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IDENTIFIYING AND ANALYZING MISCONCEPTION OF XI GRADE STUDENTS ABOUT BASIC KINEMATICS MATERIAL BY USING TWO TIER-TEST METHOD IN SMA NEGERI 1 PERCUT SEI TUAN

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Abstract

Conceptual difficulties in fundamental physics, particularly basic kinematics, represent a persistent challenge in secondary education that significantly hinders students' subsequent learning. Misconceptions are alternative frameworks students hold that deviate from scientifically accepted concepts, often leading to systematic errors when solving problems or interpreting phenomena. Addressing this issue is critical, as a weak foundation in kinematics the description of motion can severely impact the comprehension of dynamics and energy. This study was specifically aimed at identifying and quantitatively analyzing the prevalence and patterns of student understanding and misconceptions regarding basic kinematics among 11th-grade science students at SMA Negeri 1 Percut Sei Tuan.The research employed a descriptive quantitative methodology, utilizing the robust Two-Tier Diagnostic Test method to collect and categorize student data. The study sample consisted of 30 students from the Grade XI Matlangraf class who participated in a 10-item questionnaire covering core kinematics concepts. Analysis of the diagnostic test results revealed a critical issue in conceptual mastery. The findings indicated that only 6 students (20%) demonstrated a solid conceptual understanding. Conversely, a significant majority 17 students (57%) were classified as experiencing specific misconceptions, while the remaining 7 students (23%) showed no understanding of the concepts. This substantial finding confirms that a majority of the 11th-grade cohort harbors underlying misconceptions related to basic kinematics material, underscoring the urgent necessity for the implementation of effective intervention strategies to address these cognitive obstacles directly.

Keywords:
Misconception
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PENDAHULUAN

Physics learning is essentially a structured process that enables students to understand natural phenomena by employing scientific inquiry and logical reasoning. This process requires not only memorizing formulas but also developing a deep and coherent conceptual structure, promoting critical thinking, and nurturing scientific (Habellia et al., 2021). Effective physics instruction should be designed to bridge the gap between abstract theoretical models and the tangible reality students experience, fostering a comprehensive grasp of the subject.However, if the instructional design is poor or too focused on rote calculation, students often encounter significant learning difficulties (Sitinjak, 2023).

Basic kinematics, as the study of motion without reference to the forces causing it, serves as a crucial foundational topic in high school physics. Mastering concepts like displacement, velocity, acceleration, and their graphical representations especially in Uniform Rectilinear Motion (GLB) and Uniformly Accelerated Rectilinear Motion (GLBB) is paramount for future studies in dynamics and energy (Giancoli, 2014).The complexity often arises when students transition from intuitive, everyday understandings of motion to the precise, vector-based definitions required in physics, often leading to confusion between speed/velocity or distance/displacement. A weak foundation in kinematics can severely hamper students' success in higher-level physics courses.

Misconception is defined as a concept that is not in accordance with the scientific concept or understanding accepted by experts, and often resists change even after formal instruction.These errors are not random mistakes but rather systematic, incorrect frameworks of thought that students actively use to interpret phenomena or solve problems. Identifying the source of a misconception is crucial, as it could stem from textbooks, teacher explanations, or students' own common-sense theories. Because these incorrect ideas are often deeply entrenched, they require specialized diagnostic tools for detection and targeted intervention for remediation. (Gumay, 2021).

Student misconceptions related to fundamental concepts are particularly prominent in the early stages of learning, where students frequently confuse scientific terms with their everyday usage. For instance, students often fail to differentiate between velocity (a vector) and speed (a scalar), or believe that zero velocity automatically implies zero acceleration (Julianda & Halim, 2022). These deeply held naive ideas act as serious obstacles, as new, correct information is often filtered or misinterpreted through the lens of the existing incorrect framework Therefore, understanding the scope and nature of these initial misconceptions is the necessary first step to improving learning outcomes in physics (Sufiyah, 2020)

The Two-Tier Test method is a reliable diagnostic instrument specifically designed to identify the existence and the underlying reasons for student (Sundari, 2021)This method consists of two parts for each question: the first tier tests the content knowledge (multiple-choice answer), and the second tier asks the student to justify their answer from the first tier (multiple-choice reason). By requiring students to provide both a correct answer and the correct reason, it effectively differentiates between sound conceptual understanding, a genuine misconception (correct answer/wrong reason or wrong answer/correct reason), and a simple lack of understanding or mere guessing. (Habellia, 2021)

The primary goal of this research was to meticulously map the landscape of conceptual challenges faced by Eleventh Grade students in basic kinematics at SMA Negeri 1 Percut Sei Tuan. Specifically, the study aimed to use the validated Two-Tier Test instrument to: (1) accurately determine the percentage of students who truly understand the concepts; (2) identify the specific areas where the most prevalent and persistent misconceptions occur; and (3) establish a quantitative baseline that can be used by educators to design evidence-based remedial instructions.

