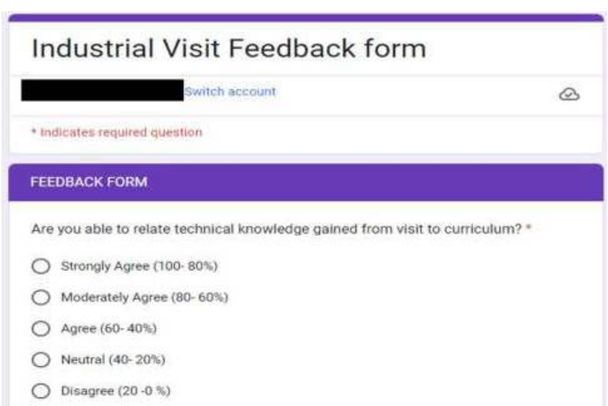

Fig. 1 : Google form for Industrial Visit: Question 01

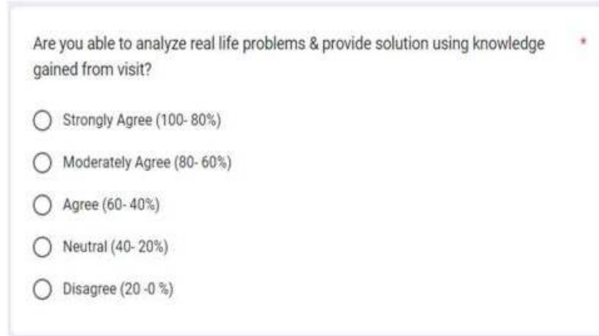

Fig. 2: Google form for Industrial Visit: Question 02

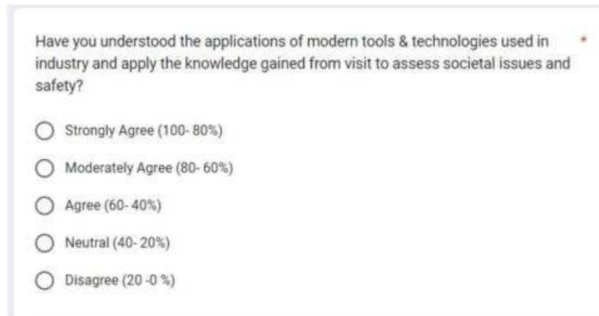

Fig. 3: Google form for Industrial Visit: Question 03

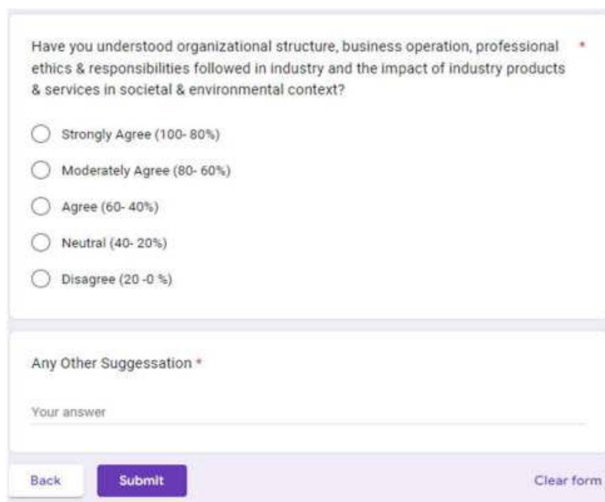

Fig. 4 : Google form for Industrial Visit: Question 04

C. Indirect Assessment and PO/PSO Attainment

Technical engineering and technology programs are assessed and approved by the National Board of Accreditation (NBA), an independent body in India. Outcome-based education is a primary focus of NBA accreditation standards (OBE). Program Specific Outcomes (PSOs) are statements that specify the abilities and information that students need to have upon completion of a specific course of study. PSOs are more focused than Program Outcomes (POs) and contain information on the skills, knowledge, and attitudes that students should acquire in their chosen field of study. PSOs are designed especially for each academic program and are intended to support the overall learning objectives of the organization. In the context of NBA's Outcome-Based Education, the following components are typically included in the program outcomes: (NBA UGEngg Tier II Manual, n.d.)

