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Students' Perceptions of the Usability, Safety, and Design of an Embedded Motor Trainer for an Embedded Robotics Course

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Abstract. Practical learning plays an essential role in the Embedded Robotics course, particularly in supporting students' understanding of DC, Stepper, and Servo Motors concepts. An Embedded Motor Trainer was developed as an interactive teaching aid to enable students to conduct experiments and comprehend motor operating principles in a practical manner. This study evaluates students' perceptions of the trainer in terms of usability and effectiveness, safety, and design suitability. A quantitative survey approach was employed, involving students enrolled in the Embedded Robotics course at the Department of Electrical Engineering, Politeknik Mersing Johor (PMJ). Data were collected through a structured questionnaire consisting of twelve items across the three evaluation aspects. Descriptive statistical analysis was used to analyse the responses. The results indicate that all three aspects recorded similarly high mean scores, indicating consistently positive student perceptions of the Embedded Motor Trainer. Students perceived the trainer as effective in supporting learning, safe for laboratory use, and well designed for instructional purposes. The minimal variation among the evaluation aspects suggests that the trainer provides a balanced learning platform rather than excelling in a single dimension. The findings highlight the potential of the Embedded Motor Trainer as a suitable teaching and learning aid for embedded robotics education. The study also provides useful insights for educators and institutions in improving the design and implementation of laboratory-based teaching tools to enhance student engagement and understanding.

Keywords: Embedded Motor Trainer, Motor DC, Motor Stepper, Motor Servo, Embedded Robotics, Practical Learning.

1. INTRODUCTION

Engineering education increasingly emphasises hands-on approaches as a complement to theoretical learning. This balance is crucial for producing graduates equipped with both conceptual understanding and practical competence. Within the Embedded Robotics course, mastery of DC Motors, Stepper Motors, and Servo Motors is particularly important, as these components form the foundation of modern robotic applications ranging from industrial automation to autonomous systems. However, students often face difficulties in understanding motor operation when relying solely on lectures and theory, as this limits their ability to connect concepts with real-world applications [1].

Several studies have reported the effectiveness of motor-based training systems and embedded learning platforms in improving students' understanding of electromechanical and control concepts. Existing trainers and modular laboratory kits have been shown to support hands-on experimentation, enhance conceptual understanding, and increase student engagement in robotics and embedded systems education [2–4]. However, many available training systems focus primarily on technical functionality, with limited emphasis on students' perceptions of usability, safety, and design suitability in laboratory learning environments. This gap highlights the need for further evaluation of teaching aids such as the Embedded Motor Trainer from the students' perspective.

To address these challenges, the Embedded Motor Trainer was developed as an interactive teaching and learning tool that allows students to conduct direct experiments, observe real-time motor responses to input signals, and relate theoretical principles to practical outcomes. Beyond improving conceptual understanding, the trainer incorporates features of safety and ergonomic design, offering a user-friendly and reliable system for laboratory use. It is therefore essential to evaluate both its educational effectiveness and its safety and design suitability from the students' perspective.

As shown in Table 1, the three motor types central to the course play distinct roles in robotics applications: the DC Motor provides simple continuous rotation, typically used to drive the wheels of mobile robots; the Stepper Motor enables precise step-by-step rotation, making it valuable for tasks such as robotic arm positioning; and the Servo Motor allows controlled angular displacement with built-in feedback, which is crucial for accurate joint control in humanoid robots. Understanding these motors and their applications is vital for bridging theoretical learning with practical robotics implementation.

Table 1. Core Motor Types and Their Functions in Robotics

Motor Type	Main Function in Robotics	Example Application
DC Motor	Provides simple continuous rotation	Wheels of a mobile robot
Stepper Motor	Offers precise step-by-step rotation	Position control of robotic arm
Servo Motor	Provides controlled angular displacement with feedback	Joint control in humanoid robots

The structure of the Embedded Motor Trainer is illustrated in Figure 1, which highlights its integration of DC, Stepper, and Servo motor modules into a single interactive platform. Each motor module is connected to input controls that allow students to test and observe motor behaviour under different conditions. In addition to functionality, the trainer incorporates user interaction features that make it accessible for practical use, as well as built-in safety elements to minimise risks during laboratory sessions. The trainer's ergonomic design further supports ease of use, enabling students to focus on learning motor concepts without being hindered by complex or unsafe hardware setups.

