The Fourth International Conference on Government Education Management and Tourism (ICoGEMT-4)
Bandung, Indonesia, January 25, 2025

ANALYZING PHYSICS EDUCATION STUDENTS' MISCONCEPTIONS ON LINEAR MOTION CONCEPTS USING A 4-TIER DIAGNOSTIC TEST

Ayuni Nuraeni

Physics Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Yogyakarta, Indonesia

Author's email:
[1]stevani.reynita.goentomo@mhs.unj.ac.id;[2]sitizulaikha@unj.ac.id;[3]desi-rahmawati@unj.ac.id

Corresponding author: *stevani.reynita.goentomo@mhs.unj.ac.id*

Abstract. *This study aims to identify and analyze misconceptions among physics education students. The research employed a descriptive quantitative-qualitative method with a sample of 66 Physics Education students. The instruments used included a 4-tier diagnostic test and interview guidelines. The findings revealed that the average distribution for the SC (Students who understand the material) category was 44%, LK (Students lacking knowledge) was 25%, and MSC (Students with deep misconceptions) was 31%. A total of 76% of students exhibited a low level of misconceptions, 24% displayed a medium level of misconceptions, and no students were categorized as having a high level of misconceptions. Misconceptions were most frequently observed in topics such as speed, velocity, uniform rectilinear motion (URM), and uniformly accelerated rectilinear motion (UARM). Based on interview results, students with high levels of misconceptions primarily relied on everyday experiences for their understanding, while students with a high level of comprehension tended to have teaching experience.*

Keywords: *Diagnostic Test, Linear Motion, Misconception, Physics Education.*

1. INTRODUCTION

Physics education students, as prospective teachers, play a critical role in shaping future generations who deeply understand physics concepts and can teach them effectively. Physics, however, is often regarded as one of the most challenging subjects to teach (Salimpour, 2021). As future physics educators, these students frequently face the same challenges as their future pupils, such as grappling with misconceptions and understanding fundamental physics concepts (Pebriani, 2024), including linear motion mechanics. Misconceptions are errors in understanding concepts or materials that deviate from scientific explanations, often caused by non-scientific beliefs or alternative ideas inconsistent with expert understanding (Sari, 2023). These misconceptions not only hinder their comprehension of the material but also affect their ability to convey these concepts accurately to students.

Linear motion mechanics is one of the fundamental physics topics that often leads to misconceptions. This topic explores natural phenomena related to the motion of objects along straight paths. It encompasses various quantities such as speed, acceleration, distance, and displacement, which students often struggle to differentiate and relate to each other (Tarisalia, 2020). Common misconceptions include equating speed with velocity (Rahmadani, 2023), treating distance as identical to displacement (Ibnusaputra, 2023), assuming that greater speed always implies greater acceleration, and believing that displacement and position are interchangeable terms (Rahmadani, 2023). Analysis suggests that these misconceptions often stem from students' personal thought processes (Sari, 2023). This indicates that students frequently base their understanding on personal experiences or assumptions that are not aligned with scientific concepts (Amiruddin, 2025).

Misconceptions may also arise during the transition to higher education. Instructors often presume that students have mastered fundamental physics concepts in high school, bypassing verification of this mastery and directly introducing more advanced concepts (Turner, 2024). While students are considered knowledgeable in physics topics, the connection between their existing knowledge and their acceptance of theoretical explanations provided by instructors is often unclear (Kaloi, 2022). Such disconnects can occur in formal classroom settings, where theoretical physics is taught, as well as outside the classroom, where students are exposed to various sources of information that may not always be accurate (Chisango, 2023). Moreover, students' personal perspectives can influence how they interpret and accept theories, perpetuating misconceptions (Chisango, 2023).

If prospective physics teachers harbor misconceptions, these errors can impede their understanding of subsequent concepts (Mardyah, 2024). Misconceptions can also disrupt physics education students' learning processes throughout their academic journey (Mardyah, 2024). When these misconceptions remain unaddressed, they may persist into teaching practices, where educators are likely to replicate the same teaching methods without delving into deeper student comprehension. Consequently, these misconceptions may be passed down from one generation of students to the next. This cycle contradicts the primary goal of concept mastery, which is to organize information and facilitate higher-order thinking (Hasnawati, 2022).

Physics education students are often unaware of their misconceptions. As prospective educators, it is crucial for them to recognize and address their own misconceptions first. They must understand that concepts like linear motion mechanics, while abstract, require a constructivist approach to help students build correct understanding (Costa, 2023). Future physics teachers should be capable of distinguishing between students who hold misconceptions and those who merely lack understanding (Umardianti, 2023). Misconceptions should not be viewed merely as weaknesses but as opportunities to refine teaching approaches.

