

Exploring High School Students' Understanding of Physical Quantities and Derivatives Through a Narrative Questionnaire: A Study at SMA 2 Merangin

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Abstract

This study discusses how students at SMA 2 Merangin understand physics concepts, particularly those related to quantities and derivatives. The background of this study arose because many high school students still have difficulty understanding physics lessons, especially when learning about quantities and derivatives. The purpose of this study is to see how well students understand this material. The method used was a descriptive qualitative approach with field studies, which focused on students' experiences and views on how they learn. The population studied was all 30 students in grade X, and a sample of 15 students was taken so that the data obtained could represent the conditions of the class. Data collection was conducted using a questionnaire with 10 questions using a Likert scale to find out students' views, level of understanding, learning problems, and the influence of internal and external factors on their understanding. The results of this study show that many students have difficulty relating the concepts of quantities and derivatives, especially when given irrelevant examples. This study concluded that there is a need for innovation in teaching methods, reinforcement of basic concepts, and increased use of visual media and simple experiments to help students better understand the concepts of magnitude and derivatives.

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1. INTRODUCTION

An understanding of physics concepts, particularly regarding physical quantities and measurements, is a fundamental aspect that determines students' ability to solve physics problems conceptually, rather than merely memorizing formulas (Ningsih, 2022). Physics education at the high school level plays a strategic role in shaping students' ability to understand basic scientific concepts and apply their knowledge in everyday contexts. One of the fundamental concepts that often serves as the foundation for advanced topics is the concept of quantities and units, particularly basic quantities and derived quantities. In physics education literature, mastery of the concept of quantities and derivatives is considered an important foundation because errors in understanding units or types of quantities can cause systemic obstacles in physics learning. For example, research in Indonesia shows that the average understanding of students regarding the material on quantities, units, and measurement is still in the "fair" category, which indicates that there is still room for improvement in the learning process (Fitriani, Cantika, & Lolita, 2021).

Theoretically, the concepts of quantities and units have fundamental properties: basic quantities are quantities whose units are defined first, while derived quantities are combinations of several basic quantities in a functional relationship. A proper understanding of the types of quantities, units, and how derived quantities are formed is very important in preparing students to not only mechanically apply formulas, but also understand the physical meaning of numbers and units in calculations (Nikadinata, 2024). Learning physics requires a deep understanding of concepts, as these foundational concepts serve as the basis for understanding more advanced topics such as waves and related phenomena (Nada et al., 2022). Without a strong foundation in this material, students tend to experience difficulties when moving on to more complex physics topics such as force, pressure, or velocity.

In the digital age, students' critical thinking and problem-solving skills are increasingly influenced by the integration of technology into learning, particularly in terms of a deep understanding of scientific concepts (Wang & Wang, 2025). Furthermore, the problem of conceptual understanding in physics is not only a matter of memorization or calculation skills, but also about how students construct their own mental schemas that may differ from scientific schemas. A review of the literature shows that barriers to understanding (misconceptions) on various physics topics remain a significant problem to this day (Istiqomah & Subali, 2025). These misconceptions arise because students bring with them pre-scientific understandings, the learning process is teacher-centered, or the evaluation instruments are not capable of capturing students' deep understanding.

In the context of instruments for measuring student understanding, the use of narrative questionnaires (instruments that ask respondents to explain using narratives) can be a richer option than objective tests alone. The use of technology in 21st-century learning has been shown to help students better understand the material by making concepts more concrete and interactive (Sari et al., 2024). The narrative questionnaire approach allows students to describe how they think about a concept, including errors in thinking or misconceptions that may not be detected by ordinary multiple-choice instruments. This is relevant considering that most studies only use multiple-choice tests or diagnostic instruments in the form of "layered tests" (three-tier, four-tier) to detect misconceptions (Atmaja & Samsudin, 2024); however, the narrative approach has not been widely used in the field of quantities and derivatives.

High school students often struggle to understand physics concepts, primarily due to the abstract nature of the subject matter and the lack of multi-representational learning strategies, which results in reduced conceptual understanding and problem-solving skills (Azizah et al., 2023). In this regard, schools such as SMA Negeri 2 Merangin, which are located in a local context, need to evaluate the extent to which their students truly understand the concepts of quantities and derivatives, not only in terms of numerical measurement results, but also through the students' own conceptual understanding. This study aims to explore students' understanding of the concepts of basic quantities and derived quantities through a narrative questionnaire, as well as to identify the forms of understanding or misconceptions that arise. Thus, the results of this study are expected to contribute to the development of more appropriate learning strategies and assessment instruments to improve the quality of basic physics learning at the high school level.

