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Improving Student Learning Outcomes on the Concept of Momentum and Impulse Using the Discovery Learning Model through a Differentiated Approach at SMA Negeri 1 Gorontalo Utara

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ABSTRACT

This study aimed to improve students' learning outcomes on the topic of momentum and impulse through the implementation of the Discovery Learning model integrated with a differentiated instructional approach. The study employed a classroom action research design involving 34 students of Class X MIA 4 and was conducted in two action cycles. Each cycle consisted of planning, implementation, observation, and reflection stages, with students' learning outcomes assessed through a cognitive achievement test administered at the end of each cycle. The results showed that the predetermined success criterion was not achieved in Cycle I, where only 14 of the 34 students attained the minimum mastery criterion, resulting in a classical mastery level of 41%. After revising the instructional strategy, students' performance improved substantially in Cycle II, with 30 students achieving mastery and a classical mastery level of 88%, exceeding the predetermined success criterion of 80%. These findings indicate that integrating the Discovery Learning model with differentiated instruction effectively improves students' learning outcomes on the topic of momentum and impulse.

Introduction

Improving students' learning outcomes remains one of the primary goals of science education because learning outcomes reflect not only students' conceptual understanding but also their ability to apply knowledge, solve problems, and develop higher-order thinking skills required in the twenty-first century. Recent educational reforms have emphasized the need for learning environments that actively engage students through meaningful inquiry, collaborative learning, and personalized instruction rather than relying solely on teacher-centered approaches (Couch et al., 2015; Hipwell et al., 2023). Consequently, selecting an appropriate instructional model has become a critical factor in enhancing students' academic achievement and learning experiences (Tromp, 2025).

Discovery Learning has been widely recognized as an instructional model that encourages students to construct scientific concepts independently through exploration, investigation, experimentation, and problem solving. Instead of passively receiving information, students actively formulate hypotheses, analyze evidence, and derive conclusions, leading to deeper conceptual understanding and improved scientific reasoning (Sutiani et al., 2021). Previous studies have consistently reported that Discovery Learning enhances students' learning outcomes, critical thinking, and conceptual mastery across various science (Azizah & Samsudin, 2024; Fadlilah et

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al., 2020). Moreover, inquiry-oriented instructional models are considered effective in promoting active learning and supporting the development of scientific literacy and problem-solving skills (Songer et al., 2024).

Increasing diversity in students' learning readiness, interests, and learning preferences has encouraged educators to adopt differentiated instruction. Differentiated instruction emphasizes adapting learning content, instructional processes, and assessment products according to individual student characteristics, allowing every learner to achieve optimal learning outcomes regardless of their initial abilities (Kamarulzaman et al., 2018). Recent empirical studies have demonstrated that differentiated instruction positively influences students' academic achievement, engagement, and classroom participation by providing learning experiences that better accommodate learner diversity (Jebur et al., 2025; Suprayogi et al., 2024). The implementation of differentiated learning has also been shown to improve learning effectiveness in mixed-ability classrooms, where students possess varying cognitive characteristics and learning needs (Chander & Arora, 2025).

Although Discovery Learning and differentiated instruction have each demonstrated positive effects independently, studies integrating both approaches remain relatively limited, particularly in physics education. Discovery Learning emphasizes student autonomy in knowledge construction, whereas differentiated instruction ensures that learning activities are adjusted to students' readiness and learning profiles. The integration of these two approaches therefore has the potential to maximize active participation while simultaneously addressing individual learning differences. However, empirical evidence examining whether Discovery Learning implemented through differentiated instruction can significantly improve students' learning outcomes in physics learning is still insufficient, especially for abstract concepts such as momentum and impulse.

Momentum and impulse are among the most conceptually demanding topics in secondary school physics because students are required to connect mathematical representations with real-world physical phenomena. Without appropriate instructional support, many students experience misconceptions and difficulties in applying these concepts to problem-solving situations. Learning strategies that promote conceptual discovery while accommodating differences in students' learning characteristics are therefore expected to facilitate deeper understanding and improve learning achievement.

Based on these considerations, this study investigates the effectiveness of implementing the Discovery Learning model through a differentiated instructional approach to improve students' learning outcomes on the topic of momentum and impulse. The findings are expected to contribute empirical evidence regarding the integration of inquiry-based learning and differentiated instruction, thereby providing practical implications for physics teachers seeking to create more inclusive and effective science learning environments.

