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Implementation of the discovery method in teaching newton's second law for physics education students

Kristiani[1]*, Paulo Alves Cabral[2], Pedro Correia[3]
[1,2,3] Universidade Nacional Timor Lorosa'e, Timor-Leste
*Corresponding Author e-mail: kristiani.2021@untl.edu.tl

Abstract: *This study examines the implementation of the Discovery Learning method in Micro Teaching courses for Physics Education students at Universidade Nacional Timor Lorosa'e (UNTL). Discovery Learning is a student-centered approach that encourages learners to construct their own understanding through experimental activities, while the teacher serves primarily as a facilitator. The purpose of this research is to determine whether this method can be easily understood and applied by students. This study employs a qualitative design with a case study approach. Data were collected through classroom observations and documentation analysis, then analyzed descriptively to identify patterns in student performance and teaching practices. The findings reveal that most students were able to design systematic lesson plans based on the Discovery Learning framework. However, a small number of students experienced difficulties in implementing the method sequentially during teaching practice. Despite these challenges, the use of simple and easily accessible materials proved that the method can be effectively applied in classroom settings. Overall, the study concludes that Discovery Learning is feasible and beneficial for Micro Teaching students, as it promotes deeper conceptual understanding, particularly in learning complex topics such as Newton's Second Law.*
Keywords: *Discovery Method; Lesson Plan; Physics Concepts; Newton's Second Law*

Abstrack: This study explores the implementation of the Discovery Learning method in Micro Teaching courses for Physics Education students at Universidade Nacional Timor Lorosa'e (UNTL). Discovery Learning is an instructional approach in which students actively construct their own understanding by discovering concepts through experimental activities, while the teacher functions primarily as a facilitator. The purpose of this study is to determine whether the discovery method can be easily learned and applied by students. This research employs a qualitative design using a case study approach. Data were collected through classroom observations and documentation analysis, which were then analyzed descriptively to identify patterns in students' learning and teaching practices. The findings indicate that most students were able to develop systematic lesson plans in accordance with the Discovery Learning framework. However, a small number of students encountered difficulties in implementing the method sequentially during teaching practice. Despite these challenges, the use of simple and easily accessible materials demonstrates that the discovery method can be effectively applied in classroom settings. Therefore, it is expected that through the application of this method, students will achieve a deeper understanding of physics concepts, particularly Newton's Second Law.
Kata Kunci: Metode Discovery; Rencana Pembelajaran; Konsep Fisika; Hukum Kedua Newton

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INTRODUCTION

In instructional practice, teachers frequently continue to rely on lecture-based or traditional methods, in which content delivery is conducted orally through structured verbal explanations (Dulyapit & Lestari, 2024). The persistence of this approach is often attributed to teachers' limited capacity to design comprehensive lesson plans (Mubarok & Apriani, 2022), as well as the lack of laboratory facilities in schools. Consequently, there is a pressing need for more effective and efficient instructional methods that are better suited to the conditions of schools, particularly in Timor-Leste. At present, various instructional approaches are recognized for their potential to enhance students' motivation and engagement, especially in physics, a subject frequently perceived as difficult to comprehend. One method that aligns well with the contextual realities of schools in Timor-Leste is the discovery method. This approach, often referred to as discovery learning, emphasizes simple scientific inquiry processes that foster students' independence in conducting experiments, enabling them to derive answers to research problems based on their own observations (Istiadah et al., 2022). In teaching Newtonian concepts, however, instructors often require students merely to memorize theoretical principles or formulas. In contrast, Ningsih (2023) argues

that learning activities involving observation, question formulation, data collection, analysis, and conclusion drawing are essential for fostering critical thinking and problem-solving skills.

Specifically, Newton's Second Law explains the relationship between the resultant force (FR), mass (m), and acceleration (a). The law states that the acceleration produced by the resultant force acting on an object is directly proportional to the magnitude of the force, occurs in the same direction as the force, and is inversely proportional to the object's mass. Based on this principle, it can be inferred that the greater the force applied to an object, the greater the acceleration it experiences. Mathematically, Newton's Second Law is expressed as follows:

$$a = \frac{F_R}{m}$$

To verify the validity of the formula, an experiment can be conducted using various simple media and materials. Instructional decisions, including the formulation of conclusions, are often influenced by students' responses during the learning process. Sanjani (2020) asserts that the teacher's role is to guide, direct, encourage (provide stimulation), and manage the progression of all classroom activities to achieve the predetermined objectives. In every learning activity, students are required to be more active and creative, as they constitute the center of the learning process. Consequently, students' understanding of Newton's Second Law can be optimized. The instructional method that is most appropriate for implementation under these conditions is the discovery method. According to Khasinah (2021), the advantages of the discovery method are as follows:

1) It motivates and actively engages students in the learning process,
2) It enhances students' curiosity, and
3) It develops students' learning skills.

