



Research in Engineering Education Symposium (REES)
Regional Conference in Engineering Education (RCEE) &
Research in Higher Education (RHEd)
September 29 – October 3, 2025
Johor, Malaysia



Integrating AI Tools into Project-Based Learning in an Engineering Statistics Course

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ABSTRACT

BACKGROUND & CONTEXT

Mathematics and statistics are essential in engineering education for analysis, modeling, and optimization. However, students often perceive these subjects as abstract and disconnected from real-world applications, which can reduce engagement. To address this, Project-Based Learning (PBL) and the integration of Artificial Intelligence (AI) tools have emerged as effective strategies to bridge theory with industry-relevant practices.

PURPOSE OR GOAL

This study investigates the effectiveness of integrating Artificial Intelligence (AI) tools within a Project-Based Learning (PBL) framework in an Engineering Statistics course. The study aimed to explore students' perceptions of how this approach influenced their understanding of statistical concepts, analytical skills, and motivation to learn. It was driven by the need to make mathematical learning more engaging and relevant to real-world engineering practices.

METHODOLOGY

A quantitative survey was conducted with 38 second-year mechanical engineering students. The instrument included Likert-scale items covering engagement with PBL, the perceived value of AI tools, and development of technical and soft skills. Descriptive analysis was used to identify trends in student feedback and assess the impact of the integrated teaching approach.

OUTCOMES

Results showed strong student agreement that AI-enhanced PBL improved engagement, analytical skills, and understanding of course material. Students also gained confidence using AI tools and expressed interest in further exploration.

CONCLUSIONS

Findings support the continued use of AI-based PBL to enhance technical learning, skill development, and industry readiness in engineering education.

KEYWORDS

Project-Based Learning, Artificial Intelligence, Engineering Statistics.

Introduction

Mathematics and statistics are foundational pillars of engineering education, serving as essential tools for system modeling, data interpretation, and optimization of engineering solutions. Recognized as the language of engineering, mathematics underpins critical functions such as designing, analyzing, and improving systems to meet stringent safety, efficiency, and performance standards (Zvirgzdina & Kopeika, 2024). Despite their importance, many engineering students struggle with these subjects, often perceiving them as abstract and disconnected from real-world applications. This disconnect can hinder students' motivation and limit their ability to transfer mathematical concepts to practical engineering problems.

To address this gap, the integration of real-world Artificial Intelligence (AI) applications into Project-Based Learning (PBL) has emerged as an innovative and effective pedagogical strategy. Project-Based Learning (PBL) is a student-centered pedagogy that actively engages students in real-world problems over extended periods, building deeper knowledge and skills through inquiry and project creation rather than traditional lecture-based instruction. PBL transforms students from passive recipients to active problem-solvers, promoting critical thinking, creativity, collaboration, communication, and lifelong learning skills across contexts (Thomas, 2000; Zhang, 2023). In engineering disciplines, PBL has been shown to enhance student motivation, critical thinking, and collaborative problem-solving skills, all of which are crucial for professional success (De la Cruz Martínez & Zamorano, 2019). By engaging students in complex, authentic engineering challenges, such as optimizing power generation under low wind conditions or diagnosing turbine faults using machine learning, this approach reinforces the relevance of theoretical knowledge and fosters deeper, more durable learning (Khan et al., 2020). The iterative and collaborative nature of PBL also nurtures adaptability, creativity, and lifelong learning—qualities critical in navigating the evolving technological landscape (Balfagih & Balfagih, 2024).

Artificial Intelligence (AI), particularly its subset machine learning (ML), has emerged as a transformative force in the engineering industry by enabling advancements across several critical domains. ML algorithms allow engineering systems to learn from complex datasets and improve automatically over time without explicit human programming, which optimizes design, manufacturing, predictive maintenance, quality control, and data analytics. Furthermore, AI tools handle the enormous data influx from sensors and simulations, transforming raw data into actionable insights, improving decision-making processes, and driving innovation (Sucharitha et al., 2025).