METODE PENELITIAN

Research Design and Context

This research employed a descriptive quantitative method, which is highly suitable for determining the status of a phenomenon (in this case, student conceptual understanding) through numerical data collection and statistical analysis.The goal was not to establish cause-and-effect relationships but rather to describe the levels of conceptual understanding—sound concept, misconception, and no concept understanding as they currently exist among the student population. The study was conducted at SMA Negeri 1 Percut Sei Tuan. The sampling method was purposive, targeting one specific class.

Subjects and Object research

The research subjects were students of Eleventh Grade (Kelas XI Matlangraf) who had completed the basic kinematics module, with a total sample size of 30 students. The object of the research was the students' conceptual understanding, specifically the identification and analysis of misconceptions related to basic kinematics material. The data collection technique used was a test administered through a questionnaire, where the instrument was a 10-item written Two-Tier Test. This method instrument was developed to cover core kinematics concepts such as GLB, GLBB, free fall, projectile motion, and circular motion, ensuring content validity through expert review.

Instrument and Data Analysis

The Two-Tier Test instrument consists of two parts for each item: the first part is a multiple-choice question testing the answer, and the second part is a multiple-choice question testing the reason or justification for the answer given. The combination of responses from the two tiers allows for a precise categorization of student understanding. Technique of Data Analysis followed the standard of this method scoring criteria: a student is categorized as having a "Sound Concept" if both the answer (Tier 1) and the reason (Tier 2) are correct; as having a "Misconception" if the answer is correct/incorrect but the reason is incorrect; and as having "No Concept Understanding" (or guessing) if both the answer and the reason are incorrect (Julianda & Halim, 2022) The data were then analyzed descriptively by calculating the frequency and percentage for each category of understanding for both the overall test and for individual test items.

HASIL DAN PEMBAHASAN

Alignment of Findings with Research Objectives

The research successfully met its objective of identifying and analyzing the students' conceptual understanding of basic kinematics, revealing a significant conceptual deficit. Out of 30 students, the data showed that only 6% (approximately 2 students) genuinely grasped the concepts (Sound Concept), which is a critically low figure. Conversely, the majority, accounting for 57% of the students (17 students), were categorized as experiencing distinct misconceptions, while 23% (7 students) simply lacked understanding altogether (No Concept Understanding). These findings emphasize that the fundamental problem in the classroom is not merely a lack of learning but the presence of deeply embedded incorrect knowledge, which is a much more challenging issue to overcome through traditional teaching methods.

Table 1. The categories of student understanding (Julianda, 2022); (Habellia, 2021).

Diagnostic Categories	Tier 1 (Answers)	Tier 2 (Reasons)	Diagnostic Information
Understanding of concept	True (T)	True (T)	The student provides the correct content answer and a scientifically correct justification.This demonstrates genuine mastery.
Misconceptions	True (T)	Incorrect (I)	The student selects the right answer but provides a wrong justification that aligns with a non-scientific, alternative conceptual framework. This is the definition of a stable misconception.

Not understand the concept	Incorrect (I)	Incorrect/Blank (I)	The student selects the correct answer but provides an incorrect justification, indicating a lucky guess (pseudo-understanding).

Scientific Interpretation of Misconception Patterns

The analysis of specific test items revealed clear areas of conceptual weakness, notably in questions 5, 8, and 9. Item 5, which involved the interpretation of velocity-time and displacement-time graphs for GLB and GLBB, saw high rates of misconception and lack of understanding, suggesting students struggle to translate motion phenomena into their abstract graphical representations (Wahyuni et al., n.d.) Item 8, concerning the concept of acceleration in Uniform Circular Motion (GMB), showed that many students incorrectly believe constant speed implies zero acceleration, failing to recognize acceleration as the rate of change of the velocity vector (direction change) rather than just the change in speed. Furthermore, item 9, which tested the concept of acceleration, particularly its vector nature and relationship with force, also highlighted a fundamental confusion between acceleration and velocity.

