

Board-Game-Based Gamification Improves Engagement in Petroleum Refining Engineering Course

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DOI: <https://dx.doi.org/10.47772/IJRISS.2025.924ILEIID0051>

Received: 23 September 2025; Accepted: 30 September 2025; Published: 30 October 2025

ABSTRACT

Final-semester Petroleum Refining Engineering courses in the Oil and Gas Engineering program require sustained motivation to integrate complex and interdependent topics. This study investigates whether incorporating well-designed gamification can mitigate the course's primary challenge by enhancing student engagement and interest, while facilitating their understanding and retention of key concepts. During the gamified sessions, a domain-specific board game for petroleum refining was utilized to enable team navigation through the session for two groups of a total of 52 final semester students. Outcomes were measured using exit surveys that employed a Likert scale. The outcomes showed uniformly positive perceptions across learning, organization, teamwork, instructor support, and coverage, with top-two (4–5) ratings of ~92–100% for Q1–Q11; workload was judged manageable (Q14 top-two = 88.5%), while difficulty displayed a wider spread (Q13), indicating productive challenge. These findings suggest that gamification is most effective as a motivational, application-oriented complement rather than a replacement for direct instruction. We recommend a blended approach: concise, well-scaffolded lectures to establish fundamentals, followed by targeted game-based activities to let students practice making decisions across the whole refinery process. Future work should pair satisfaction data with direct learning measures to tune game mechanics to challenging mechanisms and maximize learning gains.

Keywords: Gamification; STEAM; Board Game; Blended Learning; Engineering Education

INTRODUCTION

Gamification in engineering education is the deliberate integration of game elements into non-game coursework to increase motivation, engagement, and purposeful practice without reducing rigour. It is most effective when those elements are aligned with learning outcomes and used to complement clear instruction rather than replace it. Prior studies show that gamification has real benefits, but also clear limits. In a five-year project across two Spanish universities, Suárez-López and colleagues used board games as gamified activities in thermal-engineering courses. Students rated participation, teamwork, and organization highly, yet many felt core concepts were learned better in traditional lectures, and outcomes did not differ significantly by degree program or class size (Suárez-López et al., 2023). In two Universitat Politècnica de València engineering courses, the blended design (videos, interactive slides, synchronous lectures, virtual labs) paired with Kahoot quizzes raised attention and participation, with students reporting the activity as fun and showing improved scores after the lesson (Bracho et al., 2022). They conclude that gamification helps identify weaknesses, tailor live sessions, and enhance the teaching–learning process, while noting small sample size as a limitation and proposing continued use in future iterations.

Final-semester Petroleum Refining Engineering (PRE) demands that students integrate complex and interdependent topics, including crude characterization, distillation sequencing, catalytic conversion, hydrogen management, product quality, and energy emissions trade-offs, yet courses at this stage often struggle to sustain motivation and active engagement. In engineering education broadly, gamification (the use of game elements in non-game contexts) and board-game formats are reported to raise engagement, collaboration, and perceived value (Cafagna et al., 2019; Jun & Lucas, 2025; Riquelme et al., 2024). However, direct evidence

tailored to petroleum refining remains sparse, indicating a need for domain-specific adaptations that reflect petroleum refinery decision-making.

This study evaluates whether a domain-specific gamification intervention can address the course's primary challenge by increasing student engagement and interest while supporting the understanding and retention of key concepts. Two groups of final-semester students (total $n = 52$) completed structured sessions using a petroleum-refining board game to guide team-based navigation of refinery scenarios. Outcomes were gathered through exit surveys and analyzed using a Likert scale.

Methodology

This classroom intervention was conducted in Semester 20252, teaching two groups of Semester 8, final-year Oil and Gas Engineering undergraduate students. CEEH2438A ($n = 27$) and CEEH2438B ($n = 25$) met for a 90-minute session in a classroom configured for 5 to 6 teams (4 to 5 students each). Students had completed relevant topics in the previous term. The gamified tool was a refinery-themed board game designed in Canva (Figure 1), featuring a linear track with START/END tiles, colour-coded challenge squares, and team avatars. The question bank was aligned to the course outcomes and covered core topics: crude characterization, distillation, hydrocracking, hydrogen management, product quality, and energy–emissions trade-offs.