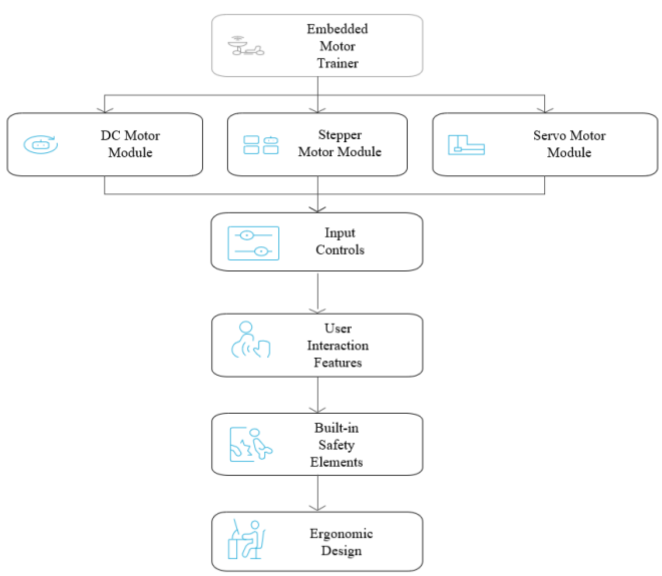

Figure 1. Conceptual Model of the Embedded Motor Trainer

The evaluation framework for this study is represented in Figure 2, which illustrates the three key dimensions used to assess the Embedded Motor Trainer: usability, safety, and design. These dimensions overlap at the centre, reflecting the central role of student perceptions in determining the overall effectiveness of the trainer. Usability captures students' views on ease of use, clarity of operation, and contribution to faster learning. Safety focuses on protection from electrical risks, understanding of safety protocols, and suitability for supervised or minimally supervised settings. Design refers to the ergonomic layout, organisation of components, and visual appeal that influence student engagement. By analysing these three interconnected aspects together, the study provides a holistic understanding of how the Embedded Motor Trainer supports learning in robotics education.

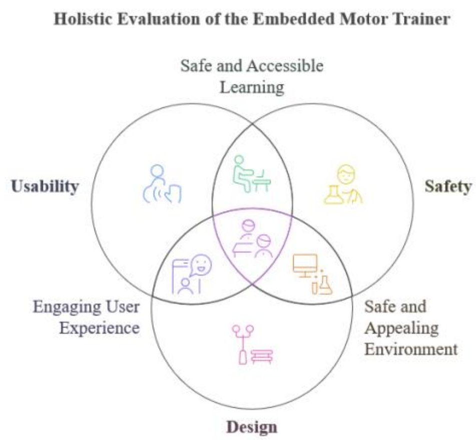

Figure 2. Dimensions of Evaluation in This Study

Accordingly, this study aims to examine the effectiveness of the Embedded Motor Trainer in supporting student learning, evaluate students' perceptions of its safety measures, and assess the suitability of its design for practical teaching and learning using a questionnaire-based survey evaluation. The research focuses on students enrolled in the Embedded Robotics course at the Department of Electrical Engineering, PMJ. The findings are expected to contribute meaningful insights for educators and institutions in improving the design of teaching aids, strengthening laboratory strategies, and enhancing innovation in engineering education.

2. Literature Review

The development of motor trainer-based learning media has been proven effective in improving students' understanding of electromechanical components. [2] highlighted that Arduino-controlled trainers provide richer practical experiences compared to theory-based learning alone. Similarly, [3] demonstrated that BLDC Media Trainers enhanced students' understanding of electric motor principles and strengthened their technical knowledge. In addition, [4] reported that DC Motor Control Training Systems improved interactivity within engineering education. These findings align with the objectives of this study, which seeks to evaluate the effectiveness of the Embedded Motor Trainer in supporting student learning in the Embedded Robotics course.

Advances in embedded system control technologies also contribute to effective learning. [5] showed that intelligent control techniques such as adaptive fuzzy controllers can be integrated into motor systems for advanced control training. Furthermore, [6] emphasised that embedded programming platforms not only simplify the understanding of technical concepts but also enhance students' microcontroller programming skills. This suggests that innovations such as the Embedded Motor Trainer provide value beyond basic motor learning, contributing to the foundation of automation and control mastery.

Robotics technology has also been shown to positively influence students' motivation and achievement. [7] reported that robotics-based learning improves student interest and performance in technical courses. Similarly, [8] noted that modular robotic kits in STEM education provide practical opportunities for students to develop problem-solving skills. A systematic review in [9] further confirmed that the use of innovative robotics tools strengthens understanding of science and engineering concepts across multiple levels of education. These findings support this study's objective of evaluating the extent to which the Embedded Motor Trainer accelerates students' comprehension of motor concepts.