The deliberate use of AI tools within PBL not only contextualizes statistical learning but also strengthens the connection between coursework and current industry practices. Furthermore, the use of Open Educational Resources (OERs) alongside PBL provides students with flexible and accessible learning materials that support varied learning needs and promote self-directed learning (Schleiss et al., 2022). Case studies have demonstrated that students favor project-based assignments over traditional instruction methods, as they contribute to improved engagement, deeper conceptual understanding, and better knowledge retention (De la Cruz Martínez & Zamorano, 2019). In this environment, learners construct knowledge through exploration and reflection while developing essential skills in AI, data analysis, and programming, skills that are increasingly in demand in today's engineering job market (Vieriu & Petrea, 2025).

This study was conducted in a compulsory second-year Engineering Statistics course, a three-credit undergraduate course covering hypothesis testing, regression analysis, statistical quality control, and machine learning. It examines student perceptions regarding the integration of Project-Based Learning (PBL) and Artificial Intelligence (AI) tools into the curriculum. The PBL approach was operationalized through structured group projects centered on authentic engineering problems, requiring the application of statistical methods, including regression, k-means clustering, and k-NN classification, within AI-driven contexts to enhance practical relevance. The instructional model adhered to a structured PBL cycle encompassing problem

identification, project planning, data analysis, and result presentation, with an emphasis on collaborative problem-solving and critical thinking.

A total of 38 students from the Department of Mechanical and Manufacturing Engineering participated in the study. The research aims to evaluate the efficacy of this integrated PBL-AI approach in fostering student engagement, developing analytical and professional skills, and improving learning outcomes. Specifically, the study investigates students' perceptions of AI's relevance, the role of PBL in enhancing analytical capabilities, and the benefits of the methodology for both individual and collaborative learning.

Methodology

The participants consisted of 38 second-year mechanical engineering students enrolled in the Mechanical and Manufacturing Engineering program, all of whom were taking the compulsory Engineering Statistics course. At the end of the semester, a quantitative survey was administered to evaluate student experiences across three core domains: (1) PBL experience and satisfaction, (2) perception toward the integration of AI in engineering statistics, and (3) group collaboration and individual development.

The survey instrument was adapted from established studies on problem-based and project-based learning in engineering mathematics (Ismail et al., 2014; Othman et al., 2016). Items from these references were modified and contextualized to align with the specific learning objectives of this course, particularly to incorporate the new dimension of Artificial Intelligence tools. A total of 20 items were included across the three domains. Responses for all items were recorded using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Descriptive statistical analysis was performed to identify central tendencies and overall trends in student perceptions across the three domains.

Results and Discussion

The study's objective was to evaluate the effectiveness of integrating AI tools within a PBL framework for teaching Engineering Statistics. The PBL tasks were explicitly designed to integrate core Engineering Statistics concepts with real-world AI applications. Students were given the flexibility to select a problem relevant to mechanical engineering that could be addressed using statistical and AI techniques. Two sample problems provided were: *Predictive Modeling of Material Properties* and *Machine Predictive Maintenance Classification*. These projects required students to apply statistical concepts such as hypothesis testing and regression, k-means clustering, and k-NN classification implemented in R/Python. For example, regression models were used to predict missing material properties, correlation analysis identified significant relationships between variables, and clustering methods helped categorize performance levels. In the predictive maintenance project, classification algorithms supported the development of early-warning systems for machine failure. By engaging in these authentic tasks, students gained both technical proficiency in applying statistical tools and practical insights into the role of AI in solving engineering challenges.

Student Demographics and Background

Figure 1 shows the entry qualification for the 38 students who participated in this study. The majority of students (63%) were admitted to UKM through the Matriculation route, which remains a dominant pathway for undergraduate engineering programmes in Malaysia. This is followed by students from the Asasi (Foundation) programme, making up 21% of the cohort. STPM (Malaysian Higher School Certificate) holders constitute 13%, while international students represent a small minority at 3%. The gender distribution for the 38 students, with male students comprising 79% and female students only 21% is shown in Figure 2.

