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# Analysis of High School Students' Learning Difficulties in Understanding the Mechanics Concept

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**ABSTRACT**
Students have difficulty learning to understand the concept of mechanics. This is due to not having mastered the prerequisite skills. This study aims to determine the difficulties of students in understanding and mastering mechanical material. This study uses a descriptive method with quantitative and qualitative approaches. The subjects of this study were 18 high school students, both private and public in Yogyakarta, which were taken using a stratified random sampling technique. The steps of this research include finding references, determining subjects, making questionnaires, distributing questionnaires, analyzing data, and concluding. The instrument used is a questionnaire with answers that can be in the form of choices, opinions, and/or suggestions. The results of the study show that most students considered physics to be a difficult subject, especially the concept of mechanics. The concepts of mechanics that are considered difficult are rotational dynamics and rigid body equilibrium; impulse, momentum, the law of conservation of energy, and fluid dynamics. The learning method applied by the teacher is not appropriate because it only provides material without a more complete explanation. Students have difficulty physics learning on mechanics material because of their perception and inappropriate learning methods.

**INTISARI**
Banyak siswa yang mengalami kesulitan belajar dalam memahami konsep mekanika. Hal ini disebabkan tidak dikuasainya keterampilan prasyarat. Penelitian ini bertujuan mengetahui kesulitan siswa dalam memahami dan menguasai materi mekanika. Penelitian ini menggunakan metode deskriptif dengan pendekatan kuantitatif dan kualitatif. Subyek penelitian ini yaitu 18 siswa SMA baik swasta maupun negeri di Yogyakarta yang diambil dengan teknik stratified random sampling. Langkah penelitian ini meliputi mencari referensi, menentukan subyek, membuat kuisioner, menyebarkan kuisioner, menganalisis data, dan menyimpulkan. Instrumen yang digunakan berupa angket dengan jawaban dapat berupa pilihan, pendapat, dan/atau saran. Hasil penelitian menunjukkan kebanyakan siswa menganggap fisika merupakan mata pelajaran yang sulit khsusunya pada konsep mekanika. Adapun konsep mekanika yang dianggap sulit yaitu dinamika rotasi dan kesetimbangan benda tegar; impuls, momentum, dan hukum kekekalan energi, serta fluida dinamis. Metode pembelajaran yang diterapkan oleh guru kurang tepat karena hanya sekadar memberikan materi tanpa penjelasan yang lebih lengkap. Siswa mengalami kesulitan belajar fisika pada materi mekanika karena persepsi yang mereka ciptakan sendiri dan metode pembelajaran yang kurang tepat.

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## A. Introduction

Physics is one of the topics that discusses natural phenomena, both real and abstract which are packaged in a collection of facts, concepts, and principles [1-3]. In physics learning, students need to understand basic concepts, so that they are able to solve the problems they face. However, there are still many students who think that physics is one of the difficult subjects to understand [4]. Most of the difficulties in learning physics are because the basic concepts given are not in line with existing theories [5]. This concept error must be avoided in learning physics.

In physics learning, problem solving ability is one of the indicators in understanding physics concepts. In fact, students more often directly use mathematical equations without doing analysis, guessing formulas, and memorizing sample questions to work on physics questions given by the teacher [6]. This causes students to have difficulty when dealing with complex problems. In addition, students still often use a plug and chug and memory based approach in solving physics problems [7,8]. In fact, one of the goals of learning physics is to create people who can solve complex problems by applying their knowledge and understanding to everyday situations.

Physics lessons taught by teachers to high school students also teach some basic material in physics, one of which is mechanics. Mechanics is a branch of physics that studies the motion of objects and the effects of forces in motion [9]. Given that mechanics is a basic material in physics, students are required to understand and master the concepts of mechanics. Furthermore, mechanics consists of two branches, namely kinematics and dynamics. Kinematics is a science that studies how objects move without regard to the causes of object movement, while dynamics is a science that studies the motion of objects by paying attention to the causes of object movement [10]. The concepts of mechanics include vectors, straight motion, circular motion, parabolic motion, Newton's law, gravitational force, torque, angular momentum, moment of inertia, center of gravity, static fluid, dynamic fluid, work, energy, momentum, and impulses. Meanwhile, the concepts of mechanics which include kinematics include straight motion, circular motion, and parabolic motion. While other concepts include dynamics [11].