By identifying their misconceptions, physics education students can correct their erroneous understanding and replace it with accurate scientific knowledge. If their misconceptions are not properly addressed, misinformation will continue to propagate and take root in their comprehension (Bei, 2024). This would disrupt both their learning and teaching processes (Bei, 2024). Misconceptions in learning not only diminish teaching effectiveness and learning outcomes but also undermine students' confidence in physics itself (Jolles, 2021). Failure to grasp fundamental physics concepts can exacerbate learning difficulties, preventing students from developing critical problem-solving skills in physics (Bei, 2024; Jolles, 2021). Therefore, physics education students must experience the process of identifying and correcting their misconceptions. This experience will enable them to better understand the challenges faced by their students in learning physics (Kuang-Chen, 2024).

Through this process, students can develop a more profound and accurate understanding of the concepts they will teach (Prinz, 2022). They will also build a strong conceptual foundation, enabling them to anticipate areas where students may struggle with misconceptions (Sri, 2023). This process fosters a shift in thinking and enhances teaching effectiveness, while also preventing the spread of misinformation to future students (Özmen, 2022; Götzfried, 2024).

Previous studies have largely focused on identifying misconceptions among high school students, with limited attention to the misconceptions held by physics education students who are prospective teachers. Thus, this study identifies misconceptions among physics education students using a 4-tier diagnostic test. The 4-tier diagnostic test is designed not only to measure correct or incorrect answers but also to assess students' confidence levels and the reasoning behind their responses (Rahmadani, 2023). This test allows students to express their confidence in their answers and the reasoning provided (Mardyah, 2024), enabling a more in-depth and accurate identification of misconceptions. Using this test, prospective teachers can recognize their misconceptions, heighten their awareness of conceptual weaknesses, and motivate themselves to learn better (Rahmadani, 2023). By addressing misconceptions during teacher training, it is hoped that prospective teachers will be able to teach physics more effectively and minimize the transmission of misconceptions to their future students.

2. LITERATURE REVIEW

2.1 Misconceptions

Misconceptions are a major barrier to learning physics, particularly among students who often struggle with understanding basic concepts. Misconceptions are generally divided into two main categories: incommensurate misconceptions and inaccurate misconceptions. Incommensurate misconceptions involve errors in concept categorization, while inaccurate misconceptions relate to incorrect understanding of mental models or scientific theories (Götzfried, 2024). The approach to correcting these misconceptions differs, incommensurate misconceptions require a better understanding of proper categorization or foundational knowledge, whereas inaccurate misconceptions necessitate the correction of mental models and beliefs through experiments or more in-depth instruction (Götzfried, 2024). Misconceptions typically arise due to mistaken assumptions and misunderstandings (Rahmadani, 2023; Ibnusaputra, 2023), personal reasoning, and everyday experiences (Sari, 2023; Amiruddin, 2025). Furthermore, misconceptions are exacerbated by exposure to inaccurate information both inside and outside the classroom, influencing how students understand physics theories (Kaloi, 2022; Chisango, 2023). If left unaddressed, these misconceptions can interfere with further learning, particularly for prospective physics teachers who will be responsible for teaching the material (Mardyah, 2024). Therefore, it is crucial to identify and address misconceptions, especially among prospective teachers. Various studies suggest that appropriate correction of misconceptions can lead to changes in understanding among future educators (Özmen, 2022). However, caution must be exercised in addressing misconceptions, as ineffective attempts may inadvertently reinforce them through the backfire effect (Götzfried, 2024). Hence, media that can facilitate more effective conceptual change is essential to improve students' understanding of physics concepts (Götzfried, 2022).

2.2 4-Tier Diagnostic Test

The 4-tier diagnostic test is a method used to identify misconceptions in a more comprehensive manner. This method consists of four stages: multiple-choice answers in the first stage, certainty level of the answers in the second stage, justification of the answers in the third stage, and the confidence level in the justification in the fourth stage (Hunaidah, 2022). This test is designed to address the limitations of the 2-tier and 3-tier tests by adding a layer of validation and reliability in identifying misconceptions and gaps in students' knowledge (Bessas, 2024). The primary advantage of the 4-tier test is its ability to more clearly differentiate between misconceptions, lack of knowledge, and students' confidence in their answers (Wu, 2024). In this test, a correct answer accompanied by a low confidence level may indicate uncertainty or random guessing, whereas an incorrect answer with a high confidence level suggests a misconception (Wu, 2024; Bessas, 2024). However, the 4-tier test also has its drawbacks, such as a more time-consuming process and greater complexity in administration and analysis (Bessas, 2024). Nonetheless, the 4-tier test offers significant advantages in identifying misconceptions and is particularly useful in the educational context, especially in preparing prospective teachers to understand and teach physics concepts accurately (Hunaidah, 2022).