Methods

This study was conducted to examine the effectiveness of implementing the Discovery Learning model integrated with differentiated instruction in improving students' learning outcomes on the topic of momentum and impulse. To achieve this objective, a classroom action research (CAR) approach was employed, allowing instructional practices to be systematically planned, implemented, observed, and refined through iterative cycles. This approach facilitates continuous improvement of classroom instruction based on evidence gathered during the teaching and learning process, making it appropriate for evaluating and enhancing pedagogical interventions in authentic classroom settings.

Research Design

This study employed a classroom action research (CAR) design to improve students' learning outcomes through the implementation of the Discovery Learning model integrated with differentiated instruction. The study was conducted using two iterative action cycles, each consisting of four stages: planning, implementation, observation, and reflection. Reflection at the end of each cycle was used to evaluate the effectiveness of the intervention and to identify improvements required for the subsequent cycle. This cyclical design enables continuous refinement of instructional practices based on evidence collected during classroom implementation and is widely applied to improve learning quality through reflective teaching practices (Couch et al., 2015; Songer et al., 2024).

Participants and Research Setting

The research was conducted at SMA Negeri 1 Gorontalo Utara, Indonesia. The participants were 34 tenth-grade science students (Grade X MIA IV), consisting of 10 male and 24 female students. The class was selected purposively because preliminary classroom observations indicated that students experienced difficulties in understanding the concepts of momentum and impulse and demonstrated relatively low learning achievement.

Intervention Procedure

The instructional intervention integrated Discovery Learning with differentiated instruction throughout both action cycles. Learning activities followed the stages of Discovery Learning, including stimulation, problem identification, data collection, data processing, verification, and generalization. Differentiated instruction was implemented by adapting learning content, learning processes, and learning products according to students' learning readiness and learning characteristics. During classroom activities, students explored physics concepts through collaborative investigations, problem-solving tasks, experimental activities, and class discussions, while teachers provided differentiated guidance and learning resources to accommodate diverse learning needs (Chander & Arora, 2025; Suprayogi et al., 2024; Sutiani et al., 2021)).

Research Instruments

Three instruments were employed to collect research data. First, a learning implementation observation sheet was used to evaluate the fidelity of the instructional implementation during each meeting. Second, a student activity observation sheet was used to assess students' participation, collaboration, and engagement throughout the learning process. Third, a learning achievement test consisting of momentum and impulse problems was administered at the end of each cycle to measure students' conceptual understanding and learning outcomes. The use of multiple instruments enabled comprehensive evaluation of both the learning process and instructional outcomes (Azizah & Samsudin, 2024; Huang et al., 2025).

Data Analysis

The collected data consisted of qualitative and quantitative data. Qualitative data were obtained from classroom observations of teacher performance and student learning activities, while quantitative data were derived from students' learning achievement tests. Observation data were analyzed descriptively to identify strengths and weaknesses of the instructional implementation in each cycle and to formulate improvements for the subsequent cycle. Student learning outcomes were analyzed using descriptive statistics, including mean scores and the percentage of students achieving the minimum mastery criterion. The classroom action research was considered successful when at least 80% of the students achieved the predetermined mastery criterion, indicating that the integration of Discovery Learning and differentiated instruction effectively improved students' learning outcomes. Descriptive analysis of learning performance is commonly used to evaluate the effectiveness of instructional interventions in educational research (Alturki et al., 2021; Avella et al., 2016).

Result and Discussions

The classroom action research was conducted over seven meetings distributed across two action cycles. Cycle I consisted of four meetings, including an initial non-cognitive diagnostic assessment to identify students' learning styles, two instructional meetings, and one post-cycle achievement test. Cycle II comprised two instructional meetings followed by a final achievement test. Data were collected from three sources: (1) classroom observation of learning implementation, (2) observation of student learning activities, and (3) students' cognitive learning outcomes on the topic of momentum and impulse. The results obtained during Cycle I are presented in Table 1.

Table 1
Results of Cycle I Implementation

No.	Instrument	Achievement (%)
1.	Learning implementation	83
2.	Student learning activities	72.5
3.	Cognitive learning outcomes	72

The findings indicate that the implementation of Discovery Learning integrated with differentiated instruction had begun to improve the quality of classroom learning. The implementation fidelity reached 83%, suggesting that most instructional stages were conducted as planned. However, student participation (72.50%) and cognitive learning outcomes (72.00%) had not yet achieved the predetermined success criterion of 80%. Classroom observations revealed that several students still experienced difficulties in independently identifying problems, formulating hypotheses, and connecting experimental findings with the underlying physics concepts. Furthermore, some students were still adapting to learning activities that required greater autonomy than conventional instruction.

