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Variable Frequency Drives Based on Motor Control Electrical Trainer for Mastery in Electrical Machines 2 for Electrical Engineering Students at University of Cebu Lapu-Lapu and Mandaue

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Abstract **-** This study has created a Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer for Electrical Engineering students to boost mastery in Electrical Machines 2. The trainer was developed to combine theory with practice through realistic motor control activities. The study employed a quantitative experimental design following the PDCA cycle. Data was collected from third- and fourth-year students through surveys, observation, and system testing. The trainer was evaluated by ISO/IEC 25010 standards. The results showed that the system passed all tests and obtained positive ratings in functionality, maintainability, dependability and safety. The findings also demonstrated an increase in student understanding, abilities and confidence. The trainer is considered to be an effective training tool and is suggested for laboratory usage and further enhancement.

Keywords **-** *Electrical Trainer, Machines 2, Maintainability, Safety, Hands-on Learning, Variable Frequency Drive*

I. INTRODUCTION

Electrical Engineering education has to blend the theory and practice for the current fast-paced industrial world. Courses such as Electrical Machines 2 give students an insight into the theory, operation and management of electrical machines and also build the technical abilities for working in real industrial settings. The subject generally includes induction motors, synchronous machines, rotating magnetic fields, torque-speed characteristics and motor control systems. These topics are very important in engineering practice but many students have difficulties in grasping them if they are taught only via lectures and short laboratory demonstrations.

In modern businesses, Variable Frequency Drives (VFDs) are commonly used to manage motor speed, torque, and efficiency by adjusting the voltage and frequency provided to the motor. VFDs are critical in industrial automation because they improve the performance of the system, reduce the mechanical stress and save electrical energy. As industries are moving towards more automated and energy efficient systems, Electrical Engineering students need to be exposed to the functioning, programming and troubleshooting of VFDs. Nevertheless, some universities are still not equipped with modern laboratory equipment which reflects the present industrial practices leading to a gap between theoretical learning and practical application.

Electrical Theory states that the fundamental principles that must be understood in order to know how electrical machines function are voltage, current, resistance, power, and the behavior of circuits. These principles clarify the conversion of electrical energy to mechanical motion, and how motors respond to frequency and voltage changes in VFD-based systems. This link is significant in understanding speed management, torque control and efficiency of the motor. Learning theories that support this idea include Kolb's Experiential Learning Theory, Piaget's Constructivist Theory, and Vygotsky's Social Development Theory. These theories emphasize that students learn best through hands-on experience, active exploration, collaboration, and guided instruction.

Practical training gadgets, simulation systems and laboratory trainers have been found to considerably improve students' understanding of technical subjects in previous research. Researchers have found that hands-on trainers allow students to see the working of actual circuits, to troubleshoot and apply theoretical principles in a controlled environment. Additionally, studies on VFD-based educational systems have demonstrated benefits in student engagement, confidence, and performance, as students are exposed to real-world industrial motor control applications. These findings highlight the need of including advanced training facilities in engineering education.

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To solve these problems, this study created a Variable Frequency Drive-Based Motor Control Electrical Trainer for mastery in Electrical Machines 2 among Electrical Engineering students of the University of Cebu Lapu-Lapu and Mandaue. The trainer is meant to emulate the industrial motor control activities such as forward and reverse rotation, speed control, fault diagnostics and system protection. With this trainer, students may link theoretical concepts to applied knowledge in a secure and dynamic setting.

This trainer is designed to enhance laboratory instruction, expand students' technical competency, and ready future engineers for the demands of current industrial automation. Furthermore, the study assessed the trainer based on the ISO/IEC 25010 quality standards, in terms of functionality, performance efficiency, compatibility, maintainability, dependability and safety to assure its efficacy as an instructional tool.

II. STATEMENT OF THE PROBLEM

This study aimed to Variable frequency drive based on motor control of an electrical trainer for Mastery in Electrical Machines 2 for Electrical Engineering Students at UCLM.