Mechanics is also one of the materials that for high school students is physics material that is difficult to understand. Whereas mechanics is a classical physics study whose objects are macroscopic and can be observed directly by the eye [12]. The difficulty experienced by students in understanding the concept of mechanics is a condition in the learning process which is marked by obstacles in understanding mechanics, so that learning outcomes are not achieved maximally [13]. This difficulty in understanding the concept of mechanics appears as a learning difficulty caused by not mastering the prerequisite skills in mechanics. One of the prerequisite skills that students must have in understanding the concept of mechanics is that students are able

to understand the concepts of line coordinates, integrals, derivatives, and Newton's laws of motion [14].

Mechanical material also requires basic materials such as basic mathematics and basic physics. Therefore, the concepts that are prerequisites for learning further concepts are important to master and understand. Based on an explanation of the background of this problem, the purpose of this study is to find out the difficulties experienced by students in understanding and mastering mechanical material. Meanwhile, the research questions to be answered in this study are, Q1: How do students understand mechanics? Q2: What materials do high school students find difficult? Q3: How important is mathematics in mechanics?

## B. Method

This study uses descriptive research methods with quantitative and qualitative approaches. The data of this research are in the form of quantitative and qualitative data. Quantitative data analysis was interpreted with pie and bar charts. Meanwhile, qualitative data were analyzed from open questions in the questionnaire. Meanwhile, the research subjects used in this study were 18 high school students in Yogyakarta who were determined by stratified random sampling technique. These eighteen samples are considered to have represented high school students in Yogyakarta because they came from private high schools and public high schools. The questionnaire method through Google Form was chosen by the researcher because at the time of this study it was not possible to take the questionnaire directly due to the COVID-19 pandemic.

The answers to the questionnaire items can be in the form of choices, opinions, and/or suggestions. The questions in the questionnaire are used to identify mechanics concepts that are considered difficult by high school students. At the end of the questionnaire, a blank column is provided which must be filled in by students regarding opinions and suggestions regarding appropriate learning methods to improve understanding of mechanics concepts. The questions in this questionnaire can be presented in Table 1.

Table 1. Questions in the questionnaire

| No. | Question | Option |
|---|---|---|
| 1. | Is studying physics difficult? | Answer Options:<br>a. Very difficult<br>b. Difficult<br>c. Normal<br>d. Easy<br>e. Very easy |
| 2. | Did you know that in physics there is material about mechanics? | Answer Options:<br>a. Yes<br>b. No |

| No. | Question | Option |
|---|---|---|
| 3. | Choose the mechanics concept that you find difficult! | Answer Options:<br>a. Vector<br>b. Straight motion, circular motion, and parabolic motion.<br>c. Newton's Law<br>d. Gravitational force<br>e. Rotational dynamics and rigid body equilibrium<br>f. Static fluid<br>g. Dynamic fluid<br>h. Work and Energy<br>i. Collisions, impulses and the law of conservation of momentum |
| 4. | From the choices above, explain why the concept you chose was difficult? | Open question |
| 5. | Explain why the concept you didn't choose was easy for you! | Open question |
| 6. | How do you overcome difficulties in understanding the concept? | Open question |
| 7. | What is the method used by your teacher in learning physics? | Open question |
| 8. | In your opinion, is the learning method applied by your teacher appropriate? | Answer Options:<br>a. Yes<br>b. No<br>c. Maybe |
| 9. | Explain your reasons for answering the previous question! | Open question |

Based on Table 1, it can be seen the details of the questions in the questionnaire given to the sample. The steps taken to collect this data were looking for references, determining subjects, making questionnaires via Google Form, distributing questionnaires to research subjects, analyzing data, and concluding the data. Furthermore, the results of data collection using this Google Form will be presented in the results and discussion.

