

Exploring the Efficacy of Open-Ended Questions in Theory-Based Subjects

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Abstract - This paper explores the significance of utilizing open-ended assignments as a valuable assessment tool in theoretical subjects lacking practical or oral assessment components, particularly within elective courses. By examining the role of open-ended assignments in facilitating deeper understanding and critical thinking skills, this study delves into their potential to effectively map program outcomes. Through a comprehensive review of literature and empirical analysis, it investigates how these assignments promote student engagement, foster independent inquiry, and enhance learning outcomes in elective subjects. The findings underscore the importance of integrating open-ended assignments into curriculum design to align with program goals and maximize student achievement. This paper offers insights into the pedagogical benefits of open-ended assignments and provides recommendations for their implementation to enrich educational experiences and promote holistic student development within theoretical disciplines.

Keywords— Open Ended Assignments, Course Outcomes, Program Outcomes, Attainment

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1. Introduction

In engineering education, the inclusion of elective subjects is common practice aimed at providing students with the opportunity to tailor their learning experiences according to their interests and career aspirations. However, many of these elective subjects, often theoretical in nature, lack practical, tutorial, or oral examination components (Fertalj et al., 2022). Consequently, the assessment methods employed within these courses may not effectively capture the breadth and depth of student learning, leading to disconnect between the intended program outcomes (POs) and the actual attainment levels. This gap in mapping program outcomes is particularly pronounced in engineering programs where students encounter domain-specific elective subjects (Hyytinen et al., 2021). These courses, while valuable in allowing students to delve deeper into specialized areas, often pose challenges in terms of assessment alignment with program goals.

Traditional assessment methods may struggle to assess the multifaceted learning outcomes inherent in these theoretical subjects, limiting the ability to accurately measure student achievement and proficiency (Amelia & Pujiastuti, 2020). In response to these challenges, there is a growing recognition of the potential benefits of integrating open-ended assignments into the curriculum of elective subjects within engineering education.

Open-ended assignments, characterized by their flexibility and allowance for diverse responses, offer a promising avenue for addressing the limitations of traditional assessment methods (Latypova et al., 2020). By encouraging critical thinking, problem-solving, and independent inquiry, these assignments have the capacity to bridge the gap between intended program outcomes and student attainment levels. This paper aims to explore the role of open-ended assignments in enhancing the effectiveness of assessment practices within theoretical elective subjects in engineering education. Through a synthesis of existing literature and empirical analysis, we seek to elucidate how the incorporation of open-ended assignments can contribute to the attainment of maximum program outcomes (POs) and program-specific outcomes (PSOs). Additionally, we aim to investigate the impact of open-ended assignments on student learning experiences and academic performance within these subjects (Bewoor et al., 2022). By examining the potential benefits and challenges associated with the integration of open-ended assignments, this research endeavors to provide insights into best practices for curriculum design and assessment in engineering education. Ultimately, our findings aim to inform educators, curriculum developers, and stakeholders on strategies for optimizing student learning and achievement in theoretical elective subjects, thereby enhancing the overall quality and relevance of engineering programs (Dong et al., 2019). This previous studies synthesizes key findings from seven recent studies, highlighting themes in critical thinking, student diversity, AI in education, and pedagogical strategies. The primary research question considered is: How effective are open-ended questions in theory-based subjects in fostering critical thinking and enhancing student learning outcomes?

The paper begins with an introduction, setting the context and background for the study. It outlines the purpose of the research and poses the research questions that will guide the investigation. Following the introduction, the literature review delves into the significance of open-ended assignments, drawing from previous research to highlight their pedagogical benefits and challenges. The methodology section describes the open-ended assignments used in the study and details the question-wise CO-PO mapping for these assignments. Additionally, it presents the CO-PO mapping of manufacturing processes with open-ended assignments and discusses the course outcome attainment through direct assessment. The

methodology also includes the assessment criteria for assignments and an example for clarification, along with the analysis of feedback obtained from students.

