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3D E-Worksheet on Global Warming: Its Impact on High School Students' Critical Thinking Skills

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ABSTRACT

Objective: *This study aims to describe the implementation of the guided inquiry learning model assisted by a 3D e-worksheet on global warming, analyze improvements in students' critical thinking skills after the learning, and determine students' responses to the learning.* ***Method:*** *The study used a pre-experimental design with a pre-test and post-test group without a control group. The subjects were grade X students of SMA Negeri 1 Kebomas in three classes (experimental class and two replica classes). The research instruments included observation sheets for learning implementation, critical thinking tests (pre-test and post-test) based on Ennis indicators, and student response questionnaires. Data were analyzed using normality and homogeneity tests, paired t-tests, N-Gain, ANOVA, Cohen's effect size, and descriptive analysis of responses.* ***Results:*** *Learning implementation was categorized as very good, with meeting percentages of 86.30%, 89.81%, and 90.74%. There was a significant difference between pre-test and post-test scores (Sig. 0.000). The average N-Gain values in the three classes were 0.443, 0.554, and 0.396 (moderate category), indicating increased critical thinking skills. ANOVA results showed Sig. 0.000, meaning improvement varied across classes. Student responses were good, with average percentages above 70%, reflecting interest and new experiences in technology-based physics learning.* ***Novelty:*** *The novelty lies in integrating 3D e-worksheet, supported by PhET simulations, into a guided inquiry framework on global warming to train students' critical thinking skills, with consistency tested across three classes.*

INTRODUCTION

Technological developments and the demands of the 21st century bring the hope that education can shape students who not only master scientific concepts but also possess higher-order thinking skills, particularly critical thinking, collaboration, creativity, and technological and information literacy. Physics learning, as part of the natural sciences (IPA), is ideally designed to hone critical thinking skills so that students can assess information scientifically and make evidence-based decisions (Wulandari et al., 2021; Redjeki et al., 2023). At the same time, the development of physics is closely linked to technological advancements, so physics learning should be relevant, contextual, and able to foster conceptual understanding through real-life experiences close to students' lives (Zakaria et al., 2019; Villayah & Suliyanah, 2025). Therefore, integrating technology into learning is not merely an option but a necessity to create a practical, interactive, and meaningful learning process in the digital age (Idhan et al., 2025; Punzalan & Punzalan, 2025).

In fact, daily human activities contribute to greenhouse gas emissions in the atmosphere and trigger global warming, making this a persistent environmental issue discussed in various countries, including Indonesia (Fajeri, 2018; Dianjaya & Epira, 2020;