In particular, this study will achieve the following objectives:

1. Identify UCLM's current educational resources for the Machine 2 course to provide a basis for addressing the gap between theory and practical application.
2. Create an Electrical Trainer for Variable-Frequency Drive-Based Motor Control that showcases the key components of Electrical Machines 2, various wiring configurations, hands-on experiments, and essential safety features.
3. Evaluate and test the electrical trainer in terms of:
   3.1. Component Testing
   3.2. Integration Testing
   3.3. System Testing
4. Conduct user acceptance testing in accordance with ISO standards 25010;
   4.1. Functionality
   4.2. Performance Efficiency
   4.3. Compatibility
   4.4. Maintainability
   4.5. Reliability
   4.6. Safety

II. METHODOLOGY

A. Research Design

The study was a quantitative research study because it involves collecting and analyzing numerical data to assess the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer. Through quantitative analysis, the researchers can clearly observe measurable patterns and outcomes, allowing an objective evaluation of how effectively the trainer enhances students' understanding and application of theoretical concepts in Machines 2.

B. Research Environment

The study was conducted at the University of Cebu Lapu-Lapu and Mandaue at the College of Engineering laboratories where students of Electrical Engineering conduct practical activities for Electrical Machines 2. The laboratory provided a convenient setting for designing, assembling, testing and evaluating the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer.

The research environment was furnished with the electrical tools, measuring instruments, power supply and safety devices required for carrying out experiments and system tests. It also gave the respondents consisting of third year and fourth year Electrical Engineering students to engage with the produced trainer under supervised and regulated conditions. This environment provided for safe and successful performance of the study while satisfying the aims of the research.

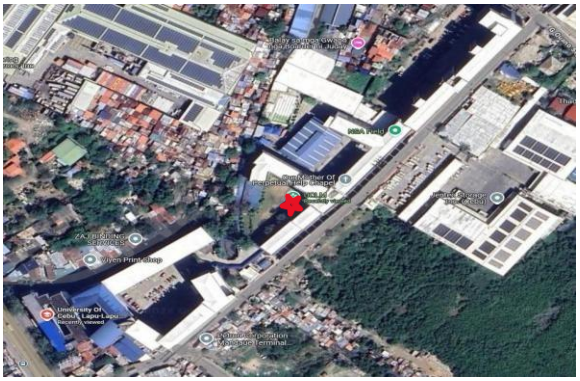

Figure 1. Research environment map

C. Research Respondents

The respondents of this study were the third year and fourth year Electrical Engineering students of the University of Cebu Lapu-Lapu and Mandaue who were enrolled in or previously exposed to Electrical Machines 2. The students were picked for their adequate prior knowledge and lab experience relevant to motor control systems.

The study included nineteen third-year students and a few fourth-year students. Their replies offered useful information on functionality, usefulness and efficacy of the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer in enhancing practical skills and understanding course ideas.

D. Research Instruments

The research instruments used in this study are survey questionnaires, observation checklists, and system testing tools. The survey questionnaire was used to gather the assessment of

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the respondents of the Variable Frequency Drive (VFD) Based Motor Control Electrical Trainer based on the ISO/IEC 25010 standards such as functionality, performance efficiency, compatibility, maintainability, reliability, and safety. Observation checklists were used to document the interaction, performance, and safety practices of the respondents while using the trainer. In addition, electrical testing instruments such as multimeter and measuring devices were used during component testing, integration testing, and system testing to validate the functionality and reliability of the developed trainer. The survey questionnaire was used to collect the respondents' assessment of the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer based on the ISO/IEC 25010 standards such as functionality, performance efficiency, compatibility, maintainability, dependability, and safety.

The interaction, performance and safety habits of the responders while using the trainer were documented using observation checklists. Moreover, electrical testing tools such as a multimeter and measuring devices were used during component testing, integration testing, and system testing to ensure the functioning and dependability of the built trainer.

E. Research Procedure

The study started with the planning and design of the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer according to the requirements of Electrical Machines 2. After the design phase, the trainer was fabricated and assembled using the required electrical components. Once the trainer was completed, it was subjected to component testing, integration testing and system testing to verify proper functionality and safety. After the testing phase, the trainer was presented to the selected respondents for their evaluation. Survey questionnaires and observation checklists were used to gather data on the trainer's performance and usability. The collected data were then analyzed using weighted mean to obtain the overall results of the study. Then the trainer was constructed and assembled with required electrical components after design phase. Once the system was complete, component testing, integration testing, and system testing were done to ensure everything worked correctly and safely. After testing, the trainer was given to the selected respondents for review. Survey questionnaires and observation checklists were utilized to collect data regarding the trainer's performance and usefulness. The data gathered were then subjected to weighted mean to establish the overall result of the study.