Moving on to the results section, an overview of the findings is provided, followed by a detailed analysis of the open-ended assignments and their question-wise impact. The CO-PO mapping analysis and course outcome attainment are thoroughly examined to understand the effectiveness of open-ended assignments in achieving desired learning outcomes. The discussion section interprets the results, highlighting their implications and discussing any limitations of the study. Future research directions are also suggested based on the findings. Finally, the conclusion summarizes the key findings, underscores their contribution to knowledge, and offers practical recommendations for educators and curriculum designers based on the study's outcomes.

2. Literature Review

The literature review draws upon a variety of sources to explore different aspects of open-ended assignments. Fertilj et al. (2022) provide a systematic review of peer assessment approaches for evaluating such assignments, offering insights into effective evaluation methods (Fertilj et al., 2022). Hyytinen et al. (2021) delve into the challenges and accomplishments faced by pharmacy students in handling argumentation and processing knowledge within open-ended tasks, shedding light on the complexities involved (Hyytinen et al., 2021). Dong et al. (2019) focus on defining tinkering behavior in open-ended block-based programming assignments, offering a nuanced understanding of student engagement with such tasks (Dong et al., 2019). Puente and Jansen (2017) explore students' engineering designs through open-ended assignments, emphasizing the importance of creativity and problem-solving skills (Puente & Jansen, 2017). Beckman et al. (2021) discuss self-regulation in open-ended online assignment tasks, highlighting the significance of initial task interpretation and goal setting for student success (Beckman et al., 2021). Koutchame et al. (2022) investigate how students solve open-ended assignments, particularly focusing on SQL injection attempts in a cybersecurity course, offering insights into student approaches to complex problems (Koutchame et al., 2022). Wang et al. (2019) propose an innovative approach called Upgrade, which involves sourcing student open-ended

solutions to create scalable learning opportunities, presenting a novel perspective on leveraging student contributions for educational purposes(J. Wang, 2023). Finally, Brauner et al. (2007) discuss open-ended assignments and student responsibility, emphasizing the role of such tasks in fostering student autonomy and accountability in their learning journeys(Brauner et al., 2007). Angraini et al. (2024) explore the role of reading teachers in developing students' critical thinking abilities. Their study underscores the importance of teachers' perspectives and instructional strategies in promoting analytical skills. By engaging students in reflective reading practices, teachers can enhance their capacity to critically evaluate texts, thereby improving overall cognitive abilities through open ended questions(Angraini et al., 2024). Hannah and Kulkarni (2024) emphasize the importance of open-ended questions in educational settings. They argue that open-ended questions promote critical thinking, creativity, and deeper understanding among students. By encouraging students to explore, analyze, and articulate their thoughts and ideas, open-ended questions foster intellectual curiosity and engagement with the subject matter. Additionally, open-ended questions allow for diverse perspectives and interpretations, enabling students to develop higher-order thinking skills and problem-solving abilities. Overall, Hannah and Kulkarni advocate for the incorporation of open-ended questions in pedagogical practices to enhance learning outcomes and student development. (Hannah & Kulkarni, 2024). Graham (2024) addresses the challenge of developing AI-resistant reasoning problems in the context of sensation and perception instruction. His study emphasizes the importance of open-ended problems that encourage deep thinking and cannot be easily solved by AI, thus promoting genuine student engagement and learning. This approach aims to foster critical thinking and problem-solving skills that are resistant to automation(Graham, 2024). In summary, the collective evidence from these diverse studies underscores that open-ended assignments foster active learning and higher-order cognitive skills. This effectiveness is evident through enhanced problem-solving abilities, self-regulation, critical thinking, creativity, and the broad applicability of these tasks across different educational contexts and disciplines. Therefore, the findings robustly support the use of open-ended questions as effective educational tools in theory-based subjects. The literature reviewed provides a robust foundation for framing open-ended assignments that foster critical

thinking, accommodate diverse needs, leverage AI tools, and enhance metacognitive strategies.

