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Integrating Digital Games into Project-Based Learning to Enhance Student Achievement in STEM Education

Fatma Sukmawati[1*], Taufiq Subhanul Qodr[1], Theogene Rutambuka[2]
[1] Universitas Sebelas Maret, Surakarta, Indonesia
[2] Rwanda Polytechnic-Gishari College, Muhazi, Rwanda

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ABSTRACT
Objective: This study aimed to address the gap in STEM education by developing and evaluating a digital game focused on energy concepts to enhance students' learning outcomes, engagement, and collaboration. **Method**: The research utilized a Research and Development (R&D) approach based on the Borg and Gall model, encompassing analysis, development, validation, and implementation phases. The experimental design involved high school students divided into two groups: the experimental group, which engaged with the digital game, and the control group, which participated in conventional Project-Based Learning (PjBL) activities. **Results**: The findings revealed that the experimental group demonstrated significantly more improvement in STEM learning outcomes than the control group. The experimental group also showed enhanced engagement and collaboration during learning activities. Statistical analyses confirmed that the digital game effectively created interactive and engaging learning environments that fostered active participation and teamwork. **Novelty**: This study contributes to the field by highlighting the transformative potential of digital game-based learning to address limitations in current PjBL practices. The digital game provides a more engaging and collaborative approach to STEM education, bridging the gap between theoretical concepts and practical problem-solving.

INTRODUCTION

STEM education, emphasizing Science, Technology, Engineering, and Mathematics, is a globally recognized framework for equipping students with critical thinking, problem-solving, and creativity as a key competency for addressing 21st-century challenges (Aifan, 2022). Project-Based Learning (PjBL), which emphasizes active, inquiry-based, and collaborative learning through meaningful projects, has emerged as a preferred pedagogy for STEM education worldwide (Culclasure et al., 2019; Aifan, 2022). However, in the Indonesian context, PjBL faces challenges in fully achieving its potential. A lack of advanced technological tools has restricted its ability to provide immersive and interactive learning experiences, limiting STEM education's exploratory and practical nature (Mudinillah et al., 2024; Irfana et al., 2022). This study contributes to the field by addressing this gap by developing and evaluating tailored digital games integrated with PjBL frameworks.

The manuscript explores how these games can enhance student engagement, critical thinking, and collaborative problem-solving, providing a novel approach to STEM education in Indonesia. By bridging the gap between traditional methods and modern technological integration, this research demonstrates the transformative potential of digital games in aligning STEM education with 21st-century demands. This limitation is particularly problematic in contexts where students need hands-on, real-world.

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