F. Gathering of Data

The respondents were third-year and fourth-year Electrical Engineering students of the University of Cebu Lapu-Lapu and Mandaue that were given a survey questionnaire. Their assessment of the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer based on ISO/IEC 25010 quality model was collected using the questionnaire.

In the course of the assessment, respondents were able to operate and observe the trainer in real laboratory conditions. Their interaction, performance and safety procedures during the operation of the technology were also recorded by observation checklists. The accomplished questionnaires were retrieved and the responses collated, tabulated and made ready for statistical analysis.

G. Treatment of Data

The gathered data from the survey questionnaires were analyzed and interpreted using statistical tools. The responses were based on a Likert Scale to measure the level of agreement and evaluation of the Variable Frequency Drive (VFD) Based Motor Control Electrical Trainer. The overall assessment of each criterion was determined using the weighted mean. This statistical method was used to evaluate the trainer in terms of functionality, performance efficiency, compatibility, maintainability, reliability and safety. The computed results served as the basis for the interpretation of the effectiveness and acceptability of the developed system. The replies were in the form of Likert Scale to determine the level of agreement and assessment of the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer.

A weighted mean was utilized to determine the overall assessment of each criterion. This statistical method was used to evaluate the trainer in terms of functionality, performance efficiency, compatibility, maintainability, reliability and safety. The results of the computation were used to interpret the effectiveness and acceptability of the constructed system.

IV. RESULTS AND DISCUSSION

The developed Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer was subjected to component testing, integration testing and system testing successfully which confirmed the system to be fully functional, dependable and safe for laboratory usage. The major components like VFD, relays, selector switches, push buttons, pilot lamps, power supply and the three phase induction motor functioned satisfactorily during all test runs.

Based on the respondents' evaluation utilizing ISO/IEC 25010 standards, the third-year students obtained an overall mean of 3.39 (Agree), while the fourth-year students obtained an overall mean of 3.42 (Strongly Agree). This means that the designed trainer was positively approved by both groups with a little better rating for the fourth year students.

The trainer was rated positively for particular criteria on functionality, performance efficiency, compatibility, maintainability, dependability and safety. Maintainability was evaluated best by fourth-year students (mean 3.46) while performance efficiency was rated highest by third-year students (mean 3.42). These results indicate that the trainer was user friendly, operationally efficient and appropriate for teaching.

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The results also indicated that the instructor was efficient in boosting students' grasp of Electrical Machines 2 principles by combining theoretical lectures with hands-on uses such as motor speed regulation, forward-reverse operation, troubleshooting, and safety practices. The results generally validated the effectiveness of the VFD-Based Motor Control Electrical Trainer as a teaching aid for Electrical Engineering students.

A. System Output

The Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer operates by controlling the speed and direction of an electric motor. It does this through the adjustment of voltage and frequency supplied by the VFD. The system begins when electrical power is supplied to the trainer. The proper wiring configuration is then verified according to the operation manual. Once configured, the VFD display activates. This allows the user to set the desired operating frequency for motor speed control.

The control circuit receives commands from push buttons and selector switches. These include start, stop, forward, and reverse. The VFD processes these signals and regulates the motor operation using Pulse Width Modulation (PWM) technology. The trainer enables smooth acceleration, deceleration, and precise motor speed control. It maintains safe operation through built-in protection features such as overload, overcurrent, and overvoltage protection.

During operation, the motor performance is continuously observed and evaluated in terms of voltage, current, speed, and rotational direction. If an abnormal operation occurs, troubleshooting procedures such as rechecking the wiring connections and VFD parameters are performed to restore proper functionality. The trainer provides students with a hands-on learning environment where they can practice motor control, troubleshooting, and automation techniques used in actual industrial applications.

B. System Testing Results

The developed Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer successfully passed the conducted system testing procedures. The testing focused on evaluating the performance of the start-stop operation, forward-reverse motor control, selector switch functionality, and overall system response during actual operation. The results confirmed that the trainer operated properly, safely, and efficiently under different operating conditions.

During the Start-Stop Forward Functionality Test, pressing the start push button caused the motor to run smoothly, while pressing the stop button immediately stopped the motor operation as expected. Similarly, in the Start-Stop Reverse Functionality Test, the motor successfully operated in reverse direction and stopped correctly when the stop button was activated.

