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Homepage : https://journal.unesa.ac.id/index.php/dpe
Email : dpe@i-ros.org

e-ISSN 3090-5354
Vol.1, No.3, December 2025

The Effectiveness of Black's Principles with Modeling-based Learning (MbL) to Improve Students' Science Process Skills

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DOI : https://doi.org/10.26740/jdpe.v1i3.45185

Sections Info

Article history:
Submitted: August 18, 2025
Final Revised: August 19, 2025
Accepted: August 19, 2025
Published: August 31, 2025

Keywords:
Black's Principles;
Modeling-Based Learning;
Science Learning;
Science Process Skills.

ABSTRACT

Objective: *This study aims to examine the effectiveness of the Modeling-based Learning (MbL) model in improving students' science process skills (SPS) on the topic of Black's Principle. SPS is essential for mastering STEM, yet remains relatively low among Indonesian students, as indicated by PISA and TIMSS results.* ***Method:*** *The research employed a quasi-experimental design using a pretest-posttest control group design. Two high school classes, each consisting of 30 students, participated in the study. The instruments used included an SPS test and questionnaires that measured skills such as observing, formulating hypotheses, conducting experiments, and interpreting and communicating data. Data analysis involved N-Gain calculations, normality tests, and paired t-tests to confirm statistical significance.* ***Results:*** *The findings revealed that the experimental class taught using the MbL model showed a significant improvement in SPS, with an average N-Gain score of 0.8 (high category). In contrast, the control class, which did not receive MbL-based instruction, only reached an average N-Gain score of 0.5 (medium category). Statistical tests confirmed the significance of these differences, demonstrating the positive impact of the MbL model on SPS development.* ***Novelty:*** *This study highlights the potential of the MbL approach as an innovative and effective teaching model to enhance science process skills at the secondary school level. By integrating modeling activities into learning, the MbL strategy provides students with deeper engagement and better mastery of scientific inquiry processes compared to traditional methods.*

INTRODUCTION

Science education in the 21st century is expected to go beyond conceptual knowledge, cultivating critical, analytical, and evidence-based scientific thinking. The integration of science process skills (SPS) into learning is considered essential to prepare students for global challenges that demand problem-solving, creativity, and innovation (NRC, 2012; Bybee, 2013). Ideally, students should not only master scientific concepts but also be able to design experiments, analyze data, and apply science in real-world contexts, aligning with STEM education goals.

However, international assessments highlight that Indonesian students still perform below the global average in science literacy. Results from the Programme for International Student Assessment (PISA) 2018 placed Indonesia at rank 71 out of 79 participating countries in science (OECD, 2019). Similarly, the Trends in International Mathematics and Science Study (TIMSS) 2019 indicated that many Indonesian students struggle with applying concepts in experimental and problem-solving contexts (Mullis et al., 2020). These findings demonstrate that science education in Indonesia has not yet fully achieved its intended outcomes in developing SPS.