## C. Results and Discussion

This research was conducted on high school students from both public and private high schools. All respondents already know that in physics there are concepts of mechanics. However, the respondents were asked for their opinion on the level of difficulty in learning physics. The results of high school students' perceptions of the level of difficulty in learning physics can be presented in Figure 1.

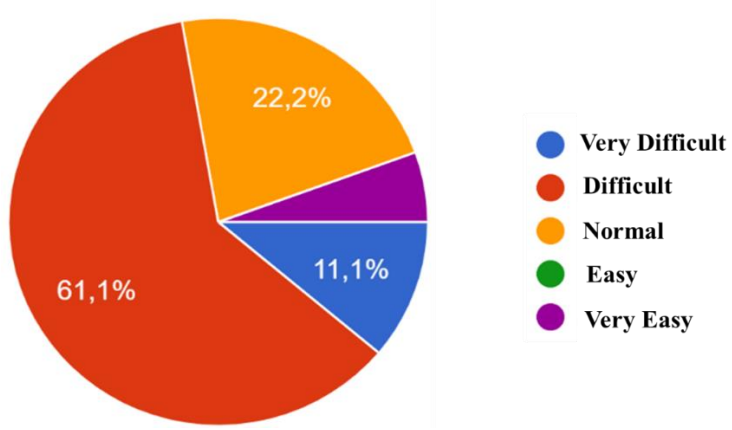


Figure 1. Students' perceptions of physics learning

Based on Figure 1, it can be seen that 61.1% of respondents consider physics to be a difficult subject to understand, 22.2% of respondents consider physics to be an ordinary subject, 11.1% of respondents consider physics to be a very difficult subject and the rest think physics is very easy. These results indicate that high school students in Yogyakarya think that physics is a difficult subject. However, all respondents who are high school students in Yogyakarta know that there is mechanics in physics. Meanwhile, students' views on the concepts of mechanics that are considered difficult can be presented in Figure 2.

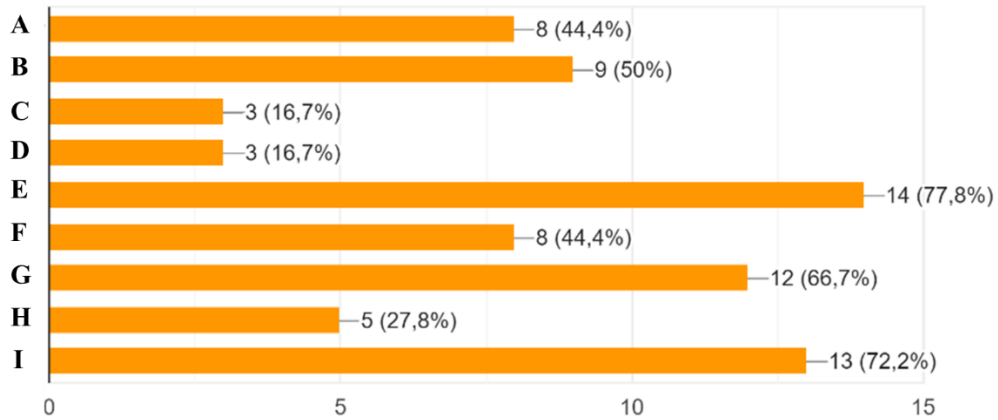


Figure 2. Students' perceptions of the mechanics concept

The information in Figure 2 includes, A is vector and B is straight motion, circular motion, and parabolic motion. C is Newton's law and D is the gravitational force. E is rotational dynamics and rigid body equilibrium. F is a static fluid. G is dynamic fluid and H is work and energy. In addition, I is collisions, impulses and the law of conservation of momentum. Based on the data presented in Figure 2, it can be seen that there are three mechanics concepts that are considered the most difficult by

high school students, namely fourteen students chose the concepts of rotational dynamics and rigid body equilibrium as the most difficult mechanics concepts. Collisions, impulses, and the law of conservation of momentum are difficult materials other than rotational dynamics and rigid body equilibrium because they were chosen by thirteen respondents. Meanwhile, twelve respondents also chose dynamic fluid as a difficult mechanics concept. Physics concepts that are considered difficult because of the many variations of questions and the lack of clarity and detail of the teacher in explaining. These results are in accordance with the findings of previous studies which showed that two important and difficult parts to understand in learning at school include the law of conservation of energy and optics [15]. In addition, dynamic fluid matter is included in the field of mechanics which is at the top of the misconceptions [16].