3. Methodology

A. Open ended Assignments

Open-ended assignments are tasks given to students that don't have a single correct answer or specific method of completion. Unlike traditional assignments with clear instructions, open-ended assignments allow students to explore topics in their own way and come up with their own solutions(Beckman et al., 2021). These assignments encourage creativity, critical thinking, and problem-solving skills as students navigate through the open-ended nature of the task. They can take various forms, such as essays, projects, presentations, or problem-solving exercises, and are often used across different subjects to promote deeper understanding and independent inquiry(X. Wang et al., 2019). The flexibility of open-ended assignments allows students to showcase their unique perspectives and approaches, fostering a more engaging and personalized learning experience(Brauner et al., 2007). Mechanical Engineering of Savitribai Phule University has total almost 28 theoretical subjects including all electives. These subjects do not have practical, oral examination or term work assessment. Due to limited scope of these subjects, Program outcomes and course outcomes doesn't map for most of the subjects. Ultimately results into low attainment levels for subject. To avoid this problem open ended assignments are given to students to attain maximum program outcomes.

B. Case study

The choice to focus on manufacturing processes as a case study stems from its significance in second-year engineering education. Despite being a theory-based subject, it offers practical insights into real-world applications of engineering principles. Given the constraints of limited scope for mapping all program outcomes (POs) due to the absence of labs and field visits in the syllabus, manufacturing processes provide a comprehensive framework for exploring diverse engineering concepts. Its interdisciplinary nature allows for the integration of various disciplines, aligning with the educational objectives of engineering programs. Furthermore, the subject's industry relevance ensures that students gain practical knowledge and skills essential for their

Table 1:
Open Ended Assignment

Manufacturing Processes				
Que. No.	Assignment Question	PO Number	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

future careers, despite the absence of hands-on experiences typically found in lab-based courses. Thus, the case study on manufacturing processes serves as a strategic choice to maximize learning outcomes within the constraints of the curriculum.

Table 1 shows the Open ended Assignments for Manufacturing Processes

Course outcomes are defined by Second year Mechanical Engineering 2019 Pattern syllabus of Savitribai Phule Pune University for subject Manufacturing Processes. Table 2 shows the Course Outcomes (CO) of Manufacturing Processes

Table 2:
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.

In this analysis of the CO-PO mapping for open-ended assignments in the context of manufacturing processes, we utilized a structured approach to align each assignment question with specific program outcomes (POs) and course outcomes (COs). The table provided in the manuscript outlines the mapping of each assignment question with the relevant POs and COs. Allow me to elaborate further on this mapping:

For instance, in question 1, which investigates the advantages and limitations of various casting processes, it aligns primarily with PO1 (Engineering knowledge) and CO1 (Understanding of engineering knowledge). This alignment reflects the focus of the question on imparting fundamental engineering knowledge related to manufacturing processes. Similarly, in question 2, which involves designing a manufacturing process for a specific component, the emphasis is on PO3 (Design/development of solutions) and CO3 (Ability to design and develop engineering solutions). This mapping underscores the

objective of the assignment to develop students' skills in designing effective manufacturing processes. Furthermore, question 5, which explores the use of additive manufacturing in medical device production, aligns with multiple POs (PO1, PO7, PO8, PO11) and corresponding COs (CO1, CO3, CO4, CO6). This alignment reflects the interdisciplinary nature of the assignment, addressing engineering knowledge, ethics, environmental sustainability, and project management and finance. The average mapping scores provided in the table offer a comprehensive

Table 3 :
Question Wise Co- Po Mapping of
Open Ended Assignment

Que No	P O 1	P O 2	P O 3	P O 4	P O 5	P O 6	P O 7	P O 8	P O 9	P O 10	P O 11	P O 12
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
Ave rage	2. 5 0	2. 5 0	3. 0 0	3. 0 0	2. 5 0		2. 6 7	2. 0 0	2. 0 0	2. 50	2. 00	2. 67