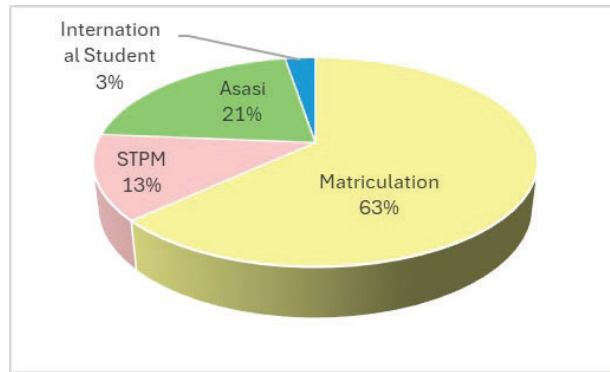


Figure 1: Entry Qualification to UKM

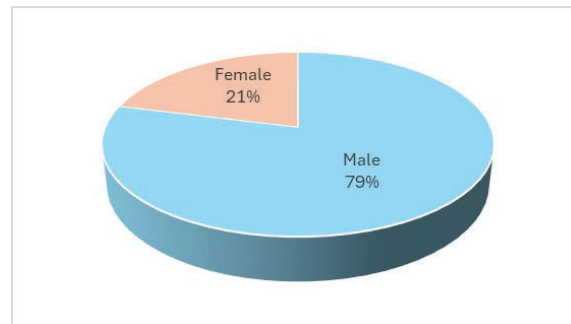


Figure 2: Gender Distribution

Perception of PBL in Engineering Statistics

The students' perception on PBL experience in the Engineering statistics course can be seen in Figure 3. The survey responses reveal a highly positive reception toward the implementation of Project-Based Learning (PBL) among the 38 mechanical engineering students. A significant majority of students found the PBL problem interesting, with 21 students (55%) strongly agreeing and 10 students (26%) agreeing. Only a small number (2 students) disagreed, while 5 were neutral (Figure 3(a)). This suggests that the PBL task successfully engaged students, likely due to its real-world context and relevance to engineering applications. Engaging problems are critical in fostering intrinsic motivation and active participation in learning, especially in technically demanding courses such as statistics.

In terms of enjoyment (Figure 3(b)), 30 students (79%) responded positively, where 12 students agreed and 18 strongly agreed. Only 1 student disagreed, and 7 remained neutral. This high level of enjoyment reflects the effectiveness of PBL in making the learning process more interactive and student-centered, which contrasts with traditional lecture-based delivery. Enjoyment in learning activities is often linked to higher engagement, improved retention, and more meaningful learning experiences.

One of the primary goals of integrating PBL with AI in statistics education is to strengthen students' analytical and problem-solving abilities. The data supports this goal and is shown in Figure 3(c). 31 students (82%) agreed or strongly agreed that the PBL helped sharpen their analytical skills, with 12 agreeing and 19 strongly agreeing. This demonstrates that students not only enjoyed the PBL but also perceived it as a tool for intellectual growth, particularly in applying statistical thinking to engineering contexts.