Safety remains a critical factor in the use of electronic and robotic training tools. [9] stressed that human interaction with robotic systems requires strict safety standards to minimise risks of injury. In line with this, [10] highlighted the importance of compliance with safety protocols to ensure safe utilisation, especially in educational environments. This emphasis corresponds with the study's objective of assessing students' perceptions of the safety of the Embedded Motor Trainer.

Beyond effectiveness and safety, the design of a training tool also influences its teaching effectiveness. [11] reported that ergonomic design, neat component arrangement, and appealing appearance increase student engagement in laboratory activities. This indicates that a systematically designed Embedded Motor Trainer can support pedagogical objectives while creating a more effective and engaging learning experience.

3. Research Methodology

3.1 Research design

This study employed a quantitative survey design to evaluate the effectiveness, safety, and design suitability of the Embedded Motor Trainer in the Embedded Robotics course. The primary instrument used was a structured questionnaire based on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

A quantitative approach was selected as it enables objective data collection and statistical analysis of students' perceptions. The use of a structured questionnaire was appropriate since the respondents were a homogeneous group of students using the same training equipment, and the data collection period was limited to immediately after the laboratory session.

3.2 Population and Sample

The study population consisted of all students enrolled in the Embedded Robotics course at the Department of Electrical Engineering, PMJ, during Semester II of the 2024/2025 academic session. A total of 29 students participated, representing the entire course enrolment. Accordingly, the study adopted a census sampling method, where every member of the population was included.

3.3 Research Instrument

The questionnaire was divided into three main sections, each addressing one of the study's core evaluation aspects:

i) Section A: Usability and Comfort (4 items)
ii) Section B: Safety (4 items)
iii) Section C: Design Suitability (4 items)

In total, the questionnaire contained 12 items, each measured on a five-point Likert scale to capture student feedback as shown in Table 2. The survey was prepared in printed form and distributed to respondents immediately after they completed the laboratory session using the Embedded Motor Trainer.

Table 2. Interpretation and values of the Likert scale

Likert Value	Interpretation
1	Strongly Disagree
2	Disagree
3	Not Sure
4	Agree
5	Strongly Agree

3.4 Data collection

Data collection was carried out after a single laboratory session in which students used the Embedded Motor Trainer to explore the operational principles of DC, Stepper, and Servo Motors. At the end of the session, the printed questionnaires were distributed to all participants and collected on the same day to ensure consistency of responses.

3.5 Data Analysis

The data collected were analysed using descriptive statistics, specifically mean scores and percentages, to identify students' perceptions of the trainer's usability, safety, and design suitability. The analysis was performed using Microsoft Excel. Table 3 presents the interpretation of mean scores, which served as the basis for analysing students' responses.

Table 3. Interpretation of Mean Scores

Min Score Range	Mean Interpretation
1.00 - 1.80	Strongly Disagree
1.81 - 2.60	Disagree
2.61 - 3.40	Not Sure
3.41 - 4.20	Agree
4.21 - 5.00	Strongly Agree

4. RESULTS

4.1 Section A: Usability and Effectiveness

This evaluation was conducted to assess the level of comfort and effectiveness of the Embedded Motor Trainer in supporting student learning. The focus was on determining how far the trainer facilitates the learning process and enhances students' understanding of motor concepts.

Table 4. Mean Scores for Usability and Effectiveness

No.	Item	Mean Score
1.	I feel comfortable using the Embedded Motor Trainer to understand the concepts of DC, Stepper, and Servo Motors.	5.00
2.	The response of the Embedded Motor Trainer is accurate according to the input given.	4.97
3.	Learning through demonstrations is more effective and efficient.	5.00
4.	The process of understanding DC, Stepper, and Servo Motors is faster.	5.00

Table 4 shows the mean scores for usability and effectiveness. Three items obtained the maximum score of 5.0, while one item accuracy of the trainer's response to input scored 4.97. These findings demonstrate that students felt comfortable using the Embedded Motor Trainer as it significantly accelerated their understanding of motor concepts and made demonstration-based learning more effective.

4.2 Section B: Safety

This section of the questionnaire aimed to evaluate the safety level of using the Embedded Motor Trainer. Safety is an important consideration as it reflects students' confidence in the electrical protection provided and their understanding of safety procedures before and during use.

Table 5. Mean Scores for Safety

No.	Item	Mean Score
1.	I feel safe when using the Embedded Motor Trainer.	5.00
2.	The system provides sufficient protection against electrical hazards.	4.97
3.	Safety procedures were clearly explained before usage.	4.93
4.	The system is suitable for use by students with minimal supervision.	4.93

Table 5 presents the mean scores for safety. Students rated this aspect very positively, with scores ranging from 4.93 to 5.0. These results indicate that students felt safe when using the trainer, expressed confidence in the electrical protection provided, and understood the safety procedures explained prior to usage. However, the slightly lower scores on some items suggest that minimal supervision may still be necessary for certain students.