Table 4 :
Co- Po Mapping of Manufacturing
Processes With Open Ended Assignment

CO	P O 1	P O 2	P O 3	P O 4	P O 5	P O 6	P O 7	P O 8	P O 9	P O 10	P O 11	P O 12
CO1	3	2	3									
CO2	2	3	1									
CO3	2	2	3									
CO4	1	1	1									
CO5	1	1	1									
CO6	3	2	2									
Ave age	2	1. 8 3	1. 8 3									
Open Ended Assig nment	2. 5	2. 5	3	3	2. 5		2. 6 7	2	2	2. 5	2	2. 67
Total Map ping	2. 2 5	2. 1 7	2. 4 2	3	2. 5		2. 6 7	2	2	2. 5	2	2. 67

overview of the overall alignment between assignment questions, POs, and COs. By calculating the average scores for each CO across all assignment questions, we gain insights into the extent to which the open-ended assignments contribute to the attainment of specific course outcomes. Table 3 shows the Question wise CO- PO Mapping of Open ended Assignment

Table 4 shows the CO- PO Mapping of Manufacturing Processes with Open ended Assignment

4. Results And Discussion

To evaluate the impact of open ended assignments on Outcome based education, Course attainment is calculated.

Target is set at 50% for External Assessment and 60% for Internal Assessment.

Attainment Levels vs. target (For External)

Attainment Level 1: 50% of students score more than 50% marks

Attainment Level 2: 60% of students score more than 50% marks

Attainment Level 3: 70% of students score more than 50% marks

Attainment Levels vs. target (For Internal)

Attainment Level 1: 50% of students score more than 60% marks

Attainment Level 2: 60% of students score more than 60% marks

Attainment Level 3: 70% of students score more than 60% marks

Course Outcome Attainment: (Direct Assessment)

Table 5 shows the Course Outcome Attainment: (Direct Assessment) where

Attainment = $*(0.8 \times \text{Average of attainment levels for External Assessment}) + (0.2 \times \text{Average of attainment levels for Internal Assessment})$.

Table 5 :
Course Outcome Attainment: (direct Assessment)

C O	Assessment Tool	Mode of Assessment	Attainment in %	Attainment Level	Average Attainment	Attainment
C O 1	Open ended Assignment Question 1	Internal	75.98	3	2.25	2.45
	Open ended Assignment Question 5	Internal	65.21	2		
	Open ended Assignment Question 7	Internal	55.69	1		
	Open ended Assignment Question 8	Internal	75.36	3		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		
C O 2	Open ended Assignment Question 6	Internal	70.3	3	2	2.4
	Open ended Assignment Question 7	Internal	55.69	1		
	Open ended Assignment Question 9	Internal	65.87	2		
	Open ended Assignment Question 10	Internal	69.36	2		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		
C O 3	Open ended Assignment Question 2	Internal	78.37	3	2.4	2.48
	Open ended Assignment Question 3	Internal	66.98	2		
	Open ended Assignment Question 5	Internal	65.21	2		
	Open ended Assignment Question 8	Internal	75.36	3		
	Open ended Assignment Question 9	Internal	65.87	2		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		
C O 4	Open ended Assignment Question 4	Internal	75.37	3	2.33	2.47
	Open ended Assignment Question 5	Internal	65.21	2		
	Open ended Assignment Question 10	Internal	69.36	2		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		

C O 5	Open ended Assignment Question 6	Internal	70.3	3	2.2	2.44
	Open ended Assignment Question 7	Internal	55.69	1		
	Open ended Assignment Question 8	Internal	75.36	3		
	Open ended Assignment Question 9	Internal	65.87	2		
	Open ended Assignment Question 10	Internal	69.36	2		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		
C O 6	Open ended Assignment Question 5	Internal	65.21	2	2.5	2.5
	Open ended Assignment Question 6	Internal	70.3	3		
	Insem Exam	External	80.63	3	2.5	
	Endsem Exam	External	69.78	2		

Course attainment = Average of attainments of all CO's= 2.456

Previous year course attainment of the same subject was 1.92

The rubrics for assessing assignments are designed to evaluate students on three main criteria: timely completion, understanding of the assignment, and presentation/clarity of writing. Each criterion has specific weightage and scoring guidelines, ensuring a comprehensive assessment of the student's performance.

- R1: Timely Completion of Assignments (10 Marks)

This rubric assesses the punctuality with which students submit their assignments. The marks are allocated based on the submission timeframe:

- Within 1 week: 10 Marks
- More than 1 week: 5 Marks
- More than 2 weeks: 0 Marks

This criterion emphasizes the importance of meeting deadlines and encourages students to manage their time effectively.