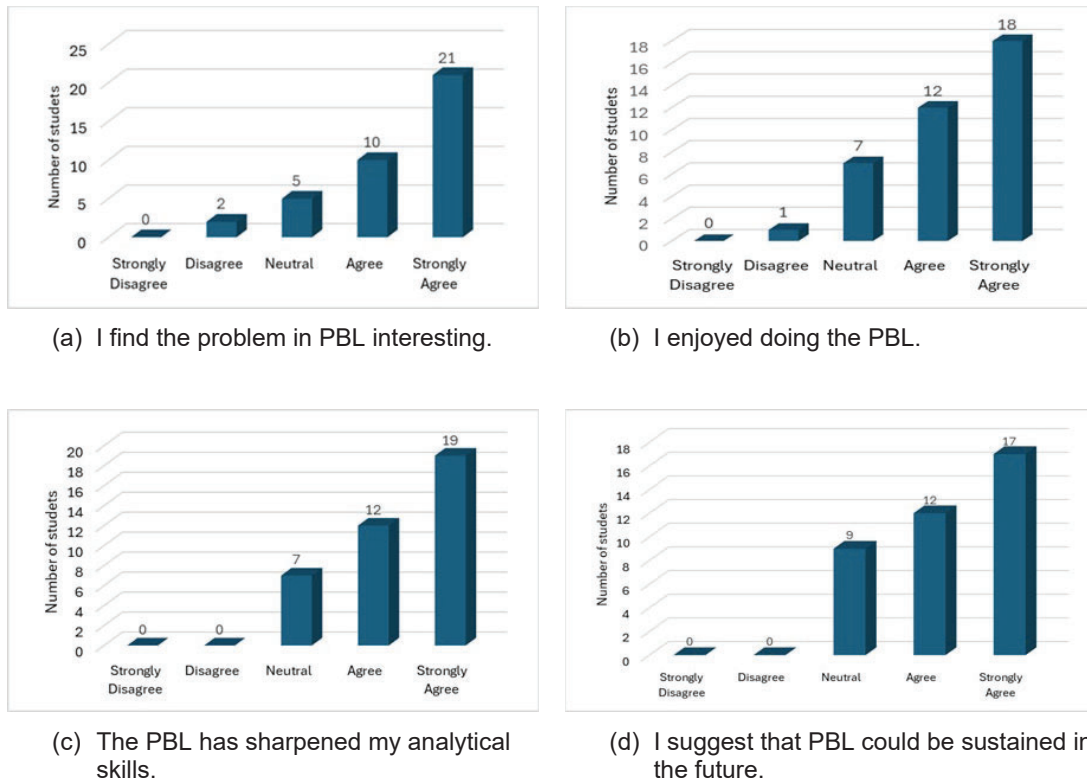


Figure 3: Students' Perceptions of the Project-Based Learning (PBL) experience in the Engineering Statistics Course

When asked whether PBL should be sustained in future courses, 29 students (76%) agreed, 17 strongly agreed and 12 agreed (Figure 3(d)). This strong endorsement signals that students value the approach and see its long-term benefit in their academic development. Sustaining and refining PBL in future semesters could further enhance learning outcomes and better prepare students for real-world engineering challenges.

Overall, the data reveals that students not only enjoyed the PBL activity but also found it intellectually valuable and relevant to their learning journey. The high levels of interest, enjoyment, skill development, and support for continuation suggest that PBL especially when integrated with AI and real-world problem-solving, can significantly enhance students' learning experiences in Engineering Statistics.

Integration of AI Tools in the Course

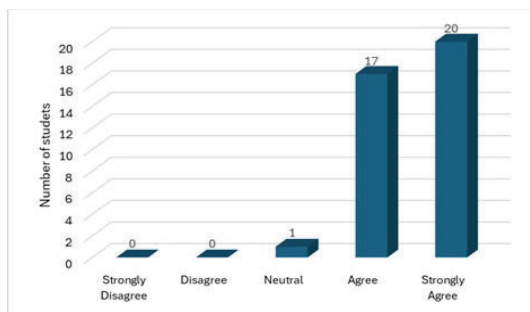
The results in Figure 4 illustrate that students hold overwhelmingly positive views about the relevance, usefulness, and motivational impact of AI tools integrated into their project-based learning (PBL) experience. An overwhelming 97% of students (37 out of 38) either agreed (17) or strongly agreed (20) that AI is relevant to engineering problem-solving Figure 4(a). This strong consensus reflects students' recognition that machine learning and AI are not just theoretical concepts but essential tools in modern engineering practice. The finding supports the integration of AI in core courses to increase contextual understanding of its role in solving real-world engineering challenges.