4.3 Section C: Design Suitability

This section assessed the suitability of the trainer's design, focusing on visual aspects, component arrangement, and overall effectiveness in supporting teaching and learning.

Table 6. Mean Scores for Design Suitability

No.	Item	Mean Score
1.	The system design is attractive and modern.	4.97
2.	The arrangement of components is neat and well-organised.	5.00
3.	The design helps me to understand the working principles of DC, Stepper, and Servo Motors.	4.97
4.	The design is suitable for use in the teaching and learning process.	5.00

Table 6 shows the mean scores for design suitability. All items received very high scores, between 4.97 and 5.0, indicating strong student approval. These findings show that students appreciated the neat organisation of components, the modern design, and the role of the trainer in enhancing their understanding of motor concepts. The results confirm that the Embedded Motor Trainer is not only functional but also highly suitable for use in practical teaching and learning contexts.

4.4 Overall Analysis of Evaluation Aspects

The overall analysis presented in Table 7 summarises the mean score obtained for the three evaluated aspects of the Embedded Motor Trainer: usability and effectiveness, safety, and design suitability. The usability and effectiveness aspect recorded the highest mean score of 4.97, followed closely by design suitability with a mean score of 4.96, while the safety aspect achieved a mean score of 4.95.

All three aspects recorded similarly high mean scores, indicating consistently positive student perceptions across usability, safety, and design. The minimal differences between the mean values suggest that students perceived the Embedded Motor Trainer as effective, safe, and well designed, without a strong preference for any single evaluation dimension.

Although the safety aspect obtained the lowest mean score among the three, the difference was marginal and does not indicate any significant concern. This finding suggests that while students generally felt confident using the trainer, continued emphasis on safety briefings and supervision during laboratory sessions may further enhance students' confidence and learning experience.

Despite the slight variation in scores, the differences were minimal, demonstrating that the Embedded Motor Trainer provided a consistently high level of satisfaction across all three evaluated aspects, supporting its suitability as an effective teaching and learning aid in embedded robotics laboratory environments.

Table 7. Mean Scores by Evaluation Aspects

Aspect	Mean Score
Usability and Effectiveness	4.97
Safety	4.95
Design Suitability	4.96

5. Discussion

The findings of this study demonstrate that the Embedded Motor Trainer was highly valued by students across all evaluated aspects: namely usability, effectiveness, safety, and design suitability. The consistently high mean scores indicate that the trainer successfully met its intended purpose as a teaching aid in the Embedded Robotics course., and fulfils its intended role as a practical teaching and learning aid.

In terms of usability and effectiveness, the results in Table 4 revealed the highest ratings, with three items achieving a perfect mean score of 5.0 and one item slightly lower at 4.97. These findings highlight that students felt comfortable using the trainer and perceived it as an effective tool for accelerating their understanding of DC, Stepper, and Servo Motors. This aligns with prior studies which emphasise that hands-on learning resources improve comprehension and make demonstration-based activities more engaging. The trainer therefore not only enhanced learning outcomes but also supported student confidence in applying theoretical concepts to practical situations.

The evaluation of safety, presented in Table 5, also yielded very positive results, with mean scores ranging from 4.93 to 5.0. Students reported feeling safe when using the trainer, expressed confidence in its electrical protection features, and acknowledged the clarity of the safety procedures. Nevertheless, the slightly lower scores on items related to supervision suggest that a small degree of monitoring may still be beneficial during practical sessions. This indicates that while the trainer meets fundamental safety standards, supplementary reinforcement of safety protocols could further enhance student confidence.

Regarding design suitability, the results in Table 6 confirmed that students strongly appreciated the trainer's modern appearance, neat organisation of components, and ability to support their understanding of motor operations. All items scored between 4.97 and 5.0, reinforcing the importance of well-structured and visually appealing design in promoting student engagement. These outcomes suggest that thoughtful design not only improves the functionality of a training tool but also contributes to its pedagogical effectiveness.

The overall analysis in Table 7 consolidates these findings, showing mean scores of 4.97 for usability, 4.96 for design, and 4.95 for safety. While safety recorded the lowest mean, the difference compared to the other aspects was marginal, indicating a balanced and consistently high level of satisfaction across all dimensions. This suggests that the Embedded Motor Trainer is not only effective in strengthening learning outcomes but also reliable and appropriate for use in laboratory teaching environments.

Taken together, these results confirm that the Embedded Motor Trainer is a well-designed, safe, and an effective, safe, and well-designed educational tool for embedded robotics education. It provides students with meaningful hands-on experiences, supports faster and deeper understanding of motor concepts, and enhances the overall quality of the Embedded Robotics course.