The Selector Switch Forward-Reverse Functionality Test also produced satisfactory results. When the selector switch was positioned to Forward (0), the motor operated smoothly in the forward direction. When switched to Reverse (1), the motor successfully changed direction and continued operating smoothly without abnormal vibration or interruption. These results verified that the trainer could reliably control motor direction and respond accurately to user inputs.

Overall, the system testing demonstrated that the VFD-Based Motor Control Electrical Trainer achieved stable motor operation, proper control response, and safe performance. The trainer effectively simulated actual industrial motor control applications, making it suitable for laboratory instruction and practical learning activities in Electrical Machines 2.

Table 1. System Testing

Components	Test Scenarios	Test cases	Expected Output
Start-Stop Forward	Functionality Test	Push Start Button	Motor starts running smoothly
		Push the Stop Button	Motor stops running
Start-Stop Reverse	Functionality Test	Push Start Button	Motor starts running smoothly
		Push the Stop Button	Motor stops running
Selector Switch Forward-Reverse	Functionality Test	Change Selector Switch position in 0 (Forward)	Motor starts running smoothly
			Motor stops running
Selector Switch Forward-Reverse	Functionality Test	Change Selector Switch position in 1(Reverse)	Motor starts running smoothly
			Motor stops running

The evaluation of the motor control system under various operating conditions, with an emphasis on the start-stop and forward-reverse functions, is presented in Table System Testing. In the Start-Stop Forward test, the motor was supposed to run smoothly upon activation and stop as instructed. The system was evaluated by pressing the start and stop buttons. In a similar vein, the Start-Stop Reverse test confirmed that the motor operated in reverse, guaranteeing a smooth start and appropriate stopping.

The Selector Switch Forward-Reverse tests also examined how the system responded when the selector switch was moved between positions. The motor was supposed to run smoothly and

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stop at position 0, indicating proper control behavior. When the selector switch was set to position 1, the same anticipated performance was seen, confirming that the system can consistently switch between forward and reverse operations.

Overall, these tests verify that the motor control system operates as planned, exhibiting stable operation in both forward and reverse directions and an appropriate response to user inputs.

Table 2. System Testing Trial

Components	Test Scenarios	Test Cases	Expected output	1	2	3
Start-Stop Forward	Functionality Test	Push Start Button Push the Stop Button	The motor starts rotating in the forward direction Motor stops running	P	P	P
Start-Stop Reverse	Functionality Test	Push the Start Button Push the Stop Button	The motor starts rotating in the reverse direction Motor stops running	P	P	P
Selector Switch Forward-Reverse	Functionality Test	Change Selector Switch position to 0 (Forward)	The motor starts rotating in the forward direction Motor stops running	P	P	P
Selector Switch Forward-Reverse	Functionality Test	Change the Selector Switch position to 1(Reverse)	The motor starts rotating in the reverse direction Motor stops running	P	P	P

The Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer's system testing trial results are shown in Table 2, with emphasis on the operational performance of the motor control functions. The Start-Stop Forward function was tested by pressing the start and stop buttons. The expected result was successful forward motor rotation, followed by a complete stop when the stop button was pressed; all three trials passed, indicating correct forward control operation. The motor was expected to rotate in the opposite direction and then stop when the Start-Stop Reverse function was assessed using the identical start-and-stop protocol. The results demonstrated consistent, successful performance across all trials. To test the forward operation selector switch, the switch was set to "0" (forward), which should start forward motor rotation and permit halting when necessary. This function also passed in every trial. Similarly, the selector switch for reverse operation was tested by setting it to position "1" (reverse), where the motor is supposed to rotate in the opposite direction and stop when instructed. In every experiment, the switch consistently produced the desired outcomes. Overall, the system testing verifies that the motor control functions forward and backward operations using selection switches and push buttons are operating consistently, safely, and dependably across all test trials.

D. User Acceptance Results

The user acceptance testing results showed that the Variable Frequency Drive (VFD)-Based Motor Control Electrical Trainer was positively accepted by the respondents based on ISO/IEC 25010 standards. The third-year students obtained an overall mean rating of 3.39 interpreted as "Agree," while the fourth- year students obtained 3.42 interpreted as "Strongly Agree." The respondents evaluated the trainer as functional, efficient, reliable, maintainable, compatible, and safe for laboratory use. The findings also revealed that the trainer improved students' understanding, practical skills, and confidence in performing motor control activities related to Electrical Machines 2.