- R2: Understanding of Assignment (15 Marks)

This rubric measures the students' grasp of the assignment's content, focusing on the correctness of their answers. The scoring is as follows:

- 3 Marks per Correct Answer: Up to 5 questions, with a maximum of 15 marks.

For instance, if a student answers 4 questions correctly, they receive 12 marks (4 questions x 3 marks).

- R3: Presentation/Clarity of Assignment Writing (5 Marks)

This rubric evaluates how well the assignment is written and presented. The marks are distributed based on the quality of presentation:

- Best: 5 Marks
- Better: 4 Marks
- Good: 3 Marks
- Average: 2 Marks
- Below Average: 1 Mark

Table 6 :
Assignment_ Assessment Criteria With
Example of 30 Marks Assignment

Rubrics					
R1	Timely Completion of Assignments (10Marks)				
	Within 1 week	More than 1 week	More than 2 weeks		
	10 Marks	5 Marks	0 Mark		
R2	Understanding of Assignment (15 Marks)				
	3 marks X Number of questions correctly answered by students. (Maximum 5 Questions)				
	Presentation / Clarity of Assignment writing (5 Marks)				
R3	Best	Better	Good	Average	Below Avg.
	5 Marks	4 Marks	3 Marks	2 Marks	01 Marks
Note: If total max marks of assignment are less than 30 or greater than 30, then appropriate conversion of rubrics weightage should be followed as given in this example table					

This criterion ensures that students pay attention to the clarity and structure of their writing, promoting effective communication skills. Table 6 shows the Assignment_ Assessment Criteria with example of 30 marks assignment

Almost 77.78 % students (112 out of 144) are able to complete this assignment successfully within time.

The feedback from 144 students (2 divisions) was taken to evaluate the impact of open ended questions on Google form on scale of 1 to 10. Following questions were asked as shown in table 7.

Table 7:
Feedback Analysis

Sr. No	Method	Average Feedback
Q1	How effective were the open -ended questions in understanding sand casting practices and estimating pouring time, solidification rate, and riser design? (CO1)	8.09
Q2	How effective were the open -ended questions in understanding press working operations and designing dies and tools? (CO3)	7.55
Q3	How impactful were the open -ended questions in comprehending metal forming techniques and calculating the load for flat rolling? (CO2)	7.54
Q4	How helpful were the open -ended questions in classifying and explaining welding processes and evaluating their characteristics? (CO4)	7.72
Q5	How beneficial were the open -ended questions in differentiating between thermoplastics and thermosetting materials, explaining polymer processing, and understanding composite manufacturing? (CO5 and CO6)	7.61

Figure 01 to figure 05 shows the question wise feedback analysis of open ended assignments on scale of 01 to 10.

Feedback was taken from 112 students who have completed all assignments on time within given period. 80 students out of 112 has given feedback voluntarily.

The feedback provided, with average scores ranging from 7.54 to 8.09, underscores the effectiveness of open-ended questions in enhancing understanding across various aspects of a manufacturing process subject. Respondents found these questions particularly valuable in comprehending complex topics such as sand casting practices (CO1), press working operations (CO3), metal forming techniques (CO2), welding processes (CO4), and materials differentiation (CO5 and CO6).