D. Descriptive Assessment of Feedback Questions and Mapped POs/PSOs:

Q.1: Are you able to relate technical knowledge gained from the visit to the curriculum?

- Description: Links practical industry knowledge with academic concepts.
- Mapped PO: PO1 - Engineering Knowledge
- Focus: Connecting real-world experiences to academic theories.

PO	Statements
PO1	Engineering knowledge
PO2	Problem analysis
PO3	Design/development of solutions
PO4	Conduct investigations of complex problems
PO5	Modern tool usage
PO6	The engineer and society
PO7	Environment and sustainability
PO8	Ethics
PO9	Individual and team work
PO10	Communication
PO11	Project management and finance
PO12	Life-long learning
PSO1	Analyze the real life problems in the field of Mechanical engineering including Design, Thermal and Manufacturing and develop appropriate solutions using modern tools
PSO2	Apply acquired professional skills, project management abilities and hands on experience in mechanical engineering and allied areas

Fig. 5 : Program Outcomes (PO) and Program Specific Outcomes (PSO)(NBA_UGEngg_Tier_II_Manual, n.d.)

Figure 05 shows the Program Outcomes (PO) and Program Specific Outcomes

Q.2: Are you able to analyze real-life problems and provide solutions using knowledge gained from the visit?

- Description: Applies industry knowledge to analyze and solve complex problems.
- Mapped POs/PSO: PO2 - Problem Analysis, PO3 - Design/Development of Solutions, PO4 - Conduct Investigations of Complex Problems, PSO1 - Analyzing real-life problems and developing solutions
- Focus: Evaluating problem-solving skills using practical knowledge.

Q.3: Have you understood the applications of modern tools and technologies used in the industry and applied the knowledge gained from the visit to assess societal issues and safety?

- Description: Applies modern tools/technologies to societal issues and safety.
- Mapped POs: PO5 - Modern Tool Usage, PO6 - The Engineer and Society
- Focus: Assessing societal implications and safety using industry knowledge.

Q.4: Have you understood organizational structure, business operation, professional ethics, and responsibilities followed in the industry, and the impact of industry products and services on societal and environmental contexts?

- Description: Comprehends organizational structure, operations, ethics, and impacts.
- Mapped POs/PSO: PO7 - Environment and Sustainability, PO8 - Ethics, PO9 - Individual and Team Work, PO10 - Communication, PO11 - Project Management and Finance, PSO2 - Applying professional skills, project management, and understanding societal and environmental impacts
- Focus: Understanding ethical responsibilities, organizational aspects, and societal/environmental implications.

Students were asked to provide feedback for the following level of understanding and satisfaction

Strongly Agree: 100% - 81%

Moderately Agree: 80% - 61%

Agree: 60% - 41%

Neutral: 40% - 21%

Disagree: 20% - 0%

This scale provides specific percentage ranges for respondents to indicate their level of agreement or disagreement, allowing for a more detailed and accurate representation of their opinions or responses.

E. Feedback and Attainment Calculation:

1. Data Preparation:

- The feedback data is organized into structured format (Google Form) containing information about industries visited, respective years, and responses to four different questions. Total 1571 responds were collected from first year to last year students.

2. Agreement Assessment:

- Each response to the questions is evaluated to determine the level of agreement. The analysis focuses on identifying if respondents either 'Strongly Agree' or 'Moderately Agree' with each question

3. Grouping and Calculation:

- The feedback data is grouped based on the industry visited and the year.
- For each industry visit in a specific year, the code assesses the percentage of respondents who either 'Strongly Agree' or 'Moderately Agree' for each question. About 60% satisfaction and understanding of the visit.

4. Average Feedback Computation:

- After calculating the agreement percentages for each question, the code determines the average agreement level across all questions for each industry visit in a particular year.

5. Attainment Level Determination:

- Based on the calculated average agreement percentages, the code categorizes the attainment level for each industry visit in a particular year into 'High' (3), 'Moderate'(2), or 'Low' (1).
- These categorizations are determined by predefined percentage ranges to indicate the overall level of agreement.