6. Conclusion

This study evaluated students' perceptions of the usability, safety, and design suitability of the Embedded Motor Trainer as a teaching and learning aid for the Embedded Robotics course. The findings indicate that students consistently perceived the trainer as effective, safe, and well designed, with all three evaluation aspects recording similarly high mean scores. These results demonstrate that the Embedded Motor Trainer successfully supports hands-on learning activities and enhances students' understanding of motor control concepts in a laboratory-based learning environment. In terms of usability and effectiveness suggest that the trainer facilitates faster comprehension and increased engagement through practical, demonstration-based learning. The safety evaluation confirmed that students generally felt secure when using the trainer, with confidence in the electrical protection features and clarity of safety procedures, although some students still preferred minimal supervision. The design assessment showed that students strongly appreciated the modern, well-organised layout and its role in enhancing their understanding of motor concepts. The overall analysis confirmed that the trainer achieved consistently high satisfaction scores across all three evaluation aspects, demonstrating its reliability as an educational tool. These outcomes directly address the study's objectives: (1) confirming the trainer's effectiveness in supporting learning of DC, Stepper, and Servo Motors, (2) affirming positive student perceptions of its safety, and (3) verifying the suitability of its design for teaching and learning contexts. In conclusion, the Embedded Motor Trainer has proven to be a safe, effective, and well-designed educational resource that significantly supports student learning in embedded robotics. In conclusion, the Embedded Motor Trainer represents a suitable and effective teaching and learning aid for embedded robotics education, offering a consistent level of effectiveness, safety, and design quality that supports practical learning and student engagement.

REFERENCES

[1] C. Tang, R. Martín-Martín, J. Hu, B. Abbatematteo, R. Chandra, and P. Stone, "Deep Reinforcement Learning for Robotics: A Survey of Real-World Successes," AAAI, vol. 39, no. 27, pp. 28694–28698, Apr. 2025, doi: 10.1609/aaai.v39i27.35095.

[2] Julianto, D., & Sukardiyono, T. (2017). Learning Media Trainer DC, Brushless, Servo, and Stepper Motor with Arduino Uno Microcontroller Control on Technique Microprocessor Subjects at SMK Negeri 2 Depok Yogyakarta. E-JPTE (Jurnal Elektronik Pendidikan Teknik Elektronika), 6(4). DOI:10.21831/e-jpte.v6i4.7634

[3] Working Principles of Electric Vehicle Motors. Proceedings of Vocational Engineering International Conference, Vol. 5 (2023), Published February 2024.

[4] Ouyang, L., Wang, D., & Wang, K. (2012). Control Engineering Training System Based QET DC Motor Control Trainer. In Mao, E., Xu, L., & Tian, W. (Eds.), Emerging Computation and Information Technologies for Education (Advances in Intelligent and Soft Computing, vol. 146) (pp. 363–367). Springer. DOI:10.1007/978-3-642-28466-3_49

[5] Khater, A. A., El-Bardini, M., & El-Rabaie, N. M. (2015). Embedded Adaptive Fuzzy Controller Based on Reinforcement Learning for DC Motor with Flexible Shaft. Arabian Journal for Science and Engineering, 40, 2389–2406. DOI:10.1007/s13369-015-1752-4

[6] Eder, K., Harper, C., & Leonards, U. (2014). Towards the Safety of Human-in-the-Loop Robotics: Challenges and Opportunities for Safety Assurance of Robotic Co-Workers. arXiv preprint.

[7] H.Y. & H.-J.L. (2021). Development of an Onboard Robotic Platform for Embedded Programming Education. (Sensors, MDPI).

[8] Springer Authors (2024). Does Really Educational Robotics Improve Secondary School Students' Course Motivation, Achievement and Attitude? Education and Information Technologies, 29, 23753–23780.

[9] Su, S., Liu, J., Rayo, Y. A., Peck, A. M., Montenegro, J., Gonyea, M., & Valdastri, P. (2016). STORMLab for STEM Education: An Affordable Modular Robotic Kit for Integrated Science, Technology, Engineering, and Math Education. IEEE Robotics & Automation Magazine, 23, 47–55.

[10] Anwar, S., Bascou, N. A., Menekse, M., & Kardgar, A. (2019). A Systematic Review of Studies on Educational Robotics. Journal of Pre-College Engineering Education Research.

[11] Murashov, V., Hearl, F., & Branche, C. M. (2016). Working Safely with Robot Workers: Recommendations for the New Workplace. Journal of Occupational and Environmental Hygiene.