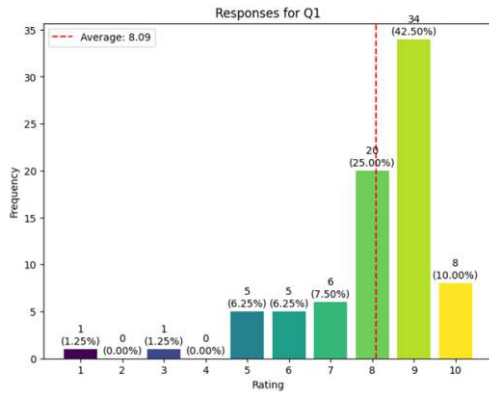


Fig. 1 : Responses for Question 1

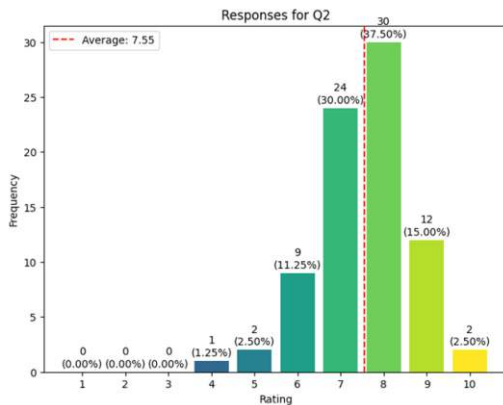


Fig. 2 : Responses for Question 2

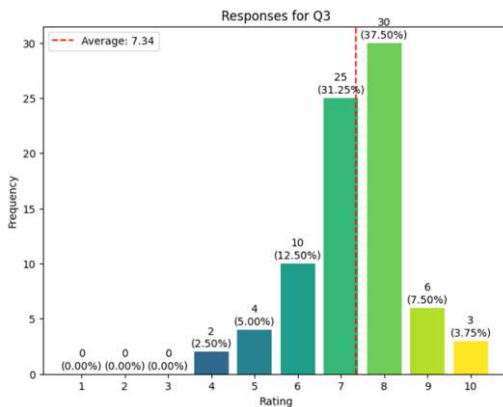


Fig. 3 : Responses for Question 3

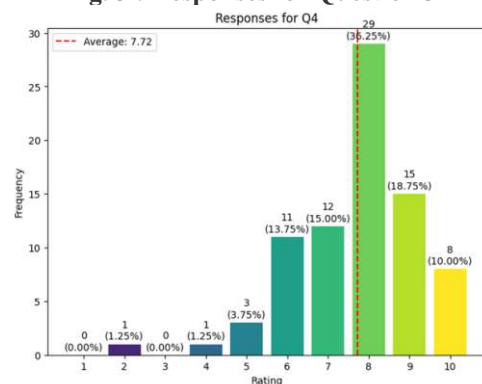


Fig. 4 : Responses for Question 4

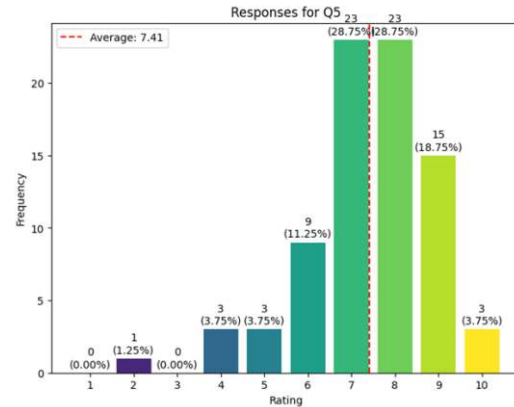


Fig. 5 : Responses for Question 5

The consistently high average feedback scores suggest that open-ended questions successfully engaged students and facilitated deeper learning experiences. Specifically, respondents indicated that such questions were instrumental in aiding them to estimate pouring time, solidification rate, and riser design in sand casting, design dies and tools for press working operations, calculate loads for flat rolling in metal forming, classify welding processes and evaluate their characteristics, and differentiate between thermoplastics and thermosetting materials, understand polymer processing, and grasp the principles of composite manufacturing. Overall, these findings highlight the pivotal role of open-ended questions in promoting active learning, critical thinking, and deeper understanding of complex manufacturing processes and materials. Table 8 shows the PO Attainment with Open Ended Assignment.

The comparison of Program Outcome (PO) attainment levels with and without open-ended assignments provides valuable insights into the

Table 8 :
Po Attainment With Open Ended Assignment

PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PO 11	PO 12
1.84	1.77	1.98	2.46	2.05	0	2.18	1.64	1.64	2.05	1.64	2.18