Meanwhile, from Figure 4(b), a total of 95% of students (36 out of 38) responded positively, 15 agreed, and 21 strongly agreed, demonstrating a high level of interest and curiosity toward AI. This level of enthusiasm highlights the potential of AI-related content to stimulate deeper learning, especially when delivered through interactive and problem-based frameworks.

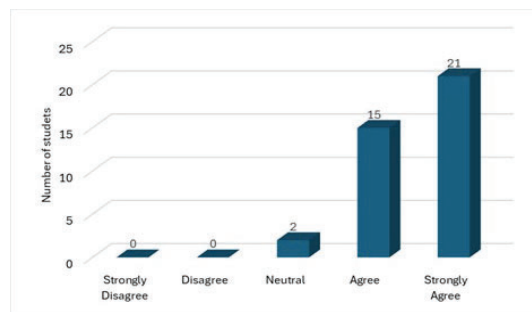
The use of AI tools in the course has positive feedback (Figure 4(c)), where the majority of students, 37 out of 38 (97%), agreed or strongly agreed that the incorporation of AI tools enhanced their learning. Specifically, 14 agreed and 23 strongly agreed. This reflects how applied AI tools helped students grasp statistical and computational concepts more effectively. It also supports the notion that AI integration bridges the gap between theory and application, making learning experiences more meaningful and practical.

From Figure 4(d), 34 students (89%) supported continued AI integration in future PBL projects where 18 agreed and 16 strongly agreed. Only a small number (4 students) were neutral. This strong endorsement indicates that students value the role of AI not only as a learning aid but as an essential component of engineering problem-solving. It also suggests that the use of AI contributes to more engaging and forward-thinking curriculum design.

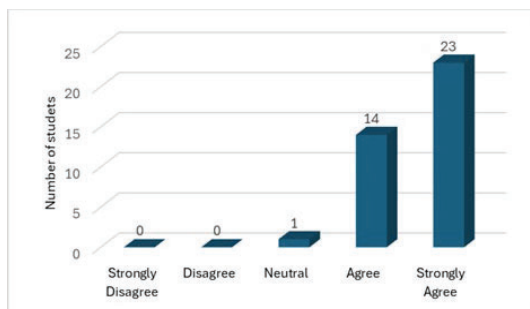
Student motivation is a key outcome of effective instructional design. Based on Figure 4(e), 33 students (87%) either agreed or strongly agreed that learning about AI applications has encouraged them to pursue further exploration where 16 agreed and 17 strongly agreed. This level of motivation indicates that the course has successfully sparked students' interest in AI, which is essential for cultivating lifelong learning and future readiness in the evolving engineering landscape.



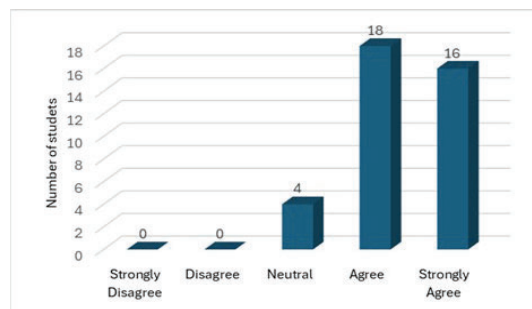
(a) AI applications such as machine learning are relevant to engineering problems.



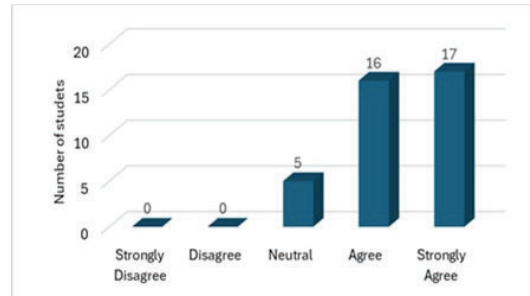
(b) I find AI interesting and would like to learn more about it.



