ESD-STEM LEARNING ON SOLAR CELL PROJECT TO ENHANCE STUDENTS' ENGINEERING DESIGN SKILLS AND SUSTAINABILITY ACTION IN SUPPORTING CLIMATE ACTION

RESEARCH PAPER

Submitted as a Requirement to Obtain a Degree of *Sarjana Pendidikan* in International Program on Science Education (IPSE) Study Program

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ESD-STEM Learning on Solar Cell Project to Enhance Students' Engineering Design Skills and Sustainability Action in Supporting Climate Action

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Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Pendidikan pada Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

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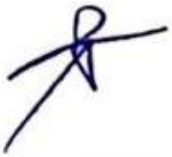

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ESD-STEM LEARNING ON SOLAR CELL PROJECT TO ENHANCE STUDENTS' ENGINEERING DESIGN SKILLS AND SUSTAINABILITY ACTION IN SUPPORTING CLIMATE ACTION

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ABSTRACT

Indonesia's global competitiveness and sustainability performance remain lower than several ASEAN neighbors, particularly in energy use, which contributes significantly to climate change. Addressing this challenge requires innovative learning approaches in the 21st century that align with the Sustainable Development Goals (SDGs). One promising approach is integrating Education for Sustainable Development (ESD) with Science, Technology, Engineering, and Mathematics (STEM). This integration aims to strengthen students' engineering design skills and promote sustainability actions, particularly in support of Climate Action (SDG 13). This study explores the implementation of ESD-STEM learning through a solar cell project designed to enhance students' competencies. A quasi-experimental design was applied, involving 69 eighth-grade students in a public school. Data collection employed pre-test and post-test questionnaires on sustainability actions using the Environmental Citizenship Questionnaire (ECQ) and rubric-based assessments of engineering design skills with the Performance-Based Evaluation Rubric (PBER), both validated and reliable. These were supported by classroom observations and student interviews. Quantitative data were analyzed using SPSS. The findings revealed that students' engineering design skills reached an average score of 88.4, surpassing results from previous studies. Furthermore, sustainability actions improved significantly, with gain scores of 0.90 in the experimental class compared to 0.72 in the control class ($p < 0.05$). These results demonstrate that ESD-STEM learning through the solar cell project effectively enhances students' engineering design skills while cultivating responsibility and proactive behavior toward climate change mitigation. However, improvements in specific aspects remain necessary to maximize the effectiveness of this approach.

Keywords: Climate Action, Engineering Design Skill, ESD Learning, STEM Learning, Sustainability Action

PENERAPAN PEMBELAJARAN ESD-STEM PADA PROYEK SEL SURYA UNTUK MENINGKATKAN KETERAMPILAN DESAIN REKAYASA DAN AKSI KEBERLANJUTAN SISWA DALAM MENDUKUNG AKSI IKLIM

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ABSTRAK

Daya saing global dan kinerja keberlanjutan Indonesia masih lebih rendah dibandingkan beberapa negara tetangga di ASEAN, terutama dalam penggunaan energi yang memberikan kontribusi signifikan terhadap perubahan iklim. Tantangan ini membutuhkan pendekatan pembelajaran inovatif pada abad ke-21 yang selaras dengan Tujuan Pembangunan Berkelanjutan (SDGs). Salah satu pendekatan yang menjanjikan adalah mengintegrasikan *Education for Sustainable Development* (ESD) dengan *Science, Technology, Engineering, and Mathematics* (STEM). Integrasi ini bertujuan untuk memperkuat keterampilan *engineering design* siswa serta mendorong tindakan berkelanjutan, khususnya dalam mendukung Aksi Iklim (SDG 13). Penelitian ini mengkaji implementasi pembelajaran ESD-STEM melalui proyek sel surya yang dirancang untuk meningkatkan kompetensi siswa. Metode yang digunakan adalah desain kuasi-eksperimen dengan melibatkan 69 siswa kelas VIII di salah satu sekolah menengah negeri. Pengumpulan data dilakukan melalui pre-test dan post-test mengenai tindakan keberlanjutan menggunakan *Environmental Citizenship Questionnaire* (ECQ) serta penilaian keterampilan *engineering design* dengan *Performance-Based Evaluation Rubric* (PBER), yang telah teruji validitas dan reliabilitasnya. Data tersebut didukung dengan observasi kelas dan wawancara siswa. Analisis kuantitatif dilakukan menggunakan SPSS. Hasil penelitian menunjukkan bahwa keterampilan *engineering design* siswa mencapai skor rata-rata 88,4, melampaui temuan penelitian sebelumnya. Selain itu, tindakan keberlanjutan meningkat secara signifikan dengan skor gain 0,90 pada kelas eksperimen dibandingkan 0,72 pada kelas kontrol ($p < 0,05$). Temuan ini menegaskan bahwa pembelajaran ESD-STEM melalui proyek sel surya efektif dalam meningkatkan keterampilan *engineering design* sekaligus menumbuhkan tanggung jawab serta perilaku proaktif dalam mitigasi perubahan iklim. Namun, masih diperlukan perbaikan pada aspek tertentu agar pendekatan ini lebih optimal.

Kata kunci: Aksi Iklim, Aksi Keberlanjutan, Keterampilan Rekayasa, Pembelajaran ESD, Pembelajaran STEM

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