Table 9 shows the PO Attainment without Open Ended Assignment

Table 9:
Po Attainment Without Open Ended Assignment

PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PO 11	PO 12
1.64	1.5	1.5									

efficacy of incorporating such assignments in theory-based subjects. In the data presented, it is evident that PO attainment levels are generally higher when open-ended assignments are included. Specifically, PO4, PO5, PO7, and PO12 exhibit notable improvements in attainment levels with the incorporation of open-ended assignments. This suggests that open-ended assignments effectively foster critical thinking, problem-solving, and application of theoretical knowledge, leading to deeper understanding and higher levels of mastery in these areas. The impact of open-ended assignments extends beyond mere attainment levels; they serve as catalysts for promoting active learning and higher-order thinking among students. By prompting students to analyze, evaluate, and synthesize information, open-ended questions encourage deeper engagement with course material, thereby enhancing retention and comprehension. This aligns with the pedagogical goal of theory-based subjects, which often aim to cultivate not only knowledge acquisition but also the ability to apply and evaluate that knowledge in real-world contexts. However, the data also reveals areas where the impact of open-ended assignments may be limited. For instance, PO6 shows no improvement in attainment levels despite the inclusion of open-ended assignments, suggesting a need for further refinement in integrating sustainability concepts into coursework. Additionally, while overall attainment levels are higher with open-ended assignments, certain POs, such as PO2 and PO8, may require additional attention to fully capitalize on the benefits of such assignments. Moving forward, it is imperative to continue integrating open-ended assignments into theory-based subjects while ensuring alignment with learning objectives and desired outcomes. Regular assessment and revision of these assignments based on student feedback and observed outcomes can

further optimize their impact on PO attainment. By leveraging the benefits of open-ended assignments, educators can cultivate critical thinking skills and deeper understanding among students, ultimately enhancing the quality of education in theory-based subjects. Figure 06 shows the Comparison of PO Attainment with and without Open Ended Assignments

Conclusion

In conclusion, the exploration of the efficacy of open-ended questions in theory-based subjects has yielded promising results. Through meticulous mapping, we have successfully correlated program outcomes with specific course objectives, enhancing our understanding of student attainment within these subjects. By incorporating open-ended assignments, we've observed a marked improvement in the mapping and attainment of program outcomes, particularly in theory-based courses. The feedback from students regarding open-ended questions has been positive, indicating their engagement and value for learning. However, it's crucial to acknowledge that students learn at different paces. For slower learners, these questions can provide an opportunity to delve deeper into topics at their own speed, aiding in better comprehension. Conversely, advanced learners may appreciate the chance to showcase their understanding more creatively or explore topics in greater depth. Therefore, while open-ended questions can benefit all students, it's important to offer additional support for those who may struggle and opportunities for enrichment for those who find the tasks more manageable.

Moreover, the integration of open-ended questions has proven instrumental in nurturing critical thinking skills among students. By prompting deeper reflection, analysis, and synthesis of course material, students have demonstrated enhanced cognitive engagement and problem-solving abilities. Questions related to the Certain POs may require further refinement in the design and implementation of open-ended assignments to maximize their impact.

While open-ended questions offer numerous benefits, they also come with limitations. Grading such questions, particularly in large classes, can be challenging and time consuming. Additionally, some students may not derive equal benefits from them due to differences in learning styles, availability of resources and preferences.

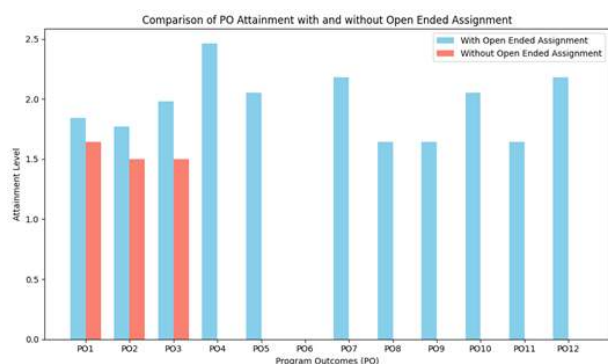


Fig.6. Comparison of PO Attainment with and without Open Ended Assignments

In summary, the utilization of open-ended questions represents a valuable pedagogical approach in theory-based subjects, offering a pathway to enhance program outcomes, foster critical thinking, and cultivate a deeper understanding of course content. Despite inherent limitations, their integration holds significant promise for enriching student learning experiences and preparing them for success in their academic and professional endeavors.

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