2. METHOD

The methodology employed in this study is a descriptive approach utilizing a phenomenological qualitative research design. Qualitative research is descriptive, meaning that the data it collects is made up of words and pictures, not numbers (Sugiono, 2014). Moleong (2014) asserts that qualitative

research seeks to comprehend the experiences of the subjects under investigation, including their motivations, attitudes, and perspectives, both holistically and descriptively through verbal and linguistic expression, employing diverse scientific methodologies. Similar to other research, quantitative descriptive methods employing survey techniques are frequently utilized to assess students' learning interests via questionnaire instruments (Sofna et al., 2023).

There were 30 tenth-grade students at SMA Negeri 2 Merangin, but only 15 of them were in this study. The goal of this study was to find out how well tenth-grade students at SMA Negeri 2 Merangin understood the ideas of Quantity and Derivatives in their physics lessons. Darmawan (2014) says that data collection methods are the ways or tools that researchers use to get information. The data gathered may comprise primary data and supplementary data (Khairinal, 2016). This study utilized questionnaires and documentation for data collection. Similar studies utilize experimental designs incorporating pre-test and post-test methodologies to assess students' learning outcomes and conceptual comprehension (Fitria & Nafiah, 2025).

We used questionnaires to collect data on things like how well students understood energy and effort concepts, as well as internal and external factors that made it hard for them to learn. Google Forms were chosen because they work well, are easy to get to, and make it easier to analyze data. The analysis of the data was done in three steps: reducing the data, showing the data, and drawing conclusions. We chose data from Google Forms, sorted it by theme (cognitive, math, learning methods, and environment), and then presented it in descriptive form to help us better understand what was making it hard for students to understand the concepts of energy and work. Furthermore, meta-analytic methodologies have frequently been employed in prior research to amalgamate results and assess the efficacy of educational models on students' critical thinking abilities (Rona, Festiyed, & Yerimadesi, 2025)).

After this study, the data will be looked at. Data analysis is a process in which we look for and put together information from interviews, field notes, and other sources so that it can be clearly understood and shared with others (Sugiyono, 2019). Also, quasi-experimental methods that use project-based learning are often used to see how different teaching methods affect how well students learn (Novallyan & Nehru, 2025).

3. RESULTS AND DISCUSSION

Research Results

This study was conducted to determine the factors that influence students' difficulties in understanding the concepts of quantities and derivatives in grade X students at SMA Negeri 2 Merangin. The number of respondents was 15 students, consisting of male and female students. Data collection was carried out using a Google Form questionnaire with 10 Likert scale statements: fully understand, partially understand, partially do not understand, and do not understand at all.

The results of the study showed variations in the level of understanding, interest in learning, the influence of learning methods, and learning environment factors that had an impact on students' understanding of the concepts of magnitude and derivatives. Of the 15 respondents, there were a relatively equal number of male and female students. All respondents were from the tenth grade, and all of them were taking physics classes with material on magnitude and derivatives in the current semester.

Here are the findings from the Google Form questionnaire:

Table 1. Students' Perceptions of Concepts

No.	Pernyataan	PK	PS	TPS	TPK
1	I can correctly explain what a physical quantity is.	4	6	3	2
2	I can name the SI base units for various quantities such as length, mass, and time.	3	8	2	2
3	I can distinguish between fundamental quantities and derived quantities.	4	6	3	2
4	I understand the symbols and dimensions of physical quantities such as force, pressure, and energy.	3	7	3	2
5	I understand how a derived quantity is obtained from its base quantity.	2	8	3	2
6	I can give real examples of the application of derived quantities such as velocity or acceleration.	3	7	2	3
7	I can convert units of measurement such as force into kg·m/s ² .	4	6	3	2
8	I can solve problems involving the concepts of magnitude and derivatives.	3	6	4	2
9	I understand the physical meaning of the results of calculating derived quantities such as energy or momentum.	3	8	2	2
10	I find the concepts of magnitude and derivatives easy to understand.	5	5	3	2

Discussion

This study aims to identify the factors that influence students' difficulties in understanding the concepts of magnitude and derivatives, the types of difficulties experienced, and the role of learning methods, media, and student interest in learning in class X at SMA Negeri 2 Merangin. The analysis of the discussion was based on the results of a questionnaire from 15 respondents, which showed variations in students' perceptions and learning experiences regarding the material on magnitude and energy.