(c) The use of AI tools (e.g., k-means, k-NN, regression) in this course enhances my learning experience.



(d) The integration of AI in PBL activities should be continued and expanded in future projects.



(e) I feel motivated to explore AI further after learning about its applications in this course.

Figure 4 Students' Perceptions of the AI tools integrated in the Project-Based Learning (PBL) in the Engineering Statistics Course

These findings clearly demonstrate the positive impact of integrating AI into engineering education through project-based learning. Students not only perceive AI as relevant and useful but also show strong interest and motivation to engage with it beyond the classroom. The high levels of agreement across all five items support the continued use and expansion of AI-enhanced PBL strategies. These results underscore the importance of equipping engineering students with both conceptual knowledge and practical experience in AI, to better prepare them for a data-driven, technology-intensive workforce.

Benefits of PBL to Individual and Group Learning

The survey results show consistently strong agreement among students that PBL not only enhanced their academic understanding but also played a crucial role in developing essential soft skills, such as problem-solving, self-confidence, and teamwork, skills vital for future engineers (Figure 5).

A vast majority of students reported that PBL helped them improve their problem-solving abilities as shown in Figure 5(a). Specifically, 20 students strongly agreed and 13 agreed, representing 87% of the respondents. Only 5 students were neutral, and none disagreed. This suggests that the PBL environment, which emphasized tackling real-world AI-related challenges, was successful in encouraging students to think critically and analytically.

Similarly, 87% of students (13 agreed, 20 strongly agreed) indicated that the PBL helped enhance their understanding of the course content (Figure 5(b)). This positive response underscores the effectiveness of applying statistical and mathematical concepts to authentic, project-based scenarios. The interactive nature of PBL enabled students to connect theoretical learning with practical application, resulting in more meaningful and retained knowledge.

Regarding self-confidence (Figure 5(c)), 33 students (15 agreed, 18 strongly agreed) stated that the PBL helped them feel more confident in their abilities. The hands-on and collaborative structure of the PBL experience likely contributed to this, as students had opportunities to take initiative, present solutions, and reflect on their contributions.

The PBL approach also fostered peer learning (Figure 5(d)), with 34 students (16 agreed, 18 strongly agreed) acknowledging that working in groups allowed them to learn from their peers. This demonstrates the value of collaborative environments in engineering education, where students benefit not only from instructor input but also from sharing diverse perspectives and strategies within their teams.

Finally, the majority of students recognized the PBL's role in developing their teamwork capabilities (Figure 5(e)). 34 students (16 agreed, 18 strongly agreed) felt that the PBL helped improve their ability to function as effective team members. Teamwork is a critical competency

in engineering, and PBL provides an ideal platform to simulate real-world engineering team dynamics, including task coordination, role sharing, and conflict resolution.

Overall, the results demonstrate that PBL had a significant positive impact on both individual development and group collaboration among students. These findings support the implementation of PBL not only as a tool for delivering technical content but also as a strategic method for cultivating soft skills that are highly valued in the engineering profession. Integrating PBL with relevant, AI-driven tasks enhances not just conceptual mastery but also student confidence, peer learning, and readiness for real-world team-based problem solving. This reinforces the importance of continuing and expanding PBL initiatives within engineering curricula.