PART I. PERFORMANCE LEVEL AS RATED BY THE RESPONDENT'S

Table 3. Year Level of Respondents

Year Level	Number of Students Who Responded	Percentage
4th year	29	60.42 %
3rd year	19	39.58 %

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Total	48	100%

Table 6. Year Level of Respondents Year Level Number of Students Who Responded Percentage 4th year 29 60.42 % 3rd year 19 39.58 % Total 48. Table 6 shows the distribution of respondents by year level. The majority of the students who participated in the study (12, 60.42%) were in their fourth year, and the remaining 8 (39.58%) were in their third year. This suggests that most participants were already in the advanced stage of their program, indicating they were more familiar with the Machines 2 course and its associated labs. Most of the 12 students involved in the study were fourth-year students (60.42%), while the rest were third-year students (39.58%). This means that the majority of participants were already in the later stages of their program, making them more familiar with the Machines 2 course and its associated laboratories.

Table 4. (3rd Year and 4th Year) Summary of Results

Indicators	3rd Year Mean	Interpretation	4th Year Mean	Interpretation
Functionality	3.32	Agree	3.44	Strongly Agree
Performance Efficiency	3.42	Strongly Agree	3.40	Agree
Compatibility	3.36	Agree	3.42	Strongly Agree
Maintainability	3.36	Agree	3.46	Strongly Agree
Reliability	3.36	Agree	3.41	Strongly Agree
Safety	3.33	Agree	3.42	Strongly Agree
Overall Mean	3.39	Agree	3.42	Strongly Agree
Overall SD	0.49		0.49	

Table 13 summarizes the findings for the VFD trainer based on assessments of third- and fourth-year students. Third-year students assessed the trainer relatively favorably across all measures, with an overall mean of 3.39, indicating agreement. Conversely, fourth-year students had a significantly higher overall mean of 3.42 (Strongly Agree), indicating a more positive evaluation. In terms of specific metrics, both groups rated Performance Efficiency, Maintainability, Reliability, and Safety highly, but fourth-year students rated Functionality and Compatibility slightly higher. The results suggest that fourth-year students are more confident in the overall trainer, indicating general acceptance of the trainer's quality features under ISO.

V. CONCLUSION

The study reveals that the Variable Frequency Drive (VFD)based motor control trainer is an efficient and reliable teaching tool for Electrical Machines 2. It was discovered that the system was functioning successfully, performing effectively, and conforming to the job and ISO/IEC 25010 standards. The positive feedback from third-and fourth-year students indicates that the trainer is adequate, easy to use, and beneficial for improving theoretical knowledge and practical skills. Furthermore, the significant relationships found among functionality, performance efficiency, and acceptability criteria imply that system quality directly affects students' intention to use and their overall attitude towards the trainer. In short, the VFD trainer is a valuable addition to electrical engineering education, as it is an excellent tool for hands-on learning and enhances the laboratory experience. The system was working successfully, performing effectively, and in conformity with the task and ISO/IEC 25010 requirements. The favorable response from third- and fourth-year students indicates that the trainer is competent, easy to use, and effective in increasing theoretical knowledge and practical abilities.

Also, the strong correlations among functionality, performance efficiency, and acceptability criteria imply that the system's quality directly affects students' intention to use and their general attitude towards the trainer. In conclusion, the VFD trainer is a valuable addition to electrical engineering education, as it is a powerful tool for hands-on learning and enhances the laboratory experience.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization, Methodology; Author 2: Data curation, Writing-Original draft preparation, Writing-Reviewing; Author 3: Investigation, Validation, Visualization, Writing- Reviewing; Author 4: Methodology, Data Visualization

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GENERATIVE AI STATEMENT

The authors used ChatGPT solely as a language-support tool to improve the clarity, coherence, and grammatical accuracy of the manuscript. All AI-assisted outputs were critically reviewed, revised, and validated by the authors to ensure the accuracy, integrity, and originality of the content. The authors accept full responsibility for the final version of the manuscript and its published content.

ETHICAL CONSIDERATIONS

Prior to the data gathering, ethical approval was obtained from the University of Cebu Academic Research Ethics Committee (UCAREC). The approved protocol ensured adherence to the principles of respect for persons, beneficence, justice, voluntary participation, informed consent, confidentiality, and anonymity, and compliance with the Data Privacy Act throughout the research process.