3. RESEARCH METHODS

This study employed a descriptive quantitative-qualitative method aimed at describing the level of students' conceptual understanding through an analysis of the results of a 4-tier diagnostic test. The subjects consisted of 66 fifth-semester students from the Physics Education Program at a state university in Tasikmalaya, West Java. All participants were selected using total sampling to obtain a comprehensive overview of their understanding of physics concepts.

The primary instrument used in this research was a 4-tier diagnostic test, designed as a multiple-choice format to investigate students' misconceptions in depth through their response patterns. Multiple-choice diagnostic tests have been widely recognized as a valid and practical method (Haladyna, 2011). The advantages of this test format include relatively short implementation time, broad material coverage, and fast and objective scoring processes (Bessas, 2024). However, the multiple-choice diagnostic test format has limitations, such as its inability to accurately capture an individual's perception due to restricted answer choices (Bessas, 2024). To address this limitation, the answer choices in the diagnostic test were designed based on interviews with students and findings from previous studies. Each question in the test comprised four tiers: problem-solving answer choices, confidence level in the chosen answer, reasons for the selected answer, and confidence level in the stated reason. The characterization of students' response patterns for each tier is presented in Table 1.

Table 1. Characteristics of states in a 4-tier test

1st tier	**2nd tier**	**3rd tier**	**4th tier**	**Decision for 4 tier test**
Correct	Sure	Correct	Sure	Scientific Conception (SC)
Correct Correct Correct Correct Correct Correct	Sure Not Sure Not Sure Sure Not Sure Not Sure	Correct Correct Correct Wrong Wrong Wrong	Not Sure Sure Not Sure Not Sure Sure Not Sure	Lack of knowledge (LK)
Wrong Wrong Wrong Wrong Wrong Wrong Wrong	Sure Sure Not Sure Not Sure Sure Not Sure Not Sure	Correct Correct Correct Correct Wrong Wrong Wrong	Sure Not Sure Sure Not Sure Not Sure Sure Not Sure	Lack of knowledge (LK)
Correct Wrong	Sure Sure	Wrong Wrong	Sure Sure	Misconception (MSC)

The data collection process was conducted in two stages. The first stage involved all students completing the 4-tier diagnostic test. The test results were analyzed using descriptive statistics to describe students' response patterns and determine the percentage distribution of categories such as Scientific Conception (SC), Misconception (MSC), and other categories.

In the second stage, six students were selected based on the test results: three students with the highest levels of Scientific Conception (SC) and three students with the highest levels of Misconception (MSC). These six students were interviewed to gain deeper insights into the reasoning and logic underlying their conceptual understanding. The interview data were analyzed qualitatively to provide a more comprehensive understanding of the factors influencing scientific conception and misconceptions among the selected students.

4. RESULTS AND DISCUSSION

This study utilized a 4-tier test designed to cover the topic of linear motion mechanics. Table 2 provides a detailed explanation of the linear motion concepts integrated into each item of the 4-tier test, offering a comprehensive overview of the scope and depth of the material being assessed.

Table 2. Specific concepts of linear motion per questions

Questions	Specific concepts of linear motion
1	Motion and position
2, 3, 4	Distance and displacement
5, 14, 15, 16, 20	Speed and velocity
9, 10, 12	URM and UARM
6, 13	Graphs of URM and UARM
17, 18, 19	Vertical motion

The 4-tier test was designed with questions targeting misconceptions identified in previous discussions and literature reviews from prior research. The purpose of the creation, structure, and organization of the 4-tier test is to systematically guide students toward specific misconceptions deemed significant by the authors to foster a deeper understanding of linear motion phenomena. Table 3 presents the categorization of questions based on indicators focusing on the types of misconceptions being highlighted. This categorization provides an overview of how each question relates to the identified types of misconceptions.

Tabel 3. Categorization of questions according to the indicator – misunderstanding sought to be highlighted

Questions	indicator	Misunderstanding sought to be highlighted
1	Identifying motion and the position of an object.	Restating the concept without correctly applying it in the given context.
2, 3, 4, 5, 14, 15, 16, 20	Differentiating between distance and displacement, speed and velocity.	Misclassifying objects based on specific attributes (e.g., treating distance and velocity as a vector or displacement and velocity as a scalar).
9, 10	Applying physical quantities in Uniform Rectilinear Motion (URM) to solve problems.	Providing examples unrelated or irrelevant to the concept being tested.
7, 8, 11, 12	Analyzing physical quantities in Uniformly Accelerated Rectilinear Motion (UARM).	Representing concepts inaccurately in mathematical forms (e.g., misapplying equations of motion).
17, 18, 19	Analyzing objects in vertical upward motion.	Developing insufficient or unnecessary conditions for the given concept.
6	Solving problems involving motion graphs and data.	Misinterpreting graphs, such as associating the area under a velocity-time graph with velocity instead of displacement.
13	Ability to apply the concept of linear motion (both uniform motion and accelerated motion) to analyze data and interpret graphs in	Misunderstanding the relationship between velocity, time, and displacement, including misinterpreting the area under the velocity-time graph as velocity instead of displacement, as well as difficulties in correlating

	solving physics problems.	numerical data with graphical representations.