Despite these significant struggles, the data indicated that a slight majority of students did demonstrate an initial understanding of the basic definitions and introductory principles of GLB and GLBB. This suggests that the initial, qualitative introduction to kinematics was somewhat successful in conveying the most basic relationship between distance, time, and speed. However, as soon as the material shifted to more complex applications involving graphical analysis, vector concepts (like GMB), or the distinction between average and instantaneous values, the students' foundational knowledge quickly proved inadequate. The results imply that while students can handle simple direct recall, they are unprepared for conceptual problems that require higher-order thinking and synthesis (Abbas, 2022).

Table 2. Analyzed result of students answer data

No. Soal	**Concept tested**	**Undestanding the concept**	**misconception**	**Not understanding the concept**	**Total N**	**Understand the concept (%)**	**misconception (%)**	**Not understanding the concept (%)**
1	Relationship between v & a	12	10	8	30	40.0%	33.3%	26.7%
2	The diference	15	8	7	30	50.0%	26.7%	23.3%

	between speed & velocity							
3	Negative accelaration's direction	9	12	9	30	30.0%	40.0%	30.0%
4	Uniform Linear Motion (Constant Speed)	18	7	5	30	60.0%	23.3%	16.7%
5	v–t Graph Interpretation (Displacement vs Distance	3	20	7	30	10.0%	66.7%	23.3%
6	Directionof displacesment (vector)	8	13	9	30	26.7%	43.3%	30.0%
7	Vertically Thrown Object	7	15	8	30	23.3%	50.0%	26.7%

	(Middle Point)							
8	Uniform Circular Motion (Centripetal Acceleration)	4	18	8	30	13.3%	60.0%	26.7%
9	Average of accelaration	5	18	7	30	16.7%	60.0%	23.3%
10	Acceleration Direction vs Motion Direction (Deceleration)	11	14	5	30	36.7%	46.7%	16.7%
Total average		**9.2**	**13.5**	**7.3**	**30**	**31.7%**	**45.0%**	**23.3%**
Final total		**60**	**170**	**70**	**300**			

Table 3. Analyzed result.

Category of Students understanding	**Total of students**	**Total Persentase (%)**	**Target**
Understanding the concept	6 students	20.0%	Tercapai (6/30)
Misconceptions	17 students	56.7%	Tercapai (17/30)
Not understanding the concept	7 students	23.3%	Tercapai (7/30)
Total Sample	30 students	100.0%	30

Implications for Learning: Targeted Remediation

The pervasive nature of misconceptions, particularly in graphical interpretation and vector concepts, suggests a strong need for pedagogical transformation in the teaching of kinematics. Instead of relying heavily on formula manipulation, instructional methods should be shifted towards conceptual change models, which actively challenge and replace students' existing incorrect ideas with scientifically accepted ones.This could involve integrating more practical laboratory activities, real-world motion analysis, and concept-building exercises that force students to confront the conflicts between their intuitive ideas and the physics model. Educators must also emphasize the vector nature of velocity and acceleration from the beginning.

Implications for Learning: Instructional Design

Specifically, to address the poor performance on graphical analysis and GMB, teachers should introduce dedicated, inquiry-based activities centered around motion sensors and data analysis. Using tools that generate real-time position-time and velocity-time graphs can help students visually connect the physical movement of an object with its mathematical representation, thereby making the concepts less abstract .Furthermore, the Two-Tier Test itself should be regularly used not just as an assessment tool, but as a teaching tool to prompt meta-cognitive discussion, allowing students to critically evaluate the reasoning behind their answers and the answers of their peers.

KESIMPULAN

This research confirms the critical presence of significant conceptual difficulties among Eleventh Grade students at SMA Negeri 1 Percut Sei Tuan regarding basic kinematics material, as evidenced by the Two-Tier Test analysis. The descriptive quantitative findings indicate that the overwhelming majority of students (57%) suffer from persistent misconceptions, while only a small minority (6%) possess a sound conceptual understanding of the topic. The most prevalent areas of struggle were identified in the interpretation of motion graphs (GLB and GLBB), the concept of acceleration in Uniform Circular Motion (GMB), and the fundamental vector nature of kinematic quantities. In light of these findings, it is concluded that the current instructional approach is insufficient in preventing the formation or persistence of non-scientific conceptual frameworks. To address this urgent pedagogical issue, educators are strongly advised to adopt diagnostic-based instruction. Future teaching strategies must move beyond traditional problem-solving, focusing instead on utilizing tools like the Two-Tier Test to identify specific student weaknesses and subsequently implementing conceptual change models to actively rectify these deep-seated misconceptions, ensuring a stronger foundation for subsequent physics topics.

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