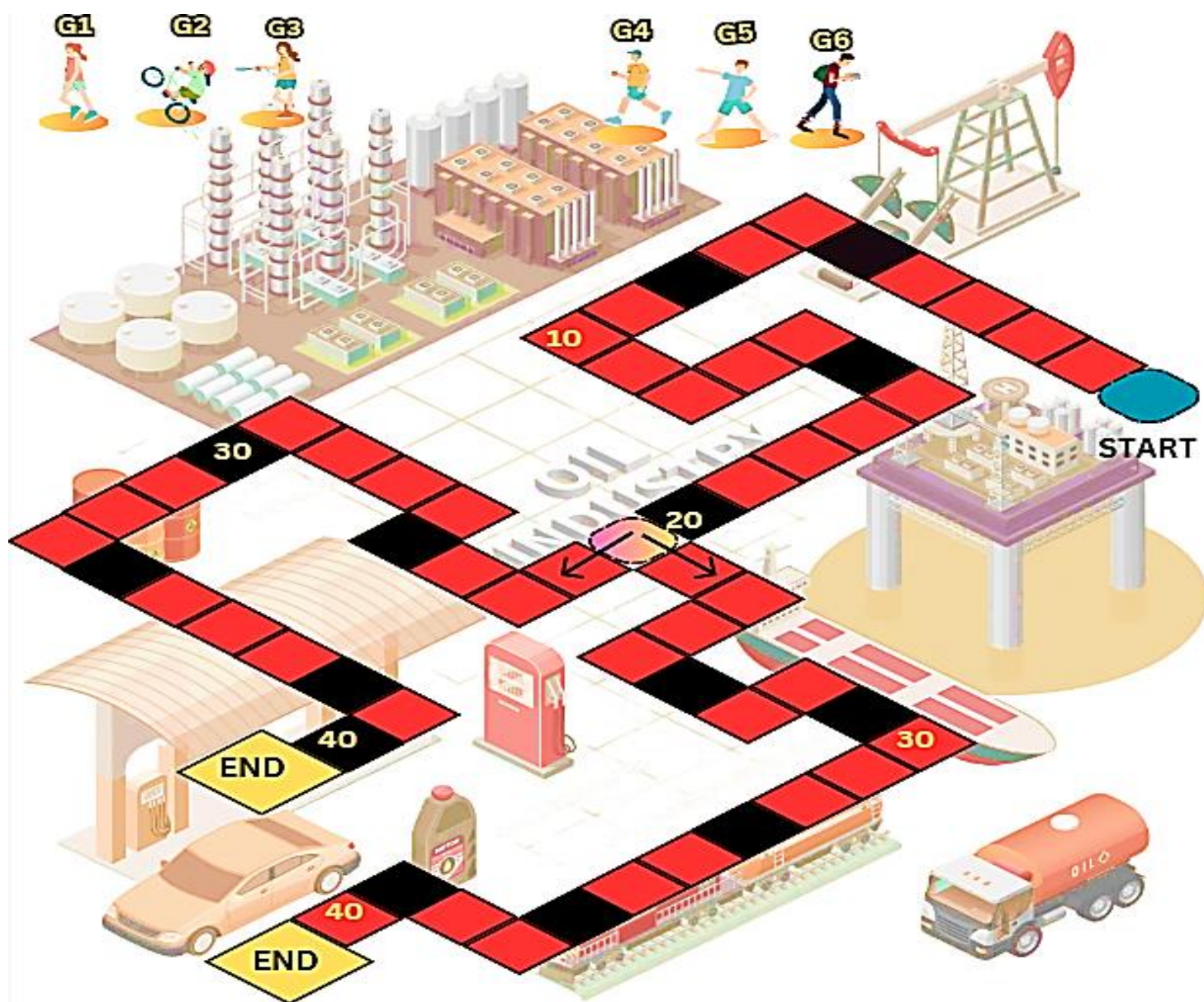


Figure 1 Refinery-themed board game designed in Canva

In each session, students formed five to six teams and chose a figurine as their marker. Teams moved by rolling a dice: landing on a red square prompted a multiple-choice question (answer correctly to roll again), while a black square prompted a short essay question (correct answers also earned an extra roll). Wrong answers meant the team stayed put until its next turn. To keep everyone involved, each turn also used the dice to randomize which team asked the following question. Instructors paced the game, checked answers, and tracked progress; the first team to reach the END won. Every session closed with a brief debrief that tied the questions and in-game choices back to petroleum refining engineering concepts and topics.

The exit survey comprised eight sections aligned to standard teaching-evaluation dimensions: Learning Value (Q1–Q3), Enthusiasm (Q4), Organization (Q5–Q6), Group Interaction (Q7), Individual Rapport (Q8–Q9), Breadth of Coverage (Q10–Q11), Supplementary Materials (Q12), and Workload/Difficulty (Q13–Q14). The exit survey used the Likert scale (1 to 5) to measure student perceptions of learning value, method effectiveness, engagement, organization, instructor support, teamwork, coverage, and workload/difficulty.

RESULTS AND DISCUSSION

Learning Value and Enthusiasm

Figure 2 shows uniformly positive ratings for the board-game session across learning value and enthusiasm. Q1 (understanding the subject) recorded 78.8% “5” and 15.4% “4” (top-2 = 94.2%), followed by Q2 (effectiveness as a learning method) with 82.7% “5” and 11.5% “4” (top-2 = 94.2%), Q3 (learn more than traditional classes) with 71.2% “5” and 23.1% “4” (top-2 = 94.3%, 5.8% neutral, no negative ratings), and Q4 (participation satisfaction) with 86.5% “5” and 13.5% “4” (top-2 = 100%). Interpreted on the Likert scale, these distributions indicate the board game most strongly elevated enthusiasm (Q4) and perceived instructional value (Q2), while also supporting conceptual understanding (Q1); the slightly lower share of “5” on Q3 suggests students view gamification as a complement rather than a substitute for lectures, yet the high top 2 proportions still evidence added learning value. Overall, the survey results support a blended model, concise, well-scaffolded explanations to anchor core mechanisms, followed by targeted gameplay to apply them under realistic constraints.