Furthermore, Table 4 provides a detailed breakdown of each question based on Table 3. This explanation includes an in-depth description of how each question was designed to reveal specific misconceptions.

Tabel 4. Detailed description of questions based on the indicator - highlighted misconception

Questions	**Questions' rationale**
1	This question is designed to assess students' ability to identify the motion and position of an object, either based on direct observation or descriptive scenarios. This is essential for ensuring students' foundational understanding of basic concepts in linear motion.
2, 3, 4, 5, 14, 15, 16, 20	These questions evaluate students' understanding of the difference between distance (a scalar quantity) and displacement (a vector quantity), speed and velocity. This concept serves as a foundation for comprehending linear motion and distinguishing between scalar and vector properties.
9, 10	These questions aim to test students' ability to model real-world situations using physical quantities related to Uniform Rectilinear Motion (URM). Problem-solving in URM connects theoretical concepts to practical applications, enhancing students' comprehension and analytical skills.
7, 8, 11, 12	These questions assess students' ability to analyze physical quantities in UARM, such as acceleration, velocity, and displacement, using various mathematical representations. This is critical for developing analytical skills in physics.
17, 18, 19	These questions focus on students' ability to analyze vertical motion, including initial conditions, gravitational acceleration, and the apex of motion. This is important for understanding the concepts of potential and kinetic energy in vertical motion.
6	These questions are designed to evaluate students' ability to read, interpret, and analyze data and graphs related to linear motion. This fosters data literacy skills, which are crucial in understanding physics concepts.
13	Question 13 is designed to assess students' ability to apply the concepts of linear motion (both uniform and accelerated) to analyze data and graphs in solving physics problems. This question integrates graph interpretation skills with theoretical understanding, such as the relationship between velocity, time, and displacement, while also identifying potential misconceptions related to graph interpretation. Its primary goal is to evaluate students' conceptual knowledge and analytical skills while fostering their data literacy in the context of physics.

Subsequently, the 4-tier test was validated by two physics education lecturers with expertise in evaluation instrument development and mechanics. The validation was conducted based on four key assessment aspects: feasibility of question construction, feasibility of content, language and clarity, and suitability of answer options. The evaluation was carried out using a Likert scale ranging from 1 to 5 (1 = "very inappropriate," 5 = "very appropriate"). The validation results from the experts were then analyzed using Aiken's V to measure the content validity of each test item, with detailed results presented in Table 5.

Tabel 5. The validity of the 4-tier test based on Aiken's V Calculation Results

Aspect	Expert 1	Expert 2	Aiken's V	Description
Feasibility of Question Construction	4	4	0,75	Valid
Feasibility of Content	4	5	0,88	Valid
Language and Clarity	5	5	1,00	Very Valid
Suitability of Answer Options	4	3	0,63	Valid

After the 4-tier test was administered to physics education students, the results were statistically analyzed to identify specific misconceptions that might have emerged during the test. This analysis aimed to delve into the patterns of understanding or misconceptions observed, as detailed further in Table 3. Additionally, Figure 1 compiles the percentage distribution of characteristic states (SC, LK, or MSC) for each question on the 4-tier test. Figure 1 provides a visual representation of the distribution of misconceptions among students for each question, mapped according to the categories described in Table 1.

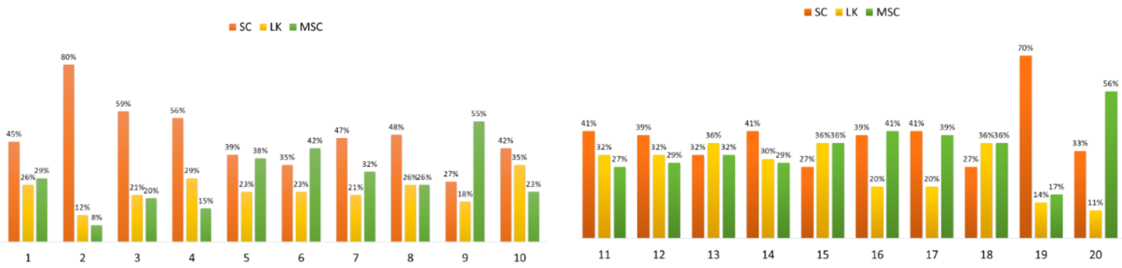

Fig 1. The percentages of the characterizations of the responses in the 4-tier test per question

