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Using Discovery Learning Strategy as A Teaching Method to Enhance Conceptual Mastery Among Polytechnic' Engineering Science Students in Learning Linear Motion

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Abstract

The fundamental goal of all education worldwide is for students to have a conceptual knowledge of concepts. Students' conceptual challenges with science topics have become the primary concern of science educators. Since physics is the primary science topic, a strategy to strengthen students' conceptual understanding is necessary. Thus, a teaching strategy for enhancing students' conceptual understanding is required. Discovery learning is one of the methods used to enhance conceptual knowledge. This study is an experimental study with a pretest-posttest design for one group. Its objective is to determine whether implementing discovery learning as a teaching strategy can enhance students' conceptual mastery. This study's subjects are 44 engineering science students from Polytechnic Sultan Idris Shah. The study's data collection approach is a test. The research design is a one-group pretest-posttest design, which means that only one group gets treatment. The pre-test and post-test scores and N-Gains scores measure how well the treatment worked. Data were collected from August through October 2022. The results reveal that students' post-test scores improved compared to the pre-test. In addition, data analysis has determined that using the discovery learning model might raise students' N-gain scores, with a medium category of $0.30<g\leq0.70$.

Keywords: Discovery learning, conceptual mastery, physic, cognitive

1. Introduction

In education, conceptual understanding is necessary for students to comprehend any science subject, particularly physics. Physics is seen as a challenging subject, and contradictory student perspectives and difficulties usually accompany it. Students struggle to comprehend fundamental physics' concepts such as motion, mechanics, electricity, magnetism, thermodynamics, waves, and optics as a result (Badruldin & Alias, 2022).When students discover contradiction or incompatibility in applying a concept, this presents the greatest obstacle to their conceptual mastery in physics. It is difficult for students to comprehend and apply the studied physics theory. Before learning a new topic in physics, students will have encountered the concept or phenomenon in their everyday life. Students tend to place their faith in their logical thinking and concepts, which they regard as answers for their experiences. This

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situation hinders students' ability to comprehend a newly introduced physics concept in their lecture (Reddy & Panacharoensawad, 2017). Understanding forces is essential to comprehending motion and how energy may be transferred. Furthermore, a conceptual understanding of forces is essential to enter various engineering disciplines. However, despite the importance of forces and motion in physics and engineering, many students at secondary and university levels struggle to grasp this concept (Alias & Ibrahim, 2015; Badruldin & Alias, 2022). To improve students' understanding of force and motion, lecturers must propose an alternate learning model.

Numerous variables can contribute to a lack of force and motion conceptual mastery, including the competence of educators, students, and instructional approaches. Students' rote memorization techniques, inability to check further the correct answer and lack of mathematical formulas are also several factors contributing to a lack of conceptual mastery in physic learning (Sulman et al., 2022). All of these indicate that one solution is applying suitable learning models Therefore, the learning model significantly affects students' conceptual understanding, particularly concerning force and motion (Rozal et al., 2021). Implementing the Discovery Learning model in physics learning is an alternative measure to improve students' conceptual knowledge. It is asserted that discovery learning as a teaching strategy represents the most effective solution for learning in diverse contexts and the future (Anisa et al., 2017; Gunawan et al., 2021; Hanafi, 2016). This model is a method of teaching in which the learning process enables the lecturer to allow students to find themselves, develop scientific thinking, integrate a concept or principle, and engage in creative learning (Setiawati et al., 2021). According to research, discovery learning enhances scientific learning since it is an educational technique in which students do observations, experiments, or other scientific tasks to conclude the scientific inquiry (Damayanti et al., 2016; Rosnidar et al., 2021). Therefore, this research aimed to investigate the effect of Discovery Learning as a teaching strategy on engineering science students' conceptual mastery of linear motion.