6. Result Representation:

- The final output displays the industry-wise and year-wise feedback assessment, presenting average agreement percentages for each industry visit along with the assigned attainment level.

F. Agreement Percentage Calculation:

For each question, the percentage of agreement (combining 'Strongly Agree' and 'Moderately Agree' responses) is calculated using this formula: (NBA_UGEngg_Tier_II_Manual, n.d.; Rao, 2020)

Agreement Percentage=

$$\frac{(\text{Number of 'Strongly Agree' + 'Moderately Agree' Responses})}{\text{Total}} * 100$$

1) Average Feedback Calculation:

After obtaining the agreement percentages for each question, the average feedback for an industry visit in a specific year is calculated by taking the mean (average) of the agreement percentages across all questions:(NBA_UGEngg_Tier_II_Manual, n.d.)

Average Feedback =

$$\frac{(\text{Agreement Percentage Q1} + \text{Agreement Percentage Q2} + \text{Agreement Percentage Q3} + \text{Agreement Percentage Q4})}{4}$$

2) Attainment Level Determination:

- The attainment level is assigned based on the average feedback percentage obtained:
- If the average feedback is greater than 80%, it is categorized as 'High' (Level 3).
- If the average feedback falls between 60% and 80%, it is categorized as 'Moderate' (Level 2).
- If the average feedback is below 60%, it is categorized as 'Low' (Level1).

(NBA_UGEngg_Tier_II_Manual, n.d.)

These formulas represent the steps involved in calculating the agreement percentages for each question, deriving the average feedback for an industry visit, and determining the attainment level based on predefined percentage ranges.

5. Sentiment Analysis From Comments

Sentiment Analysis from Suggestion / comments is done in Python using following functions.(Hussein, 2018; Wankhade et al., 2022)

A. Text Cleaning (clean_text function)

The function ensures that each comment is cleaned by removing punctuation and retaining only alphabetic characters. It checks if the input is a string and applies these cleaning operations.

B. Applying Text Cleaning (apply(clean_text))

This function is applied to the 'comments' column in the DataFrame, generating a new column labeled 'Cleaned Comments' that contains the processed text data.

C. Sentiment Categorization (categorize_sentiment function)

This function categorizes sentiment scores into either 'Positive' or 'Negative' based on whether the score is greater than or equal to zero.

D. Sentiment Analysis (get_sentiment_category function)

Utilizing the TextBlob library, this function conducts sentiment analysis on the cleaned comments. It computes the sentiment polarity of each comment and then categorizes the polarity score as 'Positive' or 'Negative' by calling the categorize_sentiment function.

E. Applying Sentiment Analysis (apply (get_sentiment_category))

This step executes the sentiment analysis function on the 'Cleaned Comments' column, resulting in a new column named 'Sentiment.' This column contains the assigned sentiment category ('Positive' or 'Negative') for each comment.

F. Counting Sentiments

After assigning sentiments, the code separates the comments into positive and negative categories based on the 'Sentiment' column. It counts the occurrences of both positive and negative sentiments separately, displaying the respective counts along with the categorized comments.

This process allows for the analysis and classification of sentiments present in the comments within the DataFrame, aiding in the assessment of positive and negative sentiments conveyed within the text data. The code, therefore, serves as a basic sentiment analysis framework applied to textual comments to categorize sentiments as positive or negative based on their polarity scores.

- Positive Sentiments Count: 1167
- Negative Sentiments Count: 14

This indicates that out of the analysed comments or
t

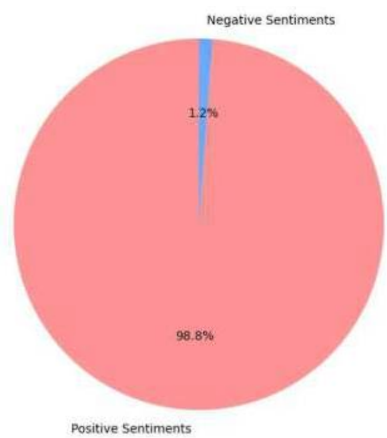

Fig. 6. Sentiment Analysis of Industrial Visits

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Positive Sentiments:
486                              It was a great experience
942                                                     No
71                           More deep knowledge is required
894                                                     No
37                                                      No
108                                                     No
1355                           Knowledge gaining field visit
221                 To give visit for gain practical knowledge
78     We got many things to learn was knowledgeable ...
680                                                     No
1495   visit gives up actual information about power ...
229                                                     Ok
784                                                Nothing
136                                                     No
1130   Provide a brief information regarding every se...
```

Fig. 7. Positive Comments