Based on Figure 1, SC dominates in question items 2 (80%), 3 (59%), 4 (56%), and 19 (70%), indicating that students have a good scientific understanding of the concepts tested in these items. This suggests that the material related to these questions, namely distance and displacement, as well as vertical motion, has been well mastered. The high percentage of LK is seen in questions 18, 15, and 13 (36%), 11 and 12 (32%), and 10 (35%), indicating that some students lack sufficient knowledge to answer the questions correctly. This could be due to inadequate explanation of the material or a lack of practice with similar questions. Next, the highest MSC percentages are found in questions 20 (56%) and 9 (55%), indicating misconceptions among students. Furthermore, the lowest MSC percentage is seen in question 2 (8%), indicating that misconceptions in this question are relatively few, which is why SC is very high in item 2.

Next, Figure 2 displays the average values of the SC, LK, and MSC characteristic percentages found in the 4-tier test. Figure 2 provides an overview of the average distribution of each characteristic category: SC (students who understand the material), LK (students lacking knowledge), and MSC (students with deep misconceptions) across all the questions in the test.

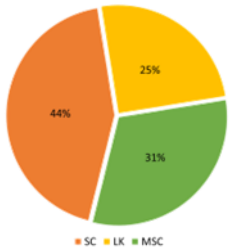

Fig 2. Mean values of the percentages of SC, LK and MSC

Based on the data analysis and students' answers to each question, 25% of the students' responses indicate a lack of understanding. However, an encouraging result is that the level of understanding of the concept of linear motion reached 44%, indicating that this concept is still grasped by students. Additionally, students' misconceptions reached 31%, which is a high percentage and indicates that most students still have misunderstandings regarding linear motion. This percentage is higher compared to the LK category, which is only 25%. This suggests that more students are confident in their incorrect understanding than those who are unsure or unaware of the correct answer.

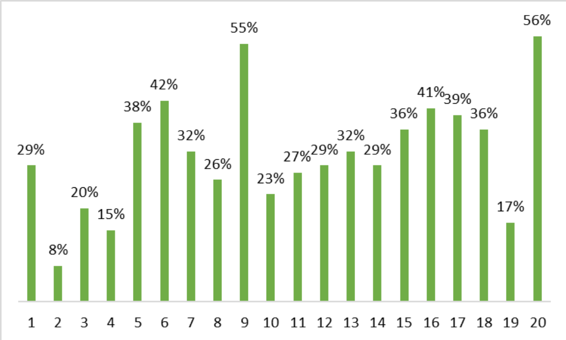

Fig 3. The percentages of the average values of decisions and especially of misconceptions per question

Based on Figure 3, it can be seen that many students experience misconceptions in questions number 6, 9, 16, and 20. These questions focus on the concepts of speed and velocity, uniform rectilinear motion (URM), and non-uniform rectilinear motion (UARM) along with their graphs. The misconceptions in these questions indicate that students tend to have difficulty distinguishing between speed and velocity, as well as interpreting the graphs depicting these types of motion. This may suggest that the material related to speed, velocity, and motion graphs has not been fully understood by most students. Therefore, there is a need for more emphasis in teaching and a more detailed explanation regarding the differences between these concepts.

Next, the students' level of misconceptions is grouped into three levels: low, medium, and high misconceptions (Pebriani, 2024). This grouping is based on the misconception scores of each student obtained from the 4-tier diagnostic test, with the detailed categories shown in Table 6.

Table 6. The percentage of students' misconception levels

Percentage of misconception	**Category**	**Precentage Student**
$0\% < x \leq 30\%$	Low	76%
$31\% < x \leq 60\%$	Medium	24%
$61\% < x \leq 100\%$	High	0%

As many as 24% of students fall into the medium misconception category, exhibiting more frequent incorrect understanding. Their responses show high confidence in incorrect answers for more than a fifth of the total questions. Students in this category require a more intensive concept clarification-based learning approach to help them understand the differences between intuition and scientific principles. Meanwhile, 76% of students fall into the low misconception category. This means the majority of students gave incorrect answers, but their confidence in those answers was relatively low. Students in this category tend to be uncertain about their answers or have low self-confidence, so their misconceptions are more easily corrected through appropriate learning interventions. Fortunately, the absence of students in the high misconception category (0%) indicates that no students had full confidence in their incorrect answers. This suggests that although all students have misconceptions, there is still room to change their understanding since none were entirely sure of their mistakes.