DECLARATION OF INTEREST

The authors declare that they have no competing financial, professional, or personal interests that could have influenced the conduct, findings, or publication of this study.

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DATA AVAILABILITY

Data will be made available by the corresponding author on request.

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REFERENCES

[1] Ahmed, A., et al. (2019). Use of electrical trainers for enhanced learning in AC machinerycourses.https://doi.org/10.21831/elinvo.v8i1.57884

[2] Almeida, A. F., & Cota, M. (2020). Experiential learning in engineering education: Bridging theory and practice. Journal of Engineering Education Research, 15(2),115128. https://doi.org/10.1002/jee.20575

[3] A New Perspective of Web-Based Systems Quality Engineering Measure by Using Software Engineering Theory ISO 25010: An Initial Study (2020). Journal of Physics: Conference Series, 1529 (022004). https://doi.org/10.1088/17426596/1529/2/02 2004

[4] Almeida, C., & Alturas, B. (2025). Users' satisfaction evaluation based on ISO standards for tourism and travel mobile applications. International Journal of Information Technology and Management, 24(1–2), 130–144. https://doi.org/10.1504/IJITM.2025.1441

[5] Alturas, B., & Almeida, C. (2023). Users' satisfaction evaluation based on ISO standards for tourism and travel mobile applications. International Journal of Information Technology and Management, 1(1). https://doi.org/10.1504/ij itm.2023.10062400

[6] De Matos Magnus, D., Carbonera, L.F.B., Pfitscher, L.L., Farret, F.A., Bernardon, A. P., Tavares, A. A. (2020). An Educational Laboratory Approach for Hybrid Project-Based Learning of Synchronous Machine Stability and Control: A Case study. IEEE Transactions on Education, 63(1), 48 https://doi.org/10.1109/te.2019.2956909

[7] A., Ong, P., Ramos, & R. Dizon, (2020). Bridging theory and practice in electrical machines through laboratory-based instruction. Journal of Technical Education and Training, 12(4), 87–98. https://doi.org/10.1109/TE.2019.2956909

[8] A., Sahu, R., Sharma, & P. Verma, (2022). Application of power electronics and VFD systems in engineering education for Industry 4.0 readiness. IEEE Access, 10, 115201–115210.https://doi.org/10.1109/ACCESS.2022.3197882

[9] Chapman, S. J. (2019). Electric machinery fundamentals (6th ed.). McGraw-HillEducation.https://doi.org/10.1016/j.sftr.2025.101224

[10] Commission on Higher Education. (2014). CHED Memorandum Order No. 46, series of 2012: Policy-standard to enhance quality assurance (QA) in Philippine higher education through an outcomes-based and typology-based QA. CHED. https://doi.org/10.37394/232015.2021.17.51

[11] Commission on Higher Education. (2017). Commission on Higher Education Memorandum Order No. 88, Series of 2017— B.S. Electrical Engineering Program Guidelines. https://www.ustp.edu.ph/wp-content/uploads/2023/07/BS-EE_CMO-88-s.-2017-BS-Electrical-Engineering.pdf

[12] Cruz, M. R., & Villanueva, J. (2018). Development of instructional electrical trainers for enhanced student learning outcomes in engineering technology. Philippine Journal of Engineering Education, 13(2),45–57. https://doi.org/10.53682/edunitro.v3i1.5488

[13] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319340.https://doi.org/10.2307/249008

[14] Elfizon, E., Candra, O., & Muskhir, M. (2018). Implementation of learning media for industrial electrical installation practicum. Journal of Physics: Conference Series, 1165(1), 012014. https://doi.org/10.1201/9781003107279-63

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[15] Elfizon, E., Candra, O., & Muskhir, M. (2019). Development of industrial electrical installation trainer for engineering education. Journal of Physics: Conference Series, 1165(1), 012014. https://doi.org/10.1088/17426596/1165/1/01 2014

[16] Fong, J., Ferreira, F. J. T. E., Silva, A. M., & De Almeida, A. T. (2020). IEC61800-9 system standards as a tool to boost the efficiency of electric motor driven systems worldwide. Inventions, 5(2),20. https://doi.org/10.3390/inventions5020020Eng, D. (2021, April 24). iRobot: From R2-D2 to practical robots. Fortune. Retrieved March 13, 2025, from https://fortune.com/2014/08/14/irobot-practical-robots/