2. Theoretical Framework

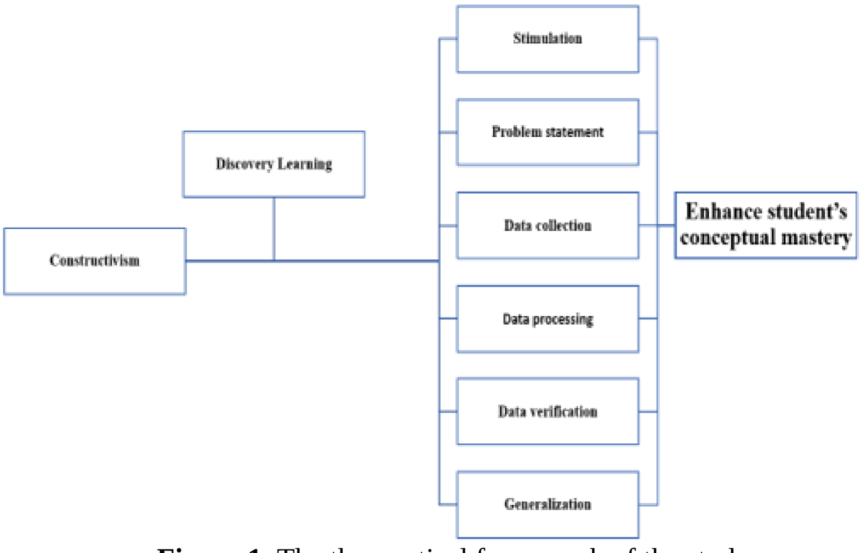

Figure 1. The theoreotical framework of the study

Constructivist Theory (Bruner, 1961) underpinned this study. This approach emphasizes students' development of their understanding through classification-based information processing and comprehension. Further, it was stated that discovery learning is a way in which students independently discover and construct knowledge. In contrast with the traditional methodology, in which knowledge is transmitted from instructor to student, this approach emphasizes independent learning. Constructivist beliefs emphasize acquiring knowledge within a meaningful context (Liu, 2019). Traditional education produces simply listeners and not learners. Consequently, students are not accustomed to learning alone. Students solely receive instruction from the teacher. Class time constraints prevent pupils from reaching their full potential.

However, when students are engaged in discovery learning, they are supposed to be able to exercise self-control in their learning process. The more effectively students manage time, the higher the quality of their education and its potential (Suratno et al., 2019). Students who have demonstrated learning independence are actively engaged in maximizing their learning chances and capacities. Thus, this theory can provide support for this investigation. Discovery learning consists of six phases, including stimulation, presentation of the problem, gathering of data, processing of data, verification, and generalization, which can be expressed in a good teaching plan for discovery learning (Syolendra & Laksono, 2019). In this study, the Stimulation stage is where the instructor initiates the teaching and learning process by posing questions.

According to research, the stimulation creates an interactive learning space that will empower students to examine the topic more effectively (Kasmiana et al., 2020; Mu'affifah & Prasetyo, 2018). Students are given opportunities to identify difficulties associated with the subject matter during the problem statement phase. Then, one was selected and formulated a quick answer as the solution to the problem. During the data collection stage, students explore resources to find information about the problems. Teachers allow them to collect as much pertinent data as possible to demonstrate whether or not the solution to the answer is valid. By examining the literature, analyzing the materials, researching the resource, and conducting their tests, it is possible to gather data (Arya Wulandari et al., 2018; Hanafi, 2016; Kasmiana et al., 2020; Mu'affifah & Prasetyo, 2018).

During this phase, students process the facts and information obtained through various resources and subsequently interpret them. Next, verification is the stage where students thoroughly study whether or not the solution has been proven based on how the data was processed. The principle of generalization is subsequently explained in light of the verification outcome (Setiawati et al., 2021). Finally, this stage highlights students concluding the problems and finalizing the answer as the solution to the problems that they investigated. With this discovery learning strategy, knowledge construction can be more significant, students may reach predicted conclusions, and student understanding may be embedded in their minds for a long time. Despite all the advantages of this model, this theory also explains numerous disadvantages, such as the fact that it can yield incorrect results and waste time due to its slow implementation (Ana, 2019). Therefore, instructors must provide guidance on work procedures, activity components, and learning objective attainment to counteract the effects of Discovery Learning's deficiencies. This theory also serves as the foundation for this study, as the basic idea of constructivism supports the study's goal of improving students' conceptual mastery in a non-traditional teaching environment while employing a specially designed teaching style known as the Discovery learning strategy (refer to Figure 1).