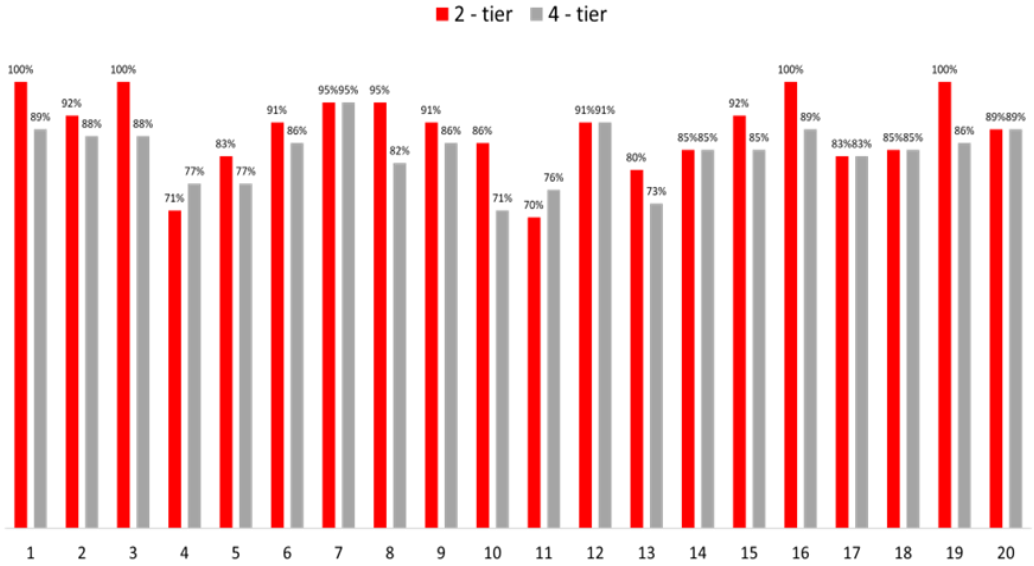

Fig 4. The % percentage of high confidence responses for 2 - tier and 4 - tier for each question separately

Figure 4 shows the percentage of students' confidence responses for the 2-tier and 4-tier tests for each question. In general, the percentage on the 2-tier test is higher than on the 4-tier test, with values ranging from 70% to 100% on the 2-tier and 71% to 95% on the 4-tier. Questions 1, 3, 16, and 19 show a significant difference, where the confidence level on the 2-tier test reaches 100%, while on the 4-tier test it drops to 86%. This reflects that the 4-tier test is more complex as it involves additional reasoning and confidence levels, which can decrease students' self-confidence. However, for some questions like 7, 12, 14, 17, 18, and 20, the confidence level was the same in both methods, indicating that these types of questions were not influenced by the difference in evaluation format. On the other hand, for questions 4 and 11, the students' confidence level increased by 6%. The largest decrease in confidence levels occurred for questions 8, 10, and 19, with a drop of 14-15%. Overall, the 2-tier test evaluates the direct application of concepts with a high level of student confidence, while the 4-tier test provides a deeper analysis by detecting misconceptions and assessing students' conceptual understanding, leading to a decrease in their confidence levels.

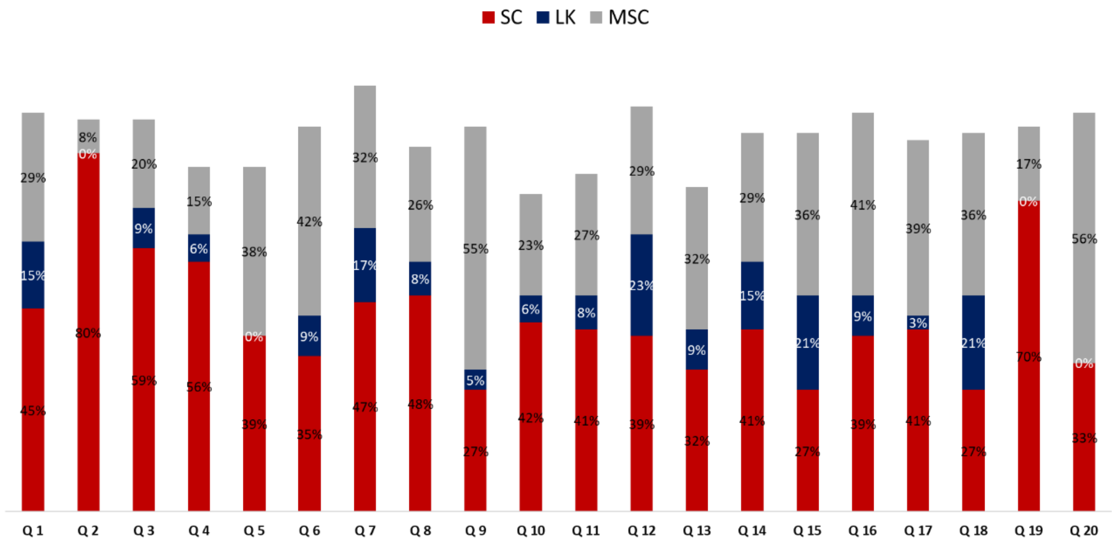

Fig 5. Cumulative % percentage of SC, LK, and MSC corresponding to the high-confidence responses of the 4 – tier