[17] Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. MIS Quarterly, 19, 213–236. https://doi.org/10.2307/249689

[18] Hernández, L., Ramos, E. A., & Torres, M. (2021). Acceptability and effectiveness of Instructional trainers in electrical installation and maintenance education. Journal of Technical Education and Training, 13(4), 97–110. https://doi.org/10.1016/B978-0-08-100636-8.00005-3

[19] Hughes, A., & Drury, B. (2013). Electric motors and drives: Fundamentals, types and applications (4th ed.).Newnes.https://doi.org/10.1016/C2011-0-07555-5

[20] International Electrotechnical Commission. (2019). IEC 61800 series: Adjustable speed electrical power drives. IEC.https://doi.org/10.3390/inventions50200 20

[21] Jonassen, D. H. (2011). Learning to solve problems: A handbook for designing problem-solving learning environments. Routledge. https://doi.org/10.4324/9780203847527

[22] Kim, J., & Park, S. (2021). Enhancing electrical engineering education through variable frequency drive-based laboratory experiments. International Journal of Engineering. https://doi.org/10.1109/ACCESS.2022.3150 360

[23] Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice Hall. https://doi.org/10.46787/elthe.v1i1.3362

[24] Lopez, J. M., & Dela Cruz, R. B. (2019). Outcomes-based learning in electrical engineering education: Integrating practical trainers for competency enhancement. Asia Pacific Journal of Educational Research, 7(1), 55–64. https://doi.org/10.59324/ejtas.2024.2(2).68

[25] Nasreen, N., Seadawy, A. R., & Lu, D. (2019). Study of modulation instability analysis and optical soliton solutions of higher-order dispersive nonlinear Schrodinger equation with dual-power law nonlinearity. Modern Physics Letters B, 33. https://doi.org/10.1142/S0217984919503093

[26] Nguyen, T. H., et al. (2023). Climate impacts on hydropower in Vietnam's Red River Basin. Energy for Sustainable Development, 75, 1–14. https://doi.org/10.4236/ajcc.2025.142012

[27] Ong, A., Ramos, P., & Dizon, R. (2020). Bridging theory and practice in electrical machines through laboratory-based instruction. Journal of Technical Education and Training, 12(4), 87–98. https://doi.org/10.1109/TE.2019.2956909

[28] Oliveira, H., & Bonito, J. (2023). Practical work in science education: A systematic literature review. Frontiers in Education. https://doi.org/10.3389/feduc.2023.1151641

[29] Pepito, J. C., & Del Fierro, E. (2022). Evaluation of the developed hardwired mechatronic trainers as educational devices. . https://www.researchgate.net/publication/37 2389859

[30] Pekárek, J., Novák, P., & Horák, M. (2018). Practical approaches in teaching electrical engineering through modular trainer systems. International Journal of Engineering Pedagogy, 8(3), 45–53. https://doi.org/10.1177/0020720918787455

[31] Pereyras, J. A. (2020). Design and development of an industrial motor control trainer for electrical engineering education. Western Visayas College of Science and Technology Research Journal, 5(2), 45–56. https://doi.org/10.47772/IJRISS.2025.903SE DU0485

[32] Petruzella, F. (2009). Electric motor drives: Control, testing, and maintenance (5th ed.). McGraw-Hill Education.https://doi.org/10.3390/en13092224

[33] Rashid, M. H. (2017). Power electronics: Devices, circuits, and applications (4th ed.). Pearson.https://doi.org/10.1201/9781315161 662

[34] Sahu, A., Sharma, R., & Verma, P. (2022). Application of power electronics and VFD systems in engineering education for Industry 4.0 readiness. IEEE Access, 10, 115201–115210. https://doi.org/10.1109/ACCESS.2022.3197882

[35] University of Cebu. (2020). Vision and mission. University of Cebu Lapu-Lapu and Mandaue. https://www.uc.edu.ph

[36] Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D.

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(2003). User acceotance of information technology: Toward a unified view. MIS Quarterly, 27, 425-478. https://doi.org/10.2307/30036540

[37] Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4

[38] Wena, M. (2011). Strategi pembelajaran inovatif kontemporer: Suatu tinjauan konseptual operasional. Bumi Aksara. https://doi.org/10.5281/zenodo.1470902

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