Reflection on Cycle I was subsequently used to improve the learning strategy implemented in Cycle II. The teacher provided clearer learning guidance, optimized differentiated learning resources based on students' learning styles, increased opportunities for collaborative discussion, and provided more structured scaffolding during the discovery process. These improvements were expected to facilitate students' conceptual understanding while maintaining active participation throughout the learning activities. The results obtained during Cycle II are presented in Table 2.

Table 2
Results of Cycle II Implementation

No.	Instrument	Achievement (%)
1.	Learning implementation	83
2.	Student learning activities	72.5
3.	Cognitive learning outcomes	72

Compared with Cycle I, all observed indicators showed substantial improvement in Cycle II. Learning implementation increased from 83.00% to 93.00%, student learning activities increased from 72.50% to 84.71%, and students' cognitive learning outcomes improved from 72.00% to 85.29%. The average learning outcome exceeded the predetermined success criterion, indicating that the intervention effectively improved students' understanding of momentum and impulse. Consequently, the classroom action research was concluded after the second cycle because the expected performance indicators had been achieved.

The improvements observed across both cycles suggest that integrating Discovery Learning with differentiated instruction created a more engaging and inclusive learning environment. Students became increasingly active in constructing knowledge through observation, discussion, experimentation, and evidence-based reasoning rather than relying solely on teacher explanations. This finding is consistent with previous studies reporting that Discovery Learning promotes conceptual understanding, scientific inquiry, and meaningful learning by actively involving students in the learning process (Azizah & Samsudin, 2024; Sutiani et al., 2021). Similar improvements in learning outcomes have also been reported when Discovery Learning is supported by inquiry-oriented learning resources and student-centered instructional activities (Fadlilah et al., 2020).

Another important finding concerns the contribution of differentiated instruction to student engagement. Students were grouped according to their dominant learning styles identified through the initial diagnostic assessment. Learners with visual preferences were provided with instructional videos and visual representations, auditory learners explored learning materials through audio-based explanations and discussions, whereas kinesthetic learners engaged in hands-on experimental activities related to momentum and impulse. Providing learning experiences that accommodated students' learning characteristics appeared to increase classroom participation and reduce learning barriers, as reflected in the increase in student activity scores from 72.50% to 84.71%.

These findings support previous research indicating that differentiated instruction enables teachers to accommodate learner diversity by adapting learning content, instructional processes, and learning products according to students' readiness and learning preferences (Kamarulzaman et al., 2018). Recent empirical evidence has likewise demonstrated that differentiated instruction improves academic achievement and student engagement, particularly in heterogeneous classrooms where learners possess diverse cognitive characteristics and learning needs (Chander & Arora, 2025; Jebur et al., 2025; Suprayogi et al., 2024).

The improvement in learning implementation from Cycle I to Cycle II also highlights the importance of reflective teaching in classroom action research. The reflection process enabled the teacher to identify instructional weaknesses and continuously refine classroom practices, resulting in more effective facilitation of students' conceptual discovery. This iterative improvement aligns with contemporary perspectives emphasizing continuous instructional refinement and active learning as essential components of effective science education (Couch et al., 2015; Songer et al., 2024).

Overall, the findings demonstrate that the integration of Discovery Learning with differentiated instruction effectively enhanced classroom implementation, student participation, and cognitive learning outcomes on the topic of momentum and impulse. The combination of inquiry-based learning and differentiated instructional strategies provides opportunities for students to actively construct scientific concepts while receiving learning experiences that are responsive to their individual learning characteristics. These results suggest that such an instructional approach represents a promising alternative for improving physics learning in heterogeneous secondary school classrooms.

Conclusions

The findings of this classroom action research demonstrate that integrating the Discovery Learning model with differentiated instruction effectively improved the quality of physics learning on the topic of momentum and impulse. The implementation of the instructional model resulted in increased learning implementation fidelity, higher student participation, and improved cognitive learning outcomes, with the average achievement increasing from 72.00% in Cycle I to 85.29% in Cycle II, exceeding the predetermined success criterion. These improvements indicate that combining inquiry-based learning with differentiated instructional strategies enables students to actively construct scientific concepts while accommodating diverse learning needs and characteristics. Therefore, this integrated approach can serve as an effective instructional alternative for improving learning outcomes in heterogeneous secondary school physics classrooms and may be adapted to other science topics that require active conceptual understanding.

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