Based on the confidence percentages from the 4-tier test, SC, which represents correct scientific concept understanding, dominates in every question. This indicates that a significant portion of students has a good understanding of the questions. However, MSC, which represents misconceptions, is also relatively high, especially for questions 20 (56%) and 9 (55%). This suggests that questions 20 and 9 may be more complex or that there are unresolved conceptual errors from the learning process. Meanwhile, LK remains stable within the low range of 3% to 9%, with the highest being 23%.

This study examined the results of a 4-tier diagnostic test, focusing on students' misconceptions in the area of mechanics of linear motion. The findings reveal three key student characteristics: SC (correct scientific concept understanding), LK (lack of knowledge), and MSC (misconceptions). A significant proportion of students (44%) demonstrated a good understanding of the material (SC), while a third (31%) still harbored deep misconceptions (MSC), and 25% of students exhibited a lack of knowledge (LK).

Regarding misconceptions, the students were categorized into three levels: low misconception (76%), medium misconception (24%), and no students exhibited high misconceptions (0%). The absence of high misconceptions indicates that although students experienced conceptual errors, no one had deeply incorrect understandings. The majority of misconceptions (76%) were at a low level, suggesting that most students still had the potential to correct their misunderstandings if provided with appropriate interventions. The medium misconception group (24%) indicates that there are significant challenges in teaching that need to be addressed. The analysis also found that students performed better on the 2-tier test (70%-100%) compared to the 4-tier test (71%-95%). This suggests that while the 4-tier test provided more varied results, students generally performed better on the simpler 2-tier test. The increased complexity of the 4-tier test, which evaluates both correct answers and reasoning behind them, likely contributed to a decrease in students' confidence. Although SC dominates, there is a relatively high tendency toward the MSC category on certain questions, particularly on question number 20 (56%) related to speed and velocity and question number 9 (55%) related to URM and UARM. This indicates that these questions may contain elements that are confusing or overly complex for students, resulting in a high level of misconceptions.

Interviews were conducted with students who scored the highest in the SC category. The results revealed that they had teaching experience, either as honorary teachers in schools or as tutors in learning centers. This experience allowed them to frequently review the material and practice various questions for teaching purposes (Guerra-Reyes, 2024). These activities enabled them to prepare the material while deepening their understanding of physics (Guerra-Reyes, 2024), making them more accustomed to tackling the questions. This teaching experience played a crucial role in helping them gain a deeper understanding of the material and answer questions accurately.

On the other hand, students with the highest MSC scores tended to lack teaching experience, and most of them relied solely on their daily experiences and personal reasoning. This suggests that students who do not engage in teaching activities or regularly practice exam questions are more likely to experience misconceptions. They tend to rely on personal reasoning when analyzing questions (Sari, 2023). Even one student with teaching experience outside the field of physics still exhibited high levels of misconceptions in physics exams, indicating that teaching experience in other fields may not be sufficiently relevant for a good understanding of physics concepts. Therefore, students should have teaching experiences aligned with their academic background. This ensures that they avoid misunderstandings while teaching due to a lack of in-depth comprehension of the concepts being taught (Kismiati, 2024). Such gaps in understanding can lead to errors or miscommunication when delivering material to students. This is critical because, in physics education, rote memorization alone is insufficient; students must engage in scientific processes to enhance conceptual understanding and reduce misconceptions (Zulfira, 2024).

Based on these findings, it is recommended that more contextual and experience-based learning approaches, such as providing opportunities for students to teach or engage in group discussions, be implemented to enhance conceptual understanding and reduce misconceptions. Additionally, developing diagnostic questions that better differentiate between correct conceptual understanding and misconceptions should be prioritized to identify students' difficulties more precisely. Another recommendation is to provide students with more opportunities to practice questions and engage in discussions with experienced instructors or peers, particularly on topics prone to high misconceptions, such as speed, velocity, URM, and UARM. In this way, more active and profound learning experiences can improve students' overall understanding and reduce errors stemming from deep-seated misconceptions.