Furthermore, Wotheysen et al. (2025) add that when teachers implement this method, students can actively participate in practical activities, design experiments, and independently formulate conclusions.

Despite its advantages, the discovery method also has several limitations. Among these is that students with low motivation toward conceptual understanding tend to be less active during group discussions and question-and-answer sessions (Sinaga, 2022). In addition, Anjaeni (2021) notes that the learning process requires a considerable amount of time, the method is less suitable for large classes, and it predominantly supports cognitive development rather than other learning domains.

According to Budiastuti et al. (2023), the implementation of the discovery method in instructional practice involves several structured stages, as outlined below:

a) Stimulation

At this initial stage, the teacher motivates students by posing questions that stimulate their interest in the material to be learned, encouraging them to read relevant resources, and engaging in learning activities that prepare them for problem-solving, thereby fostering interactive exploration of the subject matter.

b) Problem Statement

At this stage, the teacher provides opportunities for students to identify as many problems as possible that are relevant to the learning objectives. These problems are then formulated into hypotheses, allowing students to propose tentative answers based on their prior knowledge without immediate verification.

c) Data Collection

To test the validity of the hypotheses, students are given the opportunity to gather information through literature review, observation, interviews with resource persons, independent experimentation, and other relevant methods.

d) Data Processing

Data processing involves organizing the collected information through interviews and observations, followed by classification, tabulation, calculation, and interpretation at a certain level of confidence.

e) Verification

At this stage, students test the validity of their hypotheses by identifying concepts, theories, rules, or understandings derived from examples encountered in everyday life.

f) Generalization

In the final stage, students draw conclusions that address the problem after the verification process has been completed. Based on the verification results, general principles underlying the findings are formulated.

This study was conducted to align with the conditions of schools in Timor-Leste, particularly public schools that lack complete physics laboratory facilities, and to facilitate both teachers and pre-service physics education students in conducting instructional activities. The research questions guiding this study are as follows:

- Can the discovery method be easily learned by pre-service physics education students at UNTL?
- Can simple materials effectively support teachers in implementing the discovery method, particularly in teaching the concept of Newton's Second Law?

The objectives of this study are:

- To determine whether the discovery method can be easily learned by microteaching students in physics education at UNTL in preparing lesson plans.
- To examine whether simple materials can facilitate microteaching students in applying the discovery method in instructional activities, particularly in the context of Newton's Second Law.

RESEARCH METHOD

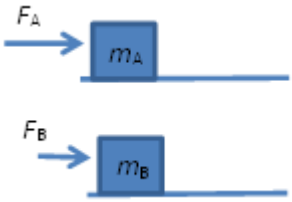
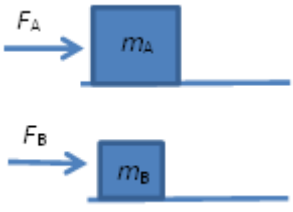
The method employed in this study is Classroom Action Research (Penelitian Tindakan Kelas—PTK) in the form of an integrated simultaneous model. In this approach, teachers or pre-service teachers do not act as the initiators of the research; instead, the research problem is formulated by the researcher (external party). The researcher is responsible for completing observation sheets based on trial teaching sessions conducted by the students. Prior to the implementation phase, participants were instructed to design lesson plans grounded in the procedural stages of the discovery learning method, utilizing simple instructional materials. Subsequently, the students carried out teaching activities and were directly involved in the research process, both in the action (implementation) phase and in reflective evaluation.

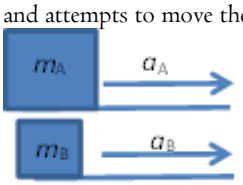
The sample of this study consisted of five pre-service physics teachers enrolled in the microteaching course at Universidade Nacional Timor Lorosa'e (UNTL). These participants had previously received training on the implementation of the discovery method and were scheduled to undertake their teaching practicum in senior high schools in Timor-Leste in the following semester.