Internal Factors

Internal factors include students' cognitive abilities, interest in learning, motivation, and independent learning efforts. From the questionnaire data, it was found that 4 students stated that they had difficulty understanding the concepts of magnitude and derivatives, while 11 students stated that they easily understood the concepts of magnitude and derivatives. This shows that there's a pretty significant gap in understanding between students who easily grasp concepts and those who have trouble (Saputra, Halim, & Busyairi, 2024).

Also, interest in learning and motivation affect students' difficulties. Eight students are really interested in learning physics, but some aren't motivated (seven students feel unmotivated). This data shows that intrinsic motivation greatly influences the understanding of physics concepts. According to Barus (2024: 25), low motivation and interest in learning are among the main causes of difficulty in understanding physics material in high school, because students tend to be inactive in the learning process and only receive information passively.

The ability to study independently is also an important factor. From the questionnaire, 8 students studied independently at home, and 7 students sought additional learning resources through the internet, videos, or books. These independent learning activities can help students understand difficult material, in line with Hutagaol's (2021: 42) findings, which state that students who actively engage in independent learning tend to find it easier to understand scientific concepts, including quantities and derivatives, compared to those who only rely on the teacher's explanations in class.

External Factors

External factors include the role of teachers, learning methods, media, and supporting facilities. From the questionnaire, most students (7–12 respondents) stated that the way teachers teach affects their understanding, and that teachers' explanations are too fast, making it difficult for some students to follow the lessons. Malotong, Syamsuriwal, & Zaky (2022: 108) emphasize that the fast pace of material delivery is often a major obstacle for students in understanding the relationship between quantities and derivatives.

Learning media and facilities are also important factors. A total of 8 students stated that visual media helped their understanding, and 6 students considered learning facilities to support the learning process. This shows that the availability of interesting media and adequate facilities can improve student understanding, as found by Pratiwi (2021: 36), who stated that the use of visual and interactive media can reduce students' misconceptions in understanding the concepts of magnitude and derivatives.

The classroom atmosphere and interaction with friends also affect learning difficulties. From the data, 7 students stated that the classroom atmosphere was conducive, but 4 students felt that classroom noise was distracting. In addition, 4 students chose the role of friends in helping when experiencing difficulties. Rezki, Lian, & Riyanti (2025: 176) emphasize that a conducive learning environment and peer-to-peer interactions can support the understanding of abstract physics concepts, especially quantities and derivatives.

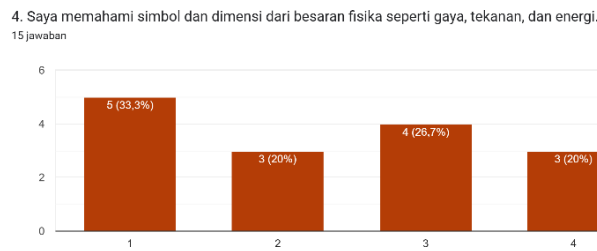
Conceptual Understanding

Overall Understanding

Overall understanding is a condition in which students understand concepts holistically, in terms of their definitions, principles, and applications. Students with this level of understanding are able to explain the concept in their own words, relate it to new contexts, and apply it in solving complex problems. According to Nurhasanah and Pratiwi (2020), comprehensive understanding reflects that students are not only able to remember information, but also able to organize and integrate that knowledge into their cognitive structure. In the context of science learning, students who have a comprehensive understanding can explain the relationships between variables and answer questions such as “why” and “how” a phenomenon occurs (Sari & Sutopo, 2022).

In addition, research by Pratama and Widodo (2021) shows that students with a full understanding of concepts tend to have higher-order thinking skills because they have passed through the stages of assimilation and accommodation of correct concepts. Thus, overall understanding is a key indicator of successful conceptual learning because it demonstrates effective knowledge transfer. Below is an example of a student's answer regarding overall understanding. We can interpret that the student is able to understand the symbols and dimensions of physical quantities such as force, pressure, and energy. Students with a complete understanding can understand concepts holistically, in terms of their definitions, principles, and applications.

Figure 1. Students' Answers: Overall Understanding



Partial Understanding

Partial understanding refers to a condition in which students only understand part of a concept, while other parts are not fully understood or are still incorrect. Students in this category are often able to answer some questions correctly, but have difficulty when they have to apply the concept in a different context. According to research by Rahmawati and Hidayat (2021), students with partial understanding usually understand formulas or terms but do not yet understand the conceptual meaning behind them.