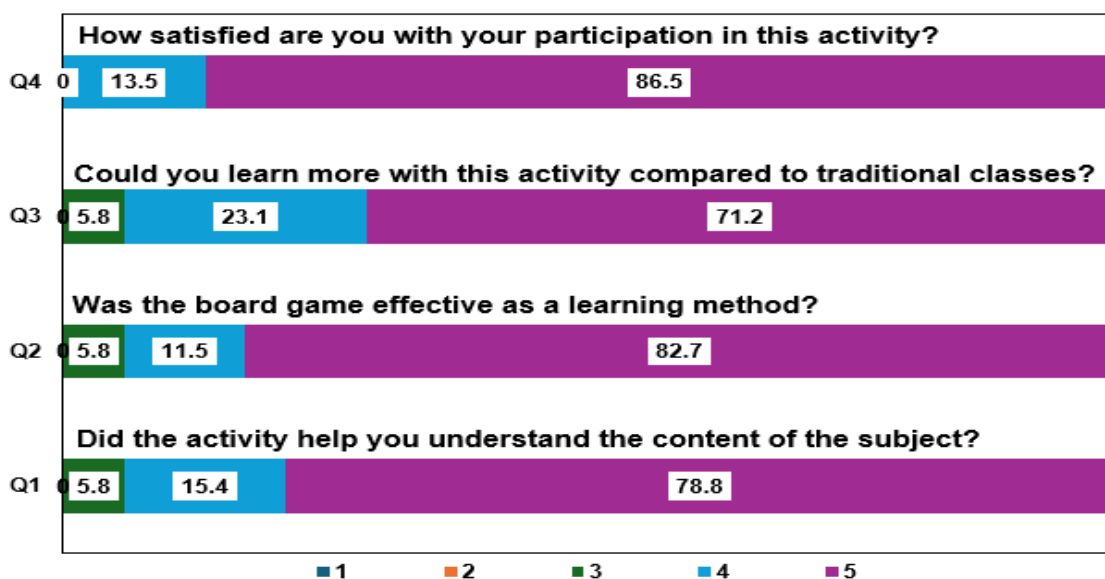


Figure 2 Responses on aspects of learning value and enthusiasm (values in percentage)

Organization and Group Interaction

Figure 3 shows that students felt the board game was straightforward, easy to run, and good for learning together: Q7 (teamwork) had 98.1% in the top two Likert options (4–5), Q6 (materials easy to find) had 98.0%, and Q5 (activity clear from the start) had 92.3%. This result suggests that the game’s cooperative setup, shared goals, turn-taking, and visible progress lowered friction and gave students a structured space to explain ideas to

one another. The small remainder (about 7.7% on Q5 and 1.9% on Q6–Q7) points to minor start-up confusion; a one-page quick-start, a 60-second demo round, and role cards would likely smooth the opening. Overall, a well-scaffolded board-game session not only boosts motivation but also supports clear organization and strong group interaction. It is ideal for a blended approach where a short pre-brief leads into targeted gameplay.

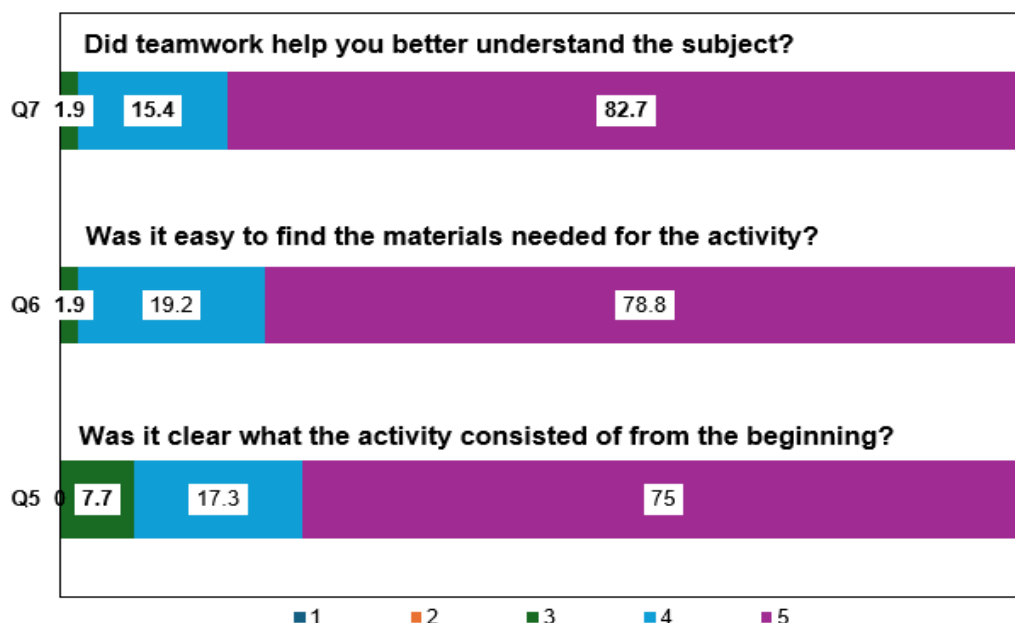


Figure 3 Responses on aspects of organization and group interaction (values in percentage)