```
3                   Would like to operate laser cutting
463             Visit should be started little bit early
471     At there is no any technical person to give cl...
548                                            No thanks
752     Pls arrange some other visits for our practica...
781                                  No more suggestions
828     Arrange some other industrial visits too to ga...
1150                                           No thanks
1176     There was less space for observing the condenser
1286    Not good we expect to visit big companies in N...
1351    Arrange such field visits on regular basis bas...
1379    This visit gives us the idea about the laser p...
1385    We can plan an industrial visit to other place...
1401    There is a small suggestion and request for co...
```

Fig. 8. Negative comments

ext samples, 1167 were categorized as conveying a positive sentiment, while only 14 were categorized as conveying a negative sentiment. It suggests a significantly higher prevalence of positive sentiments within the dataset compared to negative sentiments. Figure 06 shows the Sentiment Analysis of Industrial Visits

Figure 07 and 08 shows the Positive and Negative comments from sentiment analysis

6. Result And Discussion

Table 04 shows the Visit wise percentage Feedback and Attainment Level with POs and PSOs

- Level 1 attainment occurred only once: This suggests that there might have been a specific aspect or criterion where the performance or achievement was relatively low or unsatisfactory during these visits.

- Level 2 attainments occurred twice: It indicates that there were a few areas needing improvement, which might not have been at the expected or desired level, but they were relatively better than the Level 1 aspects.

- Level 3 attainment was recorded twenty-five times: This indicates that the majority of the assessment falls under this level. It suggests that most areas assessed during the industrial visits were at a satisfactory or expected level of attainment, meeting the desired standards or criteria.

Overall, the data suggests a predominantly satisfactory performance (Level 3) during the industrial visits, with a few specific areas identified for improvement (Level 2) and only one area identified as relatively lacking or needing substantial improvement (Level 1). Figure 09 shows the Cumulative feedback for all Industries

Name of the Industry	Q1	Q2	Q3	Q4	Average feedback	Attainment Level
I1	83.05	84.75	81.36	79.66	82.20	3
I2	100.00	100.00	100.00	100.00	100.00	3
I3	89.68	81.75	81.75	82.54	83.93	3
I4	100.00	50.00	50.00	50.00	62.50	2
I5	85.00	81.67	83.33	83.33	83.33	3
I6	93.94	78.79	87.88	78.79	84.85	3
I7	100.00	90.48	95.24	95.24	95.24	3
I8	100.00	100.00	100.00	100.00	100.00	3
I9	97.62	97.62	88.10	100.00	95.83	3
I10	88.89	79.01	80.25	74.07	80.56	3
I11	84.85	81.82	84.85	80.30	82.95	3
I12	100.00	100.00	93.75	81.25	93.75	3
I13	50.00	50.00	50.00	50.00	50.00	1
I14	100.00	85.71	71.43	85.71	85.71	3
I15	100.00	100.00	100.00	0.00	75.00	3
I16	95.65	88.04	92.39	85.87	90.49	3
I17	85.71	78.57	78.57	64.29	76.79	3
I18	77.78	76.92	78.63	82.05	78.85	3