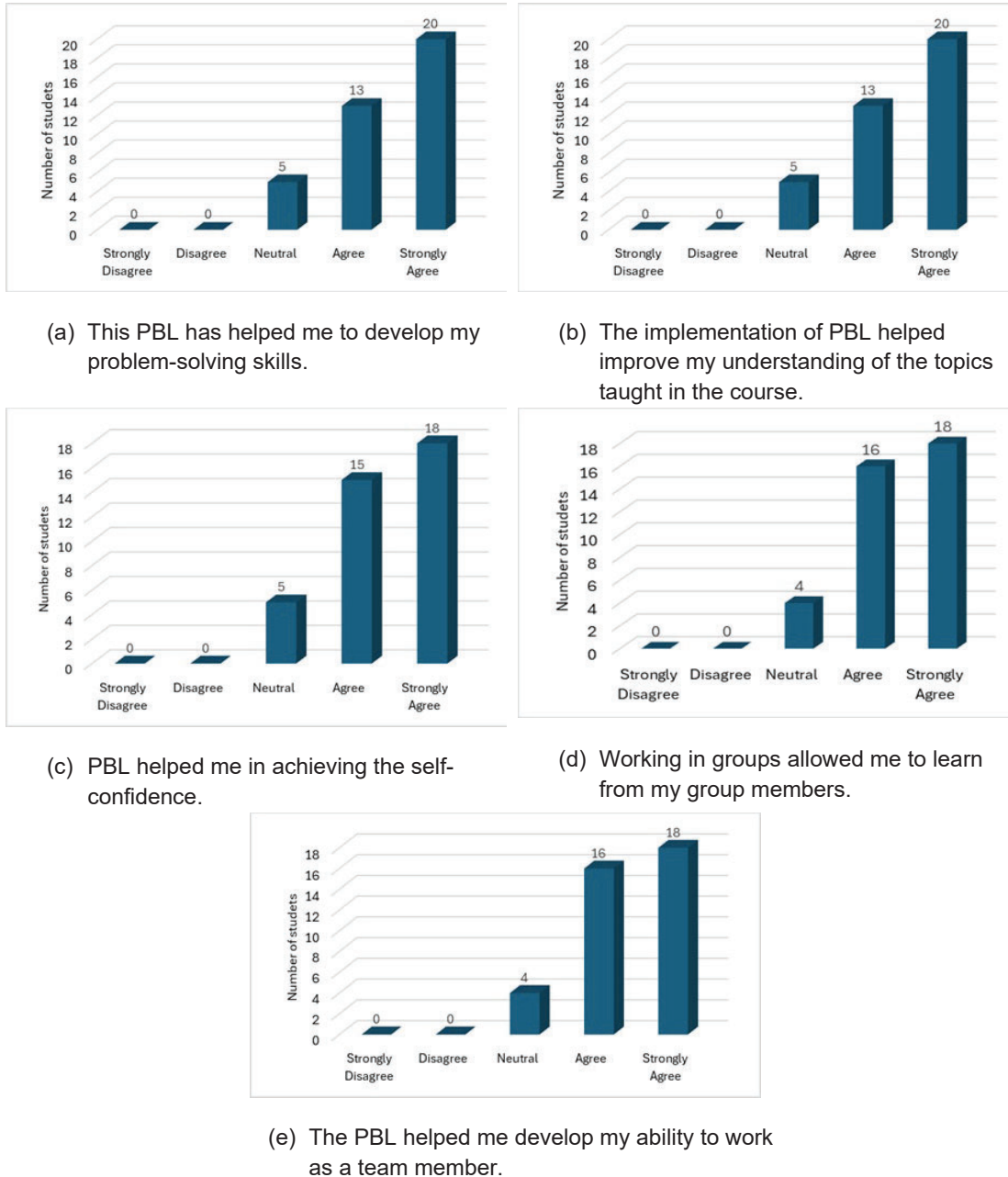


Figure 5: Students' Perceptions on the Benefit of PBL to Individual and Group Learning

Conclusion

This study demonstrates the positive impact of integrating Project-Based Learning (PBL) and Artificial Intelligence (AI) tools in an Engineering Statistics course for mechanical engineering students. By engaging students in real-world, AI-driven problem-solving tasks, the PBL approach significantly enhanced their understanding of statistical concepts, improved analytical thinking, and developed essential soft skills such as teamwork, communication, and self-confidence. Most students expressed strong interest in AI, acknowledged its relevance to engineering practice, and showed motivation to explore its applications further. The use of AI tools such as k-means, k-NN, and regression within a collaborative project framework effectively bridged the gap between theoretical statistical concepts and their practical application in modern industry.