Individual Rapport and Breadth of Coverage

Students strongly endorsed the board-game session for both motivation and lecturer support on the 5-point Likert scale (Figure 4): interest (Q8) drew 82.7% “5” and 15.4% “4” (top-2 = 98.1%); instructor helpfulness (Q9) had 84.6% “5” and 13.5% “4” (top-2 = 98.1%); valuing student initiative (Q10) reached 88.5% “5” and 7.7% “4” (top-2 = 96.2%); and additional knowledge (Q11) peaked at 90.4% “5” (top-2 $\geq$ 90%). This pattern aligns with the purpose of board-game gamification. To set clear goals, provide immediate feedback, and facilitate role-based collaboration, while transitioning the instructor into a facilitator who prompts questions and supports agency. A small tail of low ratings ($\approx$ 2–6%) suggests that some students would benefit from additional support, such as quick check-ins, optional hint cards, or targeted facilitator passes. Overall, the board-game format not only heightens interest but also strengthens instructor–student rapport and supports knowledge gain, confirming its value as a motivational, application-focused complement to direct instruction.

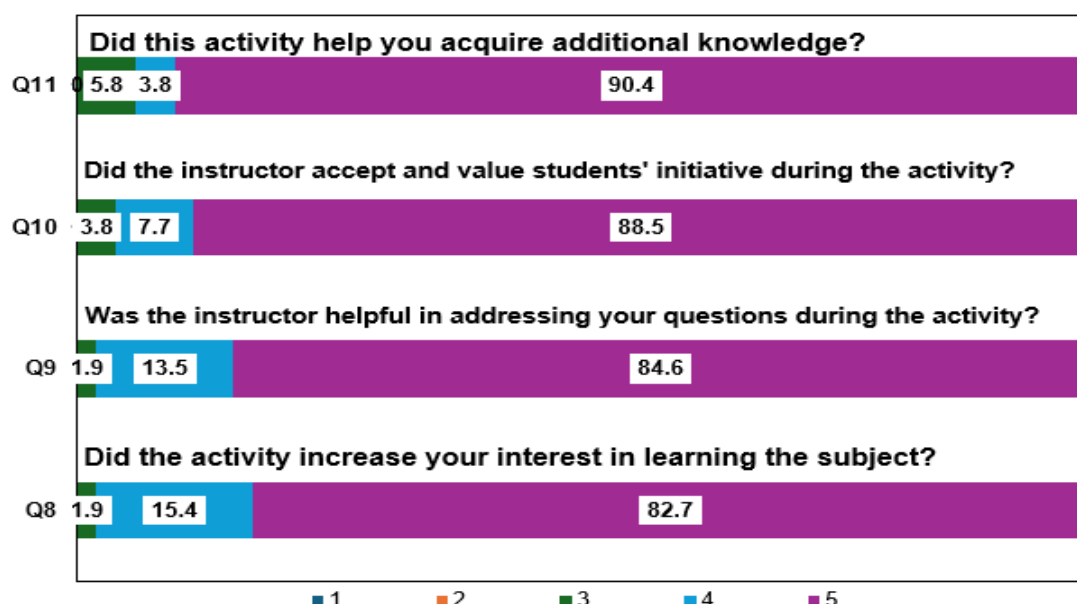


Figure 4 Responses on aspects of individual rapport and breadth of coverage (values in percentage)

Supplementary Materials and Workload/Difficulty

Students felt well supported and not overburdened. On the 5-point Likert scale (Figure 5), class notes/explanations were rated as very helpful (Q12: 84.6% “5”, 13.5% “4”; top-2 = 98.1%), and the workload was seen as reasonable (Q14: 63.5% “5”, 25.0% “4”; top-2 = 88.5%). Difficulty showed more spread (Q13: 44.2% “5”, 23.1% “4”, 21.2% “3”, 7.7% “2”, 3.8% “1”), suggesting the board-game tasks were challenging but still doable. What you want from gamification is a mix of quick multiple-choice checks and short, explanation-based prompts. To keep everyone in that “productive challenge” zone, minor tweaks like a brief pre-brief, phased rounds, or optional hint/advanced cards could smooth the experience for the few who found it more challenging, while preserving the engagement benefits of the board game.