3. Conceptual Framework

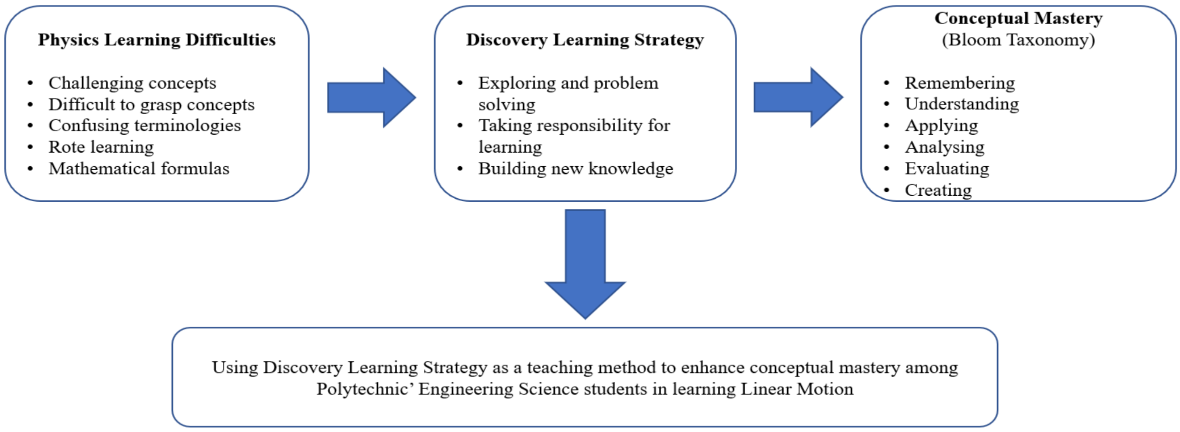

Figure 2. Conceptual framework of the study

The conceptual framework (refer to Figure 2) illustrates the use of the Discovery learning technique to improve conceptual mastery of learning Linear Motion among students. However, physics is a complex subject, and students' alternate perceptions and problems that contradict physics' basics are constantly present (Badruldin & Alias, 2022). Furthermore, high school and university students have trouble understanding force and motion, despite their relevance in physics and engineering (Alias & Ibrahim, 2015). Therefore, implementing the concept is the most challenging aspect of conceptual physics knowledge (Diyana et al., 2020). Following this, rote learning can worsen challenges in acquiring physics themes for students who struggle to understand mathematical formulas and physics vocabulary (Liu, 2019; Reddy & Panacharoensawad, 2017).

Therefore, a teaching strategy is necessary to enhance the conceptual understanding of physic (Kasmiana et al., 2020). Discovery learning is an instructional strategy that enables students to construct and discover their ideas and become more engaged in the classroom. Through discovery learning, the student's memory system absorbs, analyzes, and recalls the knowledge given (Putriani & Rahayu, 2018). In this study, discovery learning as a teaching strategy is utilized to enhance conceptual mastery in physic learning. The conceptual mastery is based on the revised bloom taxonomy, namely as remember (C1), understanding (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6). In addition, the revised bloom taxonomy instructs educators to arrange learning objectives as references in measurements and assessments (Krathwohl, 2002).

Concerning physics learning, it is known that physics studies physical and abstract objects and concrete, and it is difficult for students to understand. Thus, Revised Bloom's Taxonomy (RBT) in a two-dimensional frame provides a framework for developing the research instrument (Poluakan et al., 2019). Given the above explanations, it is crucial to conduct a study using discovery learning as a teaching strategy to strengthen students' conceptual understanding of linear motion.

4. Literature Review

Physicists have made significant contributions to a massive variety of breakthroughs that are shaping modernity, as well as to the explanation of several everyday phenomena. However, despite its significance, physics is the least chosen scientific topic, and students need help to grasp its concepts(Bello, T.O.; Opaleye, O.s.; Olatunde, 2018). Several variables likely contribute to the insufficient knowledge of physics concepts. First, all-encompassing ideas are conveyed only via the lecture process utilising rote learning methods, and the students' first competency is embedded firmly without future fact-checking (Sulman et al., 2022). Consequently, there is a shift toward utilising creative or strategic methods to improve students' conceptual comprehension and physical knowledge (Suranti et al., 2017). Discovery Learning, as one of the teaching approaches, may improve students' conceptual comprehension and enable them to grasp key ideas or frameworks for a subject via active engagement in the learning process (Gunawan et al., 2021; Yamashita et al., 2016). Discovery learning is a kind of education that enhances the pedagogical skills of instructors and allows students to generate their knowledge. Discovery is a component of discovery learning, which assists pupils in learning and information transfer (Miatun & Muntazhimah, 2018). This discovery-based learning helps pupils to explore and build their knowledge (Putriani & Rahayu, 2018). According to the preceding definition, this research validates the utilisation of discovery learning as teaching strategy to enhance students' conceptual grasp of linear motion.