I19	88.13	86.69	88.85	86.33	87.50	3
I20	80.00	70.00	70.00	60.00	70.00	2
I21	86.27	92.16	86.27	77.45	85.54	3
I22	96.77	96.77	96.77	100.00	97.58	3
I23	89.66	86.21	87.93	86.21	87.50	3
I24	97.50	88.33	92.50	89.17	91.88	3
I25	85.85	83.02	79.25	77.36	81.37	3
I26	100.00	50.00	100.00	100.00	87.50	3
I27	100.00	100.00	100.00	100.00	100.00	3
I28	100.00	100.00	100.00	100.00	100.00	3

Fig. 10 shows the sample feedback for an industry for visit of 54 students. It is clearly visible that most of the students are satisfied with content taught during visit.

At few industries multiple visits are carried out hence average of the all PO/PSO is included for single visit. Figure 11 Shows the PO Attainment Matrix with unique industry. 18 unique industries were visited in last academic year. Total 28 Industrial visits were arranged in 18 Industries. In Large scale industries multiple visits were carried out to understand different

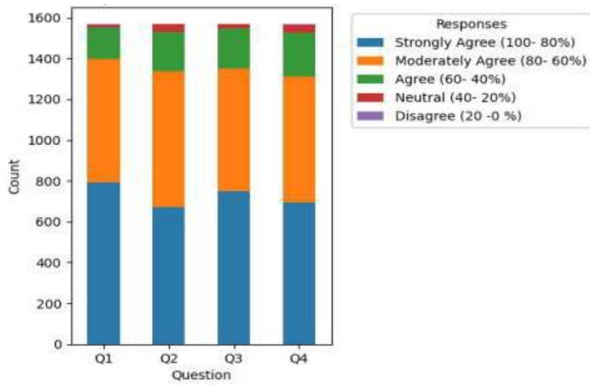

Fig.9 : Cumulative feedback for all Industries

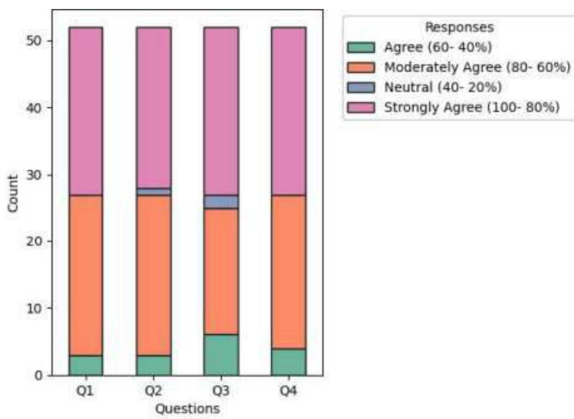

Fig.10 : Sample feedback for an Industry

topics. Such as Thermal power plant was visited twice. Once in the second year, for the "Thermodynamics" subject, to comprehend the boiler and how it operates; once more in the final year, for the "Energy Engineering" subject, to compute plant efficiency.

Sr.No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
I1	2	1			2		1		2	1	1	2	1	
I2	2	1						2		1		2	1	1
I3					1			1		1		1	1	1
I4	2	1						2		1		2	1	1
I5	1	2		1	1	1	1	1	1	1	1	1	1	1
I6	1	1		3	3	1	1	1	2	1	1	3	1	1
I7	1		1	2		3	3	2	2	2		2	2	2
I8	3	2			2		2	2			2	2		
I9	1											1		
I10	3	1	2	2		3	3	3	3	3		3	3	3
I11	2					1	1	1	2	3		3	1	1
I12	3	1	1			3	2	1		2		2	2	2
I13	3	2	2	2		2	3	3	3	3	2	3	3	1
I14	1	1		2	2	3	3	3	3	3	3	3	3	3
I15							3	2						
I16	3	2	2		2	1	1	2			1		2	
I17	2	2	2	2	3	2	3	2	2			2	2	2
I18	3	2	3	2	2	3	3	3	3	3	3	3	3	2

Fig. 11 : Industry wise POs/PSOs Mapping

Name of the Industry Visited	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
I1	2	1			2		1		2	1	1	2	1	
I2	2	1						2		1		2	1	1
I3					1			1		1		1	1	1
I4	2	1						2		1		2	1	1
I5	0.6	1.3		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
I6	1	1		3	3	1	1	1	2	1	1	3	1	1
I7	1		1	2		3	3	2	2	2		2	2	2
I8	2	1.3			1.3		1.3	1.3			1.3	1.3		
I9	1											1		
I10	3	1	2	2		3	3	3	3	3		3	3	3
I11	2					1	1	1	2	3		3	1	1
I12	3	1	1			3	2	1		2		2	2	2
I13	3	2	2	2		2	3	3	3	3	2	3	3	1
I14	1	1		2	2	3	3	3	3	3	3	3	3	3
I15							3	2						
I16	3	2	2		2	1	1	2			1		2	
I17	1.3	1.3	1.3	1.3	2	1.3	1.3	1.3	1.3			1.3	1.3	1.3
I18	3	2	3	2	2	3	3	3	3	3	3	3	3	2
Average PO/PSO Mapping	1.93	1.30	1.76	1.86	1.77	1.99	1.94	1.83	2.19	1.89	1.61	2.08	1.73	1.53

Fig. 12 : Industry wise POs and PSOs Attainment

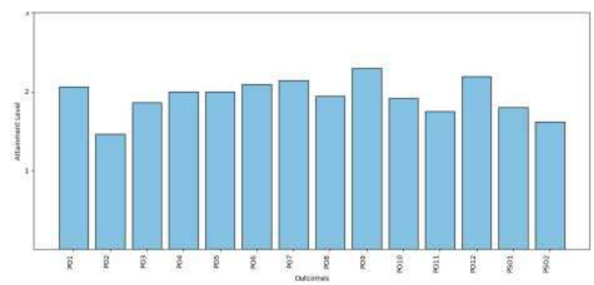

Fig. 13 : Average PO/PSO attainment of all Visits using Indirect Assessment

Figure 12 shows the Industry wise PO Mapping. Industry POs/PSOs are mapping with content delivered during visit.

Figure 13 shows the Average PO/PSO attainment of all Visits using Indirect Assessment