Some 11th graders also have misconceptions about rotational dynamics [17]. One of the students wrote down the reasons why the three concepts were difficult because so many formulas were used. Other students wrote down the three concepts that were difficult because they had varied questions. This causes students to have difficulty applying the existing formulas to solve problems of the three concepts. In this study, students also expressed their ways of overcoming difficulties in understanding the three concepts, among others, by asking teachers and friends, increasing practice questions, and looking for other learning media. Based on Figure 2 also obtained two concepts that are considered easy by students because of the eighteen respondents only three students chose this concept as difficult.

Two concepts that are considered easy are Newton's law and the force of gravity. The reason students choose the concept is easy because the material has been taught since junior high school, so it is easier to understand the basic concepts. Another reason is that the material is considered small and easy to find in practice questions. This shows that it is easier for students to understand and solve the problems of the two concepts. Meanwhile, the results of students' opinions regarding the accuracy of the physics learning method applied by the teacher can be presented in Figure 3.

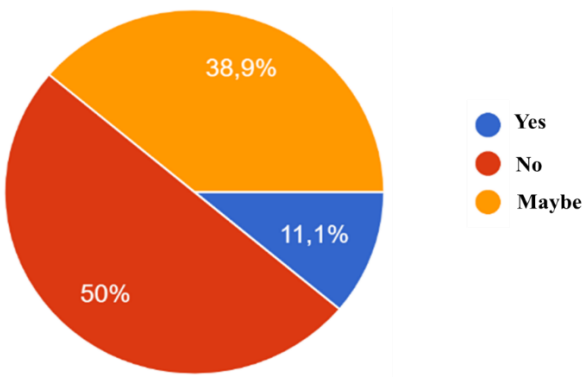


Figure 3. Students' opinions about the learning methods applied by physics teachers

Based on Figure 3, it can be seen that 50% of students considered the method applied by their physics teacher to be inappropriate, 38.9% of students answered it was possible, and 11.1% of students considered the method applied by their physics teacher to be correct. Based on these data, it can be said that most high school students in Yogyakarta view that the learning methods applied by physics teachers are not appropriate. Based on student responses to the questionnaire, the methods used by physics teachers in learning physics are such as providing material in the form of presentations, learning videos, and using online learning applications. Based on the students' arguments, the method was not appropriate because the teacher did not explain the material in detail and did not prioritize students' understanding. The learning method that is expected and deemed appropriate by students is that after giving the material, the teacher is expected to give an explanation slowly and in detail and provide examples of varied questions.

Based on the results of this study, it is hoped that the module makers will increase the variety of sample questions on materials that are considered difficult, such as rotational dynamics and rigid body equilibrium; impulse, momentum, and the law of conservation of momentum; and fluid dynamics. After this research, it is hoped that physics teachers will also know about the difficulties faced by students related to the concepts of the material. This research is also expected to know about the learning methods that should be applied by teachers and other teachers. In addition, it is hoped that from this research students are also more active in learning about physics, especially the concepts of mechanics.

## D. Conclusion

The results of this study indicate that most high school students think that physics is a difficult subject. However, all students have known that mechanics is included in physics subjects. The concepts of mechanics that are considered difficult by students are rotational dynamics and rigid body equilibrium; impulse, momentum, and the law of conservation of energy, and fluid dynamics. While the concepts of mechanics that are considered easier by students are Newton's laws and the force of gravity. Based on this study, it was also found that according to students, the learning method applied by the teacher was currently not appropriate because it only provided material without a more complete and detailed explanation. Students expect the learning method applied by the teacher is to provide a complete explanation and provide examples of varied questions. Meanwhile, this research can be used as a reference in the compilers of physics modules in order to increase the number of questions that can improve students' understanding. With the module that refers to this article, it is hoped that it will make it easier for physics teachers in delivering mechanics material that is considered difficult by students.

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