5. Methodology

This study adopted a quasi-experimental, one-group, pretest-posttest design. The research sample comprises 44 Polytechnic Sultan Idris Shah first-year Engineering Science students selected randomly. The collection of data started between August and October 2022. The instrument comprised thirty multiple-choice questions based on Revised Bloom's Taxonomy to evaluate conceptual mastery. The test instrument consisted of six components such as remembering (C1), understanding (C2), applying(C3), analysis (C4), evaluation (C5), and creation(C6) (Krathwohl, 2002). After obtaining pre-and post-test score, the researcher used the normalized gain score algorithm (N-Gain) to calculate conceptual mastery. A normalized gain score (N-Gain) provides insight into improving students' conceptual mastery prior to and during the test (Hake, 1998).

Discovery learning is implemented as an instructional technique through stimulation, problem identification, data collection, data processing, verification, and generalization. Stimulation initiates the learning process by combining the earliest phases of the discovery learning technique. At this stage, the instructor offers problems and employs out-of-the-ordinary examples to probe the students' first understandings. (Ana, 2019).

The second part of the discovery learning model is generating conflicting situations so students can detect them. After the lecturer outlines the origins of conflict situations, students can express their thoughts. The second phase of the discovery model combines data collection, data processing, verification, and generalization with the completion phase (Gunawan et al., 2021; Nisrina et al., 2017).

According to Appendix A, the discovery learning process generally consisted of five steps in the context of this investigation (Arya Wulandari et al., 2018; Hendrik & Minarni, 2017a).

Table 1. N-gain Scores

N-Gain	Interpretation
g>0.70	High
0.30<g≤0.70	Medium
g≤0.30	Low

6. Result and Discussion

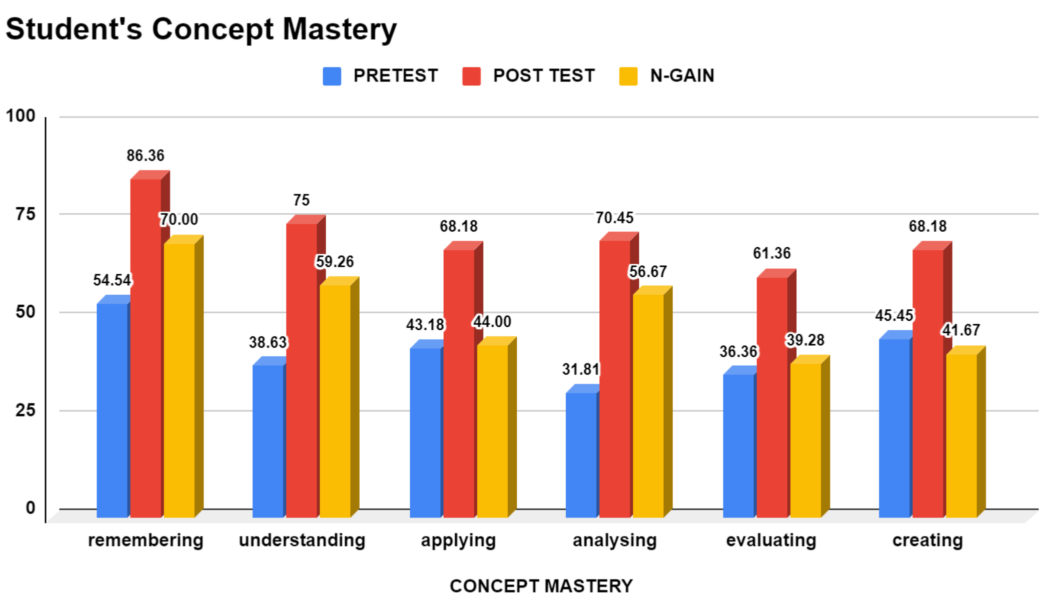

Figure 3. Pre-test, post-test and N-Gain score of conceptual mastery

Figure 3 represents the N-Gain score, which shows students' conceptual mastery progress. The outcome of the post-test exceeds that of the pre-test. Students' conceptual mastery may also improve due to the discovery of learning tools that assist them in discovering their explored conflict issues(Gunawan et al., 2021; Nisrina et al., 2017). This conclusion suggests that discovery-based learning affects students' conceptual mastery in line with previous research findings(Hendrik & Minarni, 2017b). The study's findings were consistent with (Anisa et al., 2017) which demonstrated that discovery learning improved students' comprehension of complex concepts.

Figure 3 depicts how this discovery-based learning as a teaching strategy could help students acquire a deeper conceptual understanding of linear motion. The remembering aspect

(C1) has increased from 54.54% to 86.36%. According to N-gain data, the value is 0.70 per cent. As this was the lowest category, the difficulties remained very straightforward. It did not attempt to grasp or apply the phrase, title, or formula; it just remembered or identified them. It improves learning processes by requiring pupils to retain and acquire information (Sagala & Andriani, 2019). The understanding aspect (C2) rose from 38.63% to 75%. The achieved N-gain is 59.26, or 0.59%, which is in the moderate range. Understanding is a process that occurs as a result of learning and thinking since the ability to comprehend entails grasping the subject's significance and meaning. Findings show that students could understand and summarize a particular question's main idea to find the solution (Jacob, 2017).