However, several methodological limitations must be acknowledged. The findings are based on a relatively small sample size of 38 students, which affects the generalizability of the results. Furthermore, the study design lacked a control group for comparison, making it difficult to definitively isolate the impact of the PBL-AI intervention from other variables or to assert its comparative efficacy against traditional teaching methods.

These limitations, however, provide a clear pathway for future research. Subsequent studies should address these limitations by including larger cohorts, incorporating control or comparison groups, and implementing pre/post testing or other objective assessments of student learning. Such refinements would provide stronger evidence of the effectiveness of AI-enhanced PBL and enable a clearer understanding of its impact on both technical competencies and transferable skills.

Despite these limitations, the strongly positive student perceptions reported here are highly encouraging. This study supports the sustained and expanded use of AI-enhanced PBL in engineering education as a promising means to cultivate both technical proficiency and transferable skills critical for future engineering professionals. Future implementations should consider providing structured support for students with limited programming experience and continued training for educators to ensure effective delivery and long-term impact.

References

- Balfagih, M., & Balfagih, Z. (2024). AI-enhanced engineering education: Customization, adaptive learning, and real-time data analysis. In *AI-enhanced teaching methods* (pp. 108–131).
- De la Cruz Martínez, G., & Zamorano, C. R. M. A. (2019). Teaching artificial intelligence using project-based learning. *ICERI2019 Proceedings*, 653–658.
- Haliza Othman, Nur Arzilah Ismail, Khamisah Jafar, Fadiyah Hirza Mohammad Ariff, Nuryazmin Ahmat Zainuri, Noorhelyn Razali, Firdaus Mohd Hamzah, Izamarlina Asshaari, Zulkifli Mohd Nopiah. (2016). Keberkesanan Pembelajaran Aktif Pelajar Dalam Aktiviti Pembelajaran Berasaskan Masalah Bagi Kursus-Kursus Matematik Kejuruteraan: Pendekatan Model Pengukuran Rasch. *Prosiding K-Novasi Pengajaran dan Pembelajaran UKM 2016 (Pendidikan Kejuruteraan dan Alam Bina)*, 110-117.
- Ismail, N.A., Jafar, K., Othman, H., Azam, N.A.M. (2014). Persepsi pelajar mengenai manfaat kaedah pembelajaran berasaskan masalah secara individu. *Seminar Pendidikan Kejuruteraan dan Alam Bina (PeKA 2013)*, 302-309.
- Khan, M., Ibrahim, M., Wu, N., & Patil, R. (2020). Interdisciplinary project based learning approach for machine learning and internet of things. *2020 IEEE Integrated STEM Education Conference (ISEC)*, 1–6.
- Schleiss, J., Hense, J., Kist, A., Schlingensiepen, J., & Stober, S. (2022). Teaching AI competencies in Engineering using projects and open educational resources. *Towards a New Future in Engineering Education, New Scenarios That European Alliances of Tech Universities Open Up*, 1592–1600.
- Sucharitha, G., Matta, A., Srinivas, M., & Mohanty, S. N. (Eds.). (2025). *Artificial Intelligence Technologies for Engineering Applications*. CRC Press.
- Thomas, J. W. (2000). A review of research on project-based learning.
- Vieriu, A. M., & Petrea, G. (2025). The impact of artificial intelligence (AI) on students' academic development. *Education Sciences*, 15(3), 343.

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in psychology*, 14, 1202728.
Zvirgzdina, L., & Kopeika, E. (2024). The Need and Role of High-Level Math Skills in Engineering Studies. *Research for Rural Development*, 39.

Acknowledgements

The author would like to acknowledge the support of Department of Engineering Education and Centre for Engineering Education Research (P3K), UKM for the financial support in this work.

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