RESULTS AND DISCUSSION

Based on the procedural stages of the discovery method, a lesson plan on Newton's Second Law was developed. This lesson plan was collaboratively discussed and designed by five participants; however, its implementation was carried out individually. The lesson plan is presented in the following table:

Table 1. Lesson Plan

No	Learning Stage	Classroom Activities
1	Objectives	Students are able to determine the relationship between force, mass, and acceleration in Newton's Second Law. Students are able to formulate Newton's Second Law as $F = m \cdot a$.
2	Motivation	The teacher motivates students by asking: when you are inside a car, what happens when the car suddenly stops? (we tend to maintain our position to avoid falling).
3	Problem Formulation	What is the relationship between force, mass, and acceleration in Newton's Second Law? What is the formula of Newton's Second Law?
4	Hypothesis	The teacher provides opportunities for students to answer the problem formulation questions (students' answers may not necessarily be correct).
5	Experiment and Observation	**Experiment A** The teacher prepares two blocks with equal mass ($mA = mB$) and applies different forces ($FA > FB$).  **Observation Results:** Block A moves farther than Block B; the acceleration of Block A is greater than that of Block B. **Conclusion:** Force is directly proportional to acceleration ($F \sim a$). **Experiment B** The teacher prepares two blocks with different masses ($mA > mB$) and applies equal forces ($FA = FB$).  **Observation Results**: Block B moves farther than Block A; the acceleration of Block B is greater. **Conclusion**: Mass is inversely proportional to acceleration $m \sim \frac{1}{a}$.

		Experiment C The teacher prepares two blocks with different masses ($mA > mB$) and attempts to move them with equal acceleration ($aA=aB$).  **Observation Results**: Block A requires a greater force than Block B. **Conclusion**: Mass is directly proportional to force ($m \sim F$).
6	Drawing Conclusions	From the experiments, it is concluded that: force is directly proportional to acceleration ($F \sim a$); mass is inversely proportional to acceleration ($m \sim \frac{1}{a}$); and mass is directly proportional to force ($m \sim F$). Therefore, Newton's Second Law is formulated as $F = m \cdot a$.
7	Application in Daily Life	Examples include: pushing a stalled car collectively to make it move, and applying greater force in bowling to knock down more pins.
8	Evaluation	The teacher asks several questions: What is Newton's Second Law? If a cart of 30 kg is pushed with a force of 45 Joules and then an additional 60 kg load is added, how does its acceleration change? A 750 g object moves with an acceleration of 5 m/s²; what is the force acting on it? Provide examples of applications of Newton's Second Law. How does acceleration change if mass increases?

The data collection instrument used in this study was an observation sheet, as presented in the following table:

Table 2. Observation Sheet

No	Activity	Score (0/1)	Remarks
1	Motivation: Asking what happens when a car suddenly stops	1	R
2	Problem Formulation: Relationship between force, mass, and acceleration; Newton's Second Law formula	1	R
3	Formulating Hypothesis	1	R
4	Conducting Experiment A	1	R
5	Observation Results	1	R
6	Conclusion of Experiment A	1	R
7	Conducting Experiment B	1	R
8	Observation Results	1	R
9	Conclusion of Experiment B	1	R
10	Conducting Experiment C	1	R
11	Observation Results	1	R
12	Conclusion of Experiment C	1	R
13	Drawing Overall Conclusion	1	R
14	Providing Real-life Applications	1	R
15	Alignment of Teaching Sequence with Lesson Plan	1	R
16	Time Allocation Suitability	1	R

Notes:
Score 1 = activity conducted
Score 0 = activity not conducted

Based on classroom observations, it was found that among the five participants, two did not fully follow the sequence outlined in the lesson plan. One participant provided motivation after the hypothesis stage rather than at the beginning, while another began the lesson with motivation and only subsequently wrote the learning objectives on the board. However, such deviations from the prescribed sequence in the discovery method do not constitute significant errors. The most critical aspect is that all procedural steps of the method were successfully implemented.

The allocated instructional time was consistent with the planned duration, namely 45 minutes. The overall success rate for the five participants in the teaching trial was 100%, indicating that all activities specified in the lesson plan were executed, and the implementation was considered successful.

Following the teaching sessions, interviews were conducted to assess participants' readiness in applying the discovery method. The interview questions had been prepared in advance by the researcher. The findings revealed that pre-service teachers found the discovery method highly supportive in designing lesson plans. Moreover, the method was perceived as highly beneficial, as it promotes students' active engagement and independence in conducting experiments and drawing conclusions. The use of

simple and easily accessible materials was found to effectively substitute laboratory activities, enabling students to understand learning concepts in accordance with the intended instructional objectives.

CONCLUSION

Based on the findings of this study, it can be concluded that the discovery method can be readily learned by physics education students at Universidade Nacional Timor Lorosa'e (UNTL) in preparing lesson plans. Furthermore, the use of simple and accessible materials can effectively support teachers and pre-service teachers in implementing the discovery method in instructional activities, particularly in teaching the concept of Newton's Second Law.

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