Due to the need for more information to comprehend the questions, it was discovered that students' mastery of concepts in comprehending the presented material still required improvement. Consequently, students must examine the questions presented (Heryani et al., 2021). The principles that students must master to apply (C3) will be more complicated than those in C1 and C2. The ability to apply is to carry out and utilize methods under certain circumstances. From 43% to 68.18%, C3 varied. The calculated N-gain is 44%, or 0.44, placing them in the middle category. The principles that C3 aspect students must learn are more complex than those in C2. The analysis results indicate that the C3 criterion is inferior to the C2 criterion because students prefer questions that require them to use formulas or perform calculations over those that require them to comprehend concepts (Heryani et al., 2021; Jacob, 2017).

Moreover, analysis is this study's fourth most crucial aspect (C4). The concept outlined in this element will be significantly more complicated than in C3. The data analysis findings revealed that the percentage of students who mastered the C4 concept ranged from 31.81% to 70.45%. N-gain results were 56.67 %, or 0.57. Based on the analysis results, the capacity to analyze is a medium due to students' difficulty relating concepts to the questions posed (Heryani et al., 2021; O’Dwyer et al., 2015). The evaluation and creating aspect is the highest domain in the revised bloom taxonomy. Evaluation ranges from 45.45% to 68.18%, and the creating aspect varies from 33.36 to 61.38 %. The N-gain results of 0.39 and 0.40 indicate that the conceptual mastery of students is at low to medium level. The scores also show that students must analyze certain situations, ideas, thoughts, or solutions by comparing them to set requirements and guidelines (Alias & Ibrahim, 2015; Gunawan et al., 2021; Heryani et al., 2021).

This study found that discovery learning enhances students' conceptual mastery of linear motion. In addition, discovering oneself makes learning more accessible(Hendrik & Minarni, 2017). The discovery learning model facilitates the search for potential solutions. This study's findings also demonstrate that discovery learning is the most effective instructional technique for developing student concept comprehension. Based on the findings of this study, researchers ensure that conceptual mastery of students is consistent with the usage of discovery learning.

7. Conclusion

The study showed that students' conceptual competence has increased moderately and demonstrated how using resources from the discovery learning model can help students better understand concepts. By employing discovery learning as a teaching approach, students can better comprehend how the taught material is structured (Damayanti et al., 2016; Gunawan et al., 2021; Heryani et al., 2021; Putriani & Rahayu, 2018). Therefore, the discovery-based teaching technique provides students to comprehend the topic of linear motion better. Students have a deeper conceptual understanding of linear motion when the discovery learning strategy is used as a teaching technique. Thus, it is highly encouraging that educators continue implementing effective teaching methods or approaches in teaching physic topics. Future research is expected to see the outcome of using discovery learning in enhancing conceptual mastery through a quasi-experimental research design with an experimental and control group. In addition, if the study is approached ethnographically and evaluates the students' perceptions of the use of discovery learning strategy in learning, a more detailed analysis may be outlined. It will help educators prepare to ease the flow of Discovery learning's activities or tasks for biology teaching and learning. In conclusion, the study benefits educators in a few aspects as instructional designers for learning material. First, they should be able to provide best practices for instructional design because the learning efficiency depends on the type of learning material used. It does not matter how simple a learning material is, but if its properties do not disturb the content, it is cooperative for the lesson. It also helped us identify which element of the teaching strategy is linked to students' advancement in physics. The results of this study have significantly contributed to teaching and learning concerning the physic topic and the body of literature on the conceptual knowledge of the physic subject.

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Appendix A

Step of Discovery learning	Topic	Activity(s)
Simulation	Description on the use of Linear Motion in our daily and review of Linear Motion	Students are given a brief glance of the film about the Linear Motion
Problem Identification	Linear motion and formulae question	Students identify learning material difficulties in groups
Data Collection	Linear motion graph problem-solving instruction	Linear motion graphs will be discussed. Students receive a discussion page with 3 linear motion graphs
Data Processing	Graph analysis and problem solving	Students answer data processing group questions.
Verification	Student answer's analysis	After discussing a solution, students draw conclusions
Generalization	Draw Conclusion	Discussion in the form of questions and answers