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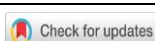
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Development of an IoT-Based 3-Phase Electric Motor Controller Trainer Equipped to Improve Critical Thinking Skills, Creativity, and Learning Outcomes: Supporting SDG 4

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ABSTRACT

Objective: To develop a learning device for an Internet of Things (IoT)-based Right-Left Rotating Induction Motor Control Trainer equipped with Student Worksheets (LKM) to improve critical thinking skills, creativity, and student learning outcomes.

Method: The research method used the ADDIE model development research. The testing or evaluation process is carried out a validity test, a student response test, and an effectiveness test. Data analysis techniques using descriptive statistics, N-Gain test, and Paired Samples Test. **Results:** The results show that the Internet of Things (IoT)-based Right-Left Rotating Induction Motor Control Trainer equipped with Student Worksheets is highly valid based on expert validation results, highly practical based on student responses, and highly effective in terms of improving critical thinking, creativity, and student learning outcomes. Therefore, the resulting trainer is highly suitable for use in electrical machinery lectures. **Novelty:** The novelty of this research lies in the integration of an IoT-based Right-Left Rotating Induction Motor Control Trainer with Student Worksheets and learning outcome measurements covering cognitive, affective, and psychomotor domains. This study highlights how technology-based learning innovation supports SDG 4 by promoting quality education, competency development, and improved learning experiences.

INTRODUCTION

The uncertainty and complexity of the 21st century require a transformation in learning. Learning in this era must prepare students for work, life, and being productive citizens in facing various challenges. Learning needs to equip students with critical and creative thinking skills (S. M. Ritter, et al., 2020) (R. J. Shavelson, et al., 2019). These skills are crucial for dealing with the emergence of new technologies that facilitate the transfer, presentation, manipulation, and re-presentation of information.

Although critical and creative thinking skills are important, many students still lack them. Research shows that the majority of students have moderate or low critical thinking skills (Y. L. O. Siahaan and R. I. Meilani, 2019). Several studies also indicate the need to improve students' critical thinking skills (M. R. Prihatin., et al., (2020). Many university, vocational, and high school students also have low creative thinking skills (H. M. Siregar, 2019).

Research also shows that students' higher-order thinking skills are still low, partly due to the suboptimal use of innovative learning models (H. M. Siregar, 2019) (N. Ika Noviyanti, 2019). Consequently, students often experience difficulty exploring ideas, resulting in difficulty solving problems (S. Paramita Siska Dewi and T. Murwaningsih, 2021). More specifically, this also affects students' creativity in understanding and solving the problems they face. The existence of problems in