For example, in physics material about friction, students may know the formula $F = \mu N$, but do not yet conceptually understand that friction depends on the properties of the surface and not on the area of contact (Rahmawati & Hidayat, 2021). Research results by Fatimah and Kartika (2020) also show that most students only master concepts at the procedural level (procedural knowledge), not at the conceptual level (conceptual knowledge). Therefore, the category of “partial understanding” indicates that learning still needs to emphasize concept exploration rather than just practicing questions.

Below is an example of a student's answer regarding partial understanding. We can interpret that the student is able to understand the physics material but is not yet able to apply the concept. Students with partial understanding tend to be more prone to errors in applying formulas and do not yet understand the conceptual meaning behind them.

Figure 2. Partially Correct Student Answers



Partial Understanding

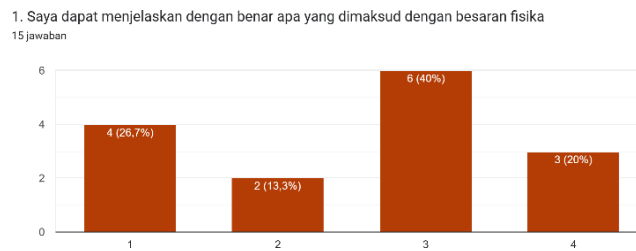
This category is often referred to as misconception, which is a condition where students have an understanding that is incorrect or contradicts the correct scientific concept. According to Suparman and Yulianti (2020), misconceptions arise due to incomplete learning processes, misinterpretations by teachers, or the use of inappropriate analogies. Students who experience misconceptions are often confident in their answers because they are based on personal logic that seems reasonable, but in fact does not correspond to scientific theory.

For example, in the material on free fall, many students assume that heavier objects fall faster,

when in fact scientifically, gravitational acceleration is constant for all masses (Dewi & Maulana, 2022). Research by Prasetyo and Putri (2023) also confirms that misconceptions are a major obstacle in science learning because they are difficult to correct without cognitive conflict-based learning interventions. Therefore, diagnosing misconceptions is important in learning assessment.

Below, we can see examples of students' answers regarding partial understanding. We can interpret that students with this level of understanding often experience misconceptions and are also confident in their answers because they are based on personal logic that is not in line with scientific theory.

Figure 3. Students' Answers: Partially Understand



No Understanding

The last category is no understanding, which describes a situation where students do not understand the concepts being taught at all. In this condition, students tend to give random, irrelevant answers, or even cannot answer at all. According to research by Wulandari and Hidayah (2021), students who do not understand the concept as a whole are usually caused by a lack of involvement in the learning process, low interest in learning, and the use of methods that are too oriented towards memorization.

Research by Latifah and Kusumawati (2022) confirms that a lack of total understanding often occurs because students do not relate new material to their prior knowledge. This condition prevents new information from being assimilated into the students' cognitive structure. In the context of science and mathematics learning, students in this category show great difficulty in explaining or applying concepts even after repeated learning.

Below, we can see an example of a student's answer about not understanding the whole concept. We can interpret that the student does not understand the concept being taught. In this condition, students tend to give random, irrelevant answers, or even cannot answer at all.

Figure 4. Students' Responses: Do Not Understand Overall



Cognitive Difficulties

Cognitive difficulties are reflected in the number of students who stated that the concepts of magnitude and derivatives (7 students) were difficult to understand. This form of difficulty is related

to students' abstract thinking and mathematical logic abilities (Saputra, Halim, & Busyairi, 2024). Hutagaol (2021: 45) emphasizes that understanding physics concepts requires adequate cognitive abilities to relate scientific principles to real phenomena.

Difficulty Understanding the Relationship Between Concepts

A total of 7 students stated that they had difficulty understanding the relationship between quantities and derivatives, and 8 students stated that example questions helped their understanding. This shows that students experience difficulties, especially when concepts are not explained contextually or when the example questions provided are not relevant. Pratiwi (2021: 38) asserts that the use of concrete examples and the application of concepts in everyday life can help students understand the interrelationships between physics concepts.

Practical Difficulties in Practice Questions

Nine students felt that the practice questions were insufficient, indicating that difficulties also arise in the form of application. Students who are not accustomed to applying theory in questions tend to experience misconceptions, such as miscalculating quantities or misidentifying types of derivatives. Malotong, Syamsuriwal, & Zaky (2022: 110) mention that the lack of varied practice questions is a major factor in the difficulty of understanding quantities and derivatives.