Self-reported surveys in this study capture perceptions, not demonstrated learning, and can be inflated by enjoyment, social desirability, or gratitude. Because the study was conducted in one course at a single institution, cohort culture and instructor effects limit generalizability. Ceiling effects on the Likert scale reduce sensitivity to differences, and a novelty boost from the new board game may temporarily raise enthusiasm. Future work should add objective measures (pre/post concept tests, graded tasks, delayed retention), use more discriminating scales, include comparison conditions, and replicate across sites and instructors.

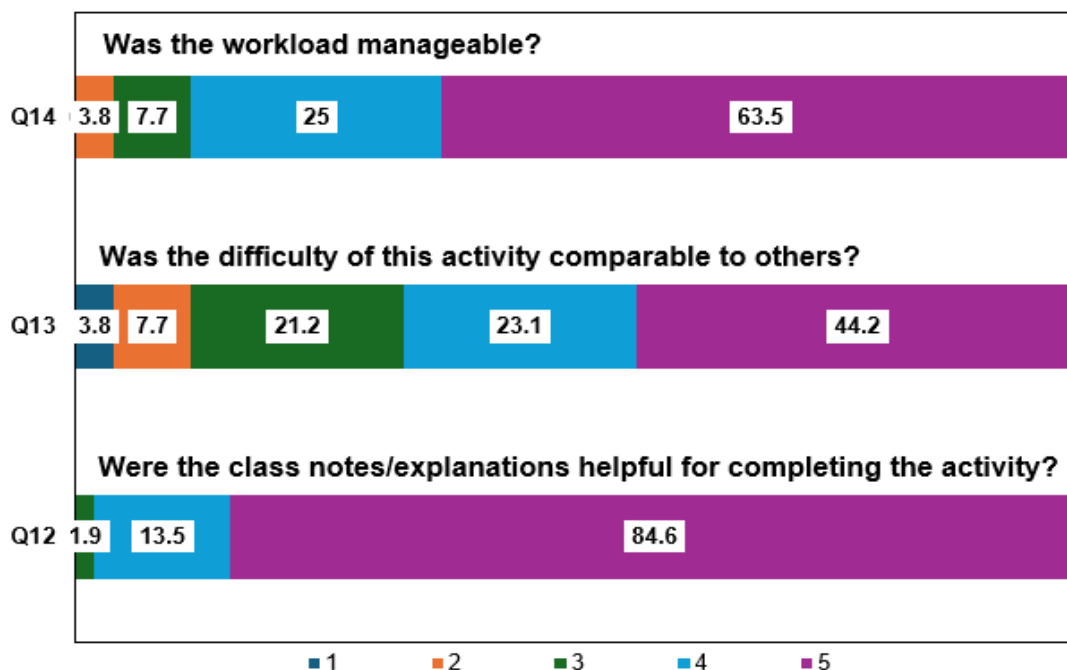


Figure 5 Responses on aspects of supplementary materials and workload/difficulty (values in percentage)

CONCLUSION

This study shows that a domain-specific board game can usefully boost engagement in a final-semester Petroleum Refining Engineering course. Students reported very high ratings for enthusiasm, perceived effectiveness, understanding, teamwork, and instructor support, while also judging the workload manageable and the difficulty at a productive level. In practice, the game works best as a complement to short, well-scaffolded lectures, turning core ideas into flowsheet-level decisions through cooperative play and fast feedback. Minor start-up hiccups noted by a few students can be eased with a one-page quick-start, a brief demo round, and clear role cards. Since our results come mainly from self-reported surveys in one course and show some ceiling effects, future runs should add objective checks such as concept quizzes, performance rubrics, and delayed tests, to confirm lasting learning gains and refine the game mechanics for the most complex topics.

ACKNOWLEDGEMENTS

The author thanks the Semester 20252 students of Petroleum Refining Engineering (CEEH2438A and CEEH2438B) at UiTM for their enthusiastic participation and thoughtful feedback. Appreciation is also extended to the Faculty of Chemical Engineering for support in providing classroom resources.

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