Khatulistiwa: Jurnal Pendidikan dan Sosial Humaniora
Volume. 5 Nomor. 2 Juni 2025
e-ISSN : 2962-4037; p-ISSN : 2962-4452, Hal. 144 -148
DOI: https://doi.org/10.55606/khatulistiwa.v5i2.5760
Available online at: https://researchhub.id/index.php/Khatulistiwa

The Influence of the Flipped Classroom-Based Adaptive Learning System on Student Learning Outcomes in Science Subjects at SMP Negeri 3 Ma'rang

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Abstract. *This study investigates the impact of an adaptive learning system based on the flipped classroom model on the learning outcomes of ninth-grade students in Natural Sciences at SMP Negeri 3 Ma'rang. Using a quasi-experimental design, the research compared an experimental group employing adaptive flipped learning with a control group using conventional methods. The results showed a significant increase in posttest scores for the experimental group (mean = 84.83) compared to the control group (mean = 69.25). The adaptive learning model encouraged personalized learning experiences and fostered student engagement. The normalized gain (N-Gain) of 43.6% for the experimental group indicates high effectiveness of the method.*

Keywords: *adaptive learning; flipped classroom; learning outcomes; science education; junior high school.*

Abstract. This study examines the impact of an adaptive learning system based on a flipped classroom model on the learning outcomes of grade IX students in science subjects at SMP Negeri 3 Ma'rang. Using a quasi-experimental design, this study compared the experimental group using adaptive flipped learning with the control group using conventional methods. The results showed a significant increase in posttest scores in the experimental group (mean = 84.83) compared to the control group (mean = 69.25). The adaptive learning model encourages personalized learning experiences and encourages student engagement. The normalized gain (N-Gain) of 43.6% for the experimental group indicates the high effectiveness of the method.

Keywords: Adaptive learning, flipped classroom, learning outcomes, science education, junior high school.

1. BACKGROUND

The rapid development of digital technology in education has led to increased attention to technology-integrated teaching models. Among these models, adaptive learning systems combined with flipped classroom strategies have gained significant momentum due to their personalized nature and potential to improve students' academic achievement (Santoso, 2010), (Raharjo, 2021).

The flipped classroom reconfigures traditional instruction by presenting new material outside of class and leveraging in-class sessions for collaborative practice and teacher feedback (Bergmann & Sams, 2012). When paired with adaptive learning—a method that modifies content based on students' learning progress—this model becomes even more effective in addressing a variety of learning needs (Putro, Fauziah, & Rahayu, 2023). In middle school, a crucial stage where students build fundamental scientific thinking, traditional methods often

Received: 31 Maret, 2025; Revised: 30 April, 2025; Accepted: 30 Mei, 2025; Published: Juni 2025

fail to accommodate individual differences, leading to disengagement and inconsistent outcomes. Thus, integrating adaptive and flipped strategies offers a promising alternative to support inclusive and meaningful science education (Afandi et al., 2019).

Adaptive systems track learner progress in real-time and adjust instructional content accordingly, allowing teachers to provide differentiated learning experiences (Suyantiningsih et al., 2021). Flipped learning models complement this by promoting self-directed learning before class followed by in-class interactions, supporting deeper understanding and the development of critical thinking (McLaughlin, White, Khanova, & Yuriev, 2016), (Susilawati, 2020). This study explores how the integration affects science learning outcomes in ninth grade at SMP Negeri 3 Ma'rang. This study contributes to the discourse on technology-supported inclusive pedagogy that is in line with the Merdeka Belajar curriculum in Indonesia (Ainia, 2020).

2. THEORETICAL STUDY

Adaptive learning refers to the use of digital systems to customize educational experiences based on the needs of individual learners (MacArthur, Metsala, & Shankweiler, 2016). These systems leverage learning analytics to adjust content in real-time, supporting a more personalized and effective teaching approach (Yilmaz, 2017). Artificial intelligence technology often powers these systems, enabling dynamic responses to learner input and recommending appropriate next steps (Flipped Learning Network, 2014).

Flipped classrooms shift direct learning from the classroom to home learning through digital content, allowing in-class time for active and collaborative engagement (Rahman, 2020). This model emphasizes learner autonomy and preparation, as students are expected to engage with the material before class. Studies show that this approach increases motivation, accountability, and depth of learning (Handayani, 2021), (Wardana & Setiawan, 2020).

Science education aims to foster not only conceptual knowledge but also critical thinking, problem solving, and practical skills. Learning outcomes are usually classified into cognitive, affective, and psychomotor domains (Adam, 2023). To maximize achievement in all these domains, educators are encouraged to adopt constructivist and inquiry-based approaches that link theory to practice while maintaining high levels of student engagement.

3. RESEARCH METHODS

This study used a quasi-experimental design with a pre-test-post-test control group approach. The experimental group received instruction through an adaptive learning system integrated with a flipped classroom model, while the control group followed a conventional teacher-centered method.

Group	N	Pre-Test Mean (SD)	Post-test Mean (SD)	Profit N (%)
Experimental	25	63.52 (7.32)	84.83 (5.21)	43.6
Control	24	62.50 (6.91)	69.25 (6.73)	23.5

The research participants were 49 ninth grade students of SMP Negeri 3 Ma'rang. The sample was divided into two groups, namely 25 students in the experimental group and 24 students in the control group. The sample selection was based on class grouping, namely one class as the experimental group and one class as the control group.

The main research instrument was a science achievement test, designed to align with the national curriculum. The test was administered before and after the intervention to both groups to evaluate improvements in learning outcomes.

Students in the experimental group accessed instructional videos and digital materials prior to class meetings. Class sessions focused on problem solving, peer discussions, and teacher-facilitated feedback. In contrast, descriptive statistics for the control group, including means and standard deviations, were calculated to summarize student performance. Inferential analyses using independent sample t-tests were conducted to determine statistical significance between groups. In addition, normalized gain (N-Gain) scores were calculated to assess relative improvement in learning outcomes.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The following table presents the means and standard deviations of the pre-test and post-test scores for both groups.

4.2 Inferential Analysis

An independent sample t-test revealed a statistically significant difference in post-test scores between the experimental and control groups ($p < 0.05$), indicating that the adaptive flipped classroom approach contributed to improved learning outcomes.

4.3 Discussion

These results support the effectiveness of combining adaptive learning systems with flipped classroom strategies. This model allows students to engage with instructional content at their own pace, which likely improves comprehension and retention. In-class activities further reinforce learning through collaborative discussions and direct feedback (Wahyuddin, Umiah, & Quraisy, 2023).

The higher normalized gains in the experimental group reflect the model's ability to differentiate instruction according to student needs. This finding is consistent with previous research highlighting improvements in critical thinking, learner autonomy, and engagement in adaptive and flipped environments.

From a practical perspective, this approach presents a viable method for implementing the Merdeka Belajar curriculum in Indonesia, which encourages flexible and student-centered learning practices. The following is an explanation for the Sub-Sub titles.

5. CONCLUSION AND SUGGESTIONS

This study concludes that the implementation of an adaptive learning system based on the flipped classroom model significantly improves students' academic achievement in science. The combination of technology-based personalization and interactive classroom activities offers a powerful framework for improving student learning outcomes.

These findings support the integration of the model in junior high school settings, particularly under the Merdeka Belajar curriculum, which emphasizes flexible and student-centered education. Future research should explore the long-term impact of this approach and assess its adaptability across subjects and educational levels.

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