The Role of Learning Methods, Media, and Interest in Learning

Learning Methods

The way students learn has a big impact on how well they understand things. Twelve students agree that the learning model helps them understand. This means that interactive methods, like problem-based learning or simple experiments, can help students learn about derivatives and magnitude. Barus (2024: 30) stresses that methods that get students involved in the learning process help them understand scientific concepts better and cut down on misunderstandings. This finding is substantiated by the adoption of inquiry-based frameworks like ASPIRE, which markedly enhance conceptual comprehension and student engagement through organized, reflective, and collaborative learning methodologies (Quileste et al., 2025). The way teachers teach is also very important. Ten students said that the way the teacher taught made it harder for them to understand, and five students said that the teacher's explanations were too fast. This means that teachers need to change the speed of their lessons so that all of their students can keep up and understand the ideas. Malotong, Syamsuriwal, and Zaky (2022: 111) stress that teachers must create opportunities for inquiry and dialogue to address cognitive challenges.

Learning Media

Learning media is a very important part of the process. Eight students said that visual media helped them, and seven students said that learning facilities helped them learn. Also, six students thought they needed interactive media. This shows that using a mix of pictures, sounds, and interactive media can help students understand better. Pratiwi (2021: 39) says that using different kinds of media can make students more interested and help them understand the ideas of magnitude and derivatives. This aligns with research indicating that contextual and locally integrated learning media can substantially improve students' science process skills, which are crucial for comprehending abstract physical quantities and derivatives (Sari et al., 2025).

Interest and Motivation to Learn

The difficulty students have in understanding ideas depends on how interested they are in learning. Six students are very interested, but four are not. The data shows that 5 students study on

their own and 6 students look for more resources, which shows that students who are highly motivated tend to do these things. Situmorang (2021: 40) stresses that intrinsic motivation and a desire to learn are the most important factors that determine how well students learn physics concepts. This is because when students are intrinsically motivated, they will actively seek to understand and work through problems on their own. This is corroborated by evidence indicating that digital learning modules can improve student autonomy and self-regulated learning, which are essential for investigating intricate concepts such as physical quantities and derivatives (Pratama et al., 2025).

Social Interaction and Learning Environment

Students' understanding is also affected by how they interact with their friends and the conditions in the classroom. The data indicates that 4 students received assistance from peers, 6 students perceived the classroom environment as favorable, and 5 students were disrupted by noise. Rezki, Lian, and Riyanti (2025: 180) stress that a good learning environment and learning with others can help students understand abstract ideas like derivatives and quantities. Furthermore, social roles and emotional influences, exemplified by bystander behavior, underscore the significance of moral responsibility and peer interaction in influencing student responses and engagement within educational settings (Nuha et al., 2025). Moreover, the psychological states of students are significant, as efficacious interventions, such as CBM-based methodologies, can alleviate anxiety and enhance cognitive preparedness, thereby promoting a deeper comprehension of abstract scientific principles (Jannah et al., 2025).

4. CONCLUSION

This study shows that students' difficulties are influenced by various internal and external factors. Internal factors include cognitive abilities, interest in learning, motivation, and independent learning efforts, while external factors include teaching methods, speed of material delivery, use of learning media, practice questions, classroom atmosphere, and learning facility support. Analysis of questionnaires from 15 respondents revealed variations in students' understanding of the concepts of quantities and derivatives, with most students stating that these concepts were quite difficult, especially in understanding the relationship between quantities and derivatives. The use of visual media, relevant example questions, and interactive teaching methods proved to contribute positively to students' understanding. This study provides an overview that physics learning, especially the material on quantities and derivatives, requires a more systematic and contextual approach that involves active student participation to overcome cognitive and applicative difficulties.

Although this study provides a fairly comprehensive understanding of the factors contributing to student learning difficulties, it has several limitations, including the limited number of respondents (only 15 students) and the data collection method, which only used questionnaires without other forms of triangulation such as interviews or direct observation. For future research, it is recommended that researchers use a mixed method approach to obtain a more in-depth picture of students' learning difficulties. The research can also be expanded by analyzing the relationship between certain factors, such as between learning interest and motivation and the level of understanding of physics concepts. The implications of this study confirm that physics teachers need to adjust their learning strategies to the needs of students through the use of interactive media, increasing contextual exercises, and creating a conducive classroom atmosphere so that students' understanding of quantities and derivatives improves. In addition, schools are expected to provide better facilities so that the learning process can take place optimally.

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