1. PO1 (Engineering Knowledge): The average attainment level is 1.93, indicating a moderate to high understanding and application of engineering knowledge gained through industrial visits.

2. PO2 (Problem Analysis): With an average of 1.3, there might be a relatively lower level of proficiency in identifying and analysing complex engineering problems. This area could require additional focus or improvements through future visits or educational strategies.

3. PO3 (Design/Development of Solutions): The average level of 1.76 suggests a moderate

understanding in designing solutions for complex engineering problems during industrial visits.

4. PO4 (Conduct Investigations): Attainment level at 1.86 suggests a moderate proficiency in conducting research-based investigations and drawing valid conclusions from data acquired during visits.

5. PO5 (Modern Tool Usage): The average of 1.77 indicates a moderate to high proficiency in utilizing modern engineering and IT tools during industrial visits.

6. PO6 (Engineer and Society): With an average level of 1.99, students seem to comprehend societal issues relevant to engineering practices moderately well during these visits.

7. PO7-PO11 (Ethics, Environment, Teamwork, and Communication): These outcomes scored moderately to highly with average values ranging between 1.64 to 2.19, indicating a decent understanding and application of ethical principles, environmental contexts, teamwork, and communication skills during the visits.

8. PO12 (Project Management and Finance): The average level of 2.08 suggests a moderate understanding of project management principles during industrial visits.

9. PSO1 and PSO2: These specific outcomes scored an average of 1.73 and 1.53, respectively, showcasing a moderate to moderate-high attainment level in applying acquired professional skills and analytical abilities in mechanical engineering and related areas.

In summary, these averages portray a varying level of proficiency across different Program Outcomes and Program Specific Outcomes. While some areas exhibit a moderate to high understanding based on the industrial visits, others might require further attention or enhancement to ensure a more comprehensive attainment of learning objectives and outcomes associated with the curriculum.

Conclusion

In engineering education, integrating industrial trips immerses students in real-world settings, effectively addressing curriculum gaps by providing invaluable insights and hands-on experiences. These experiences enhance students' technical knowledge, problem-solving skills, and ethical decision-making abilities, equipping them to confidently tackle real engineering challenges. Including industrial trips in the curriculum is essential for developing engineers who possess both theoretical understanding and practical competence. The implementation of Python programming for PO/PSO attainment computation and feedback analysis has significantly reduced manual effort. Additionally, sentiment analysis provides insightful recommendations for optimizing visit planning; ensuring industries with minimal feedback are revisited later for improvement.

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