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# Development of Technology-Enhanced Guided Inquiry Parabolic Motion Learning Devices with Sport Education to Improve High School Students' Critical Thinking

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**ABSTRACT**

***Objective:*** *This study aims to develop a parabolic motion learning tool based on a guided inquiry model with a sports education approach to improve the critical thinking skills of high school students.* ***Method:*** *This research is a research and development (R&D) study using the ADDIE model, which includes analysis, design, development, implementation, and evaluation. The subjects consisted of 11th-grade high school students involved in both limited and extensive trials. The research instruments included a tool validation sheet, a learning implementation observation sheet, a student response questionnaire, and a critical thinking skills test. Data analysis was conducted using validity, reliability, N-gain, normality, homogeneity, paired t-test, and ANOVA.* ***Results:*** *The results showed that the developed learning tool met the criteria for highly valid with a percentage between 84% and 98%; practical based on the learning implementation category (very good) and student response (87.88%), and effective based on the increase in the N-gain value in the moderate category (0.59–0.62). The statistical test results also showed a significant increase between pretest and posttest scores, and no significant differences between classes, demonstrating the consistent effectiveness of the learning tools.* ***Novelty:*** *The novelty of this research lies in the integration of a guided inquiry model with a sports education approach in physics instruction on parabolic motion to train critical thinking skills through contextual learning based on sports activities, a practice that has not been widely explored in previous research.*

## INTRODUCTION

In this era of rapid modernization and technological development, education is required to prepare students with 21st-century skills to face increasingly complex global challenges. The Partnership for 21st Century Learning framework emphasizes that essential skills students must possess include character, citizenship, communication, collaboration, creativity, and critical thinking (OECD, 2021). Among these skills, critical thinking is a fundamental competency because it plays a role in supporting problem-solving abilities, rational decision-making, and the ability to generate innovative solutions to future challenges. By mastering critical thinking skills, Indonesia's golden generation of 2045 is expected to not only be an adaptive workforce but also visionary individuals with global competitiveness (World Economic Forum, 2020).

Critical thinking skills are crucial because education must essentially shape individuals capable of understanding and solving real-world problems. Students need to be accustomed to critical thinking to analyze information, evaluate arguments, and draw logical conclusions (Saavedra & Ofper, 2012). Facione (2011) defines critical thinking as an intellectual process involving reflective and analytical thinking that encourages students to actively engage in the learning process. Through this process, students are

encouraged to ask questions, develop ideas, and find innovative solutions to complex problems. Therefore, education should not only focus on transferring knowledge but also on developing higher-order thinking skills, which are essential for modern life.

However, empirical evidence indicates that students' critical thinking skills remain relatively low. An international study showed that despite an 18% increase in Indonesia's performance in literacy and mathematics between 2018 and 2022, Indonesia still ranks 62nd out of 70 countries, below the OECD average (OECD, 2023). This situation indicates that Indonesian students' critical thinking skills still need improvement, as reflected in the results of the PISA survey (Budiarti, 2023).

The low PISA scores indicate students' weak mastery of literacy, numeracy, and science skills oriented toward contextual problem-solving. This suggests that students have not received optimal instruction in developing critical thinking skills such as the ability to analyze data, evaluate information, and draw logical conclusions. Research by Handayni et al. (2024) indicates that four indicators of critical thinking skills interpretation, analysis, evaluation, and inference remain in the low category. Research by Khoirunnisa & Dwikoranto (2021) also indicates that students' critical thinking skills in solving physics problems are still relatively low. Furthermore, research by Sari (2016) found that 86.9% of high school students have low levels of critical thinking skills in physics learning.

Preliminary research conducted by researchers also revealed a similar situation in the parabolic motion topic. The data showed that less than 50% of students possessed adequate critical thinking skills across all indicators. A total of 55.55% of students demonstrated interpretive skills, 47.22% understood concepts, 36.11% evaluated, and only 33.33% made accurate inferences. These findings indicate a persistent gap between expected competencies and the actual state of students' critical thinking skills in physics learning, particularly in parabolic motion.

Students' low critical thinking skills are influenced by various factors, both internal and external. Internal factors include individual characteristics, learning motivation, and self-confidence, while external factors include the learning environment and the teacher's teaching approach (Hayati & Setiawan, 2022). One of the main causes of low critical thinking skills is the use of learning models that are less able to encourage active student engagement. Therefore, innovative learning models are needed that can optimally develop critical thinking skills.

One learning model proven to improve critical thinking skills is the guided inquiry model. Research by Hattie & Donoghue (2016) shows that inquiry-based learning strategies significantly contribute to improving critical thinking skills. Zion & Mendelovici (2021) also stated that the guided inquiry approach can help students develop critical thinking skills through a systematic investigative process. Research by Alfieri et al. (2020) showed that the implementation of guided inquiry can improve students' critical thinking skills and academic achievement. Furthermore, research by Furtak et al. (2021) also showed that inquiry-based learning can improve students' critical