The limitations of this study include the small sample size and challenges in determining the underlying causes of misconceptions in depth. With only six students participating in the interviews, the findings may not be generalizable to a broader population. Furthermore, while the diagnostic test identified misconceptions, this study did not sufficiently explore the factors causing these misunderstandings, such as instructional errors or poorly designed questions. For future research, it is recommended to expand the interview sample and employ more in-depth methods, such as classroom observations or qualitative analyses of learning processes, to comprehensively identify and understand the root causes of students' misconceptions.

CONCLUSION

This study demonstrates that the majority of Physics Education students experience misconceptions about basic concepts in the mechanics of linear motion, such as speed, velocity, uniform rectilinear motion (URM), and uniformly accelerated rectilinear motion (UARM). Although no students exhibited high-level misconceptions, the distribution of misconceptions shows that 24% of students had misconceptions at a moderate level, while 76% had misconceptions at a low level. The distinguishing factor between students with high and low misconceptions lies in their experience. Students with a better understanding tend to have teaching experience, allowing them to regularly review the material and practice solving problems in preparation for teaching. In contrast, students with misconceptions rely on everyday experiences and personal reasoning. Therefore, it is crucial to enhance teaching approaches that focus on deeper conceptual understanding to address these misconceptions, incorporating more varied learning experiences. This will help improve the quality of Physics Education students as future teachers and prevent the transmission of misconceptions to future generations.

REFERENCES

Amiruddin, M. Z. (2025). An analysis of first years senior high school students' mental models: a case study on the concept of straight motion. Journal of Education and Learning (EduLearn), 19(1), 249-256.

Bei, E. A. (2024). Neuromyths: Misconceptions about neurodevelopment by Italian teachers. Trends in Neuroscience and Education, 34, 100219. doi:https://doi.org/10.1016/j.tine.2023.100219

Bessas, N. T. (2024). Diagnosing students’ misconception in Hydrostatic Pressure through a 4-tier test. Heliyon, 10(23). doi:https://doi.org/10.1016/j.heliyon.2024.e40425

Chisango, T. M. (2023). Racial misconceptions of the theory of evolution predict opposition to the theory and science in general among a sample of Zimbabwean university students. Heliyon, 9(6). doi:https://doi.org/10.1016/j.heliyon.2023.e16783

Costa, J. B. (2023). Construct map development for the propagation of sound in the air. Eurasia Journal of Mathematics, Science and Technology Education, 19(9). doi:https://doi.org/10.29333/ejmste/13510

Götzfried, J. N. (2022). Revision des Lerntypenmythos durch Konzeptwechselpodcasts im Lehramtsstudium. Unterrichtswissenschaft, 50 (4), 639-659.

Götzfried, J. N. (2024). Learning styles unmasked: Conceptual change among pre-service teachers using podcasts and texts. Learning and Instruction, 94, 101991. doi:https://doi.org/10.1016/j.learninstruc.2024.101991

Guerra-Reyes, F. G.-D.-T.-A.-B. (2024). Misconceptions in the Learning of Natural Sciences: A Systematic Review. Education Sciences, 14(5), 497.

Haladyna, T. M. (2011). Twelve steps for effective test development (1 ed.). Routledge: Handbook of test development.

Hasnawati, H. S. (2022). Analysis of Understanding Science Concepts for Prospective Elementary School Teacher Candidates. Jurnal Penelitian Pendidikan IPA, 8(6), 2954-2960.

Hunaidah, H. E. (2022). our-tier diagnostic test to assess students' misconceptions about fluids: a story from development to measurement from three environmental sites. Jurnal Penelitian Pendidikan IPA, 8(3), 1586-1592.

Ibnusaputra, M. W. (2023). Development of Electronic Worksheet Guided Inquiry to Reduce Misconceptions and Improve High School Students' Concept Mastery on Straight Motion Material. Jurnal Penelitian Pendidikan IPA, 9(5), 2653-2663.

Jolles, J. &. (2021). On neuroeducation: Why and how to improve neuroscientific literacy in educational professionals. Frontiers in Psychology, 12, 752151.

Kaloi, M. H. (2022). Exploring the relationship between science, religion & attitudes toward evolution education. The American Biology Teacher, 84(2), 75-81.

Kismiati, D. A. (2024). Teacher Misconceptions: A Phenomenon of the Lack of Knowledge in Science Subjects. Jurnal Penelitian Pendidikan IPA, 10(6), 3493-3500.

Kuang-Chen, L. S. (2024). Identifying and Correcting Programming Language Behavior Misconceptions. Proceedings of the ACM on programming languages. 8(OOPSLA1), (pp. 334-361).

Mardyah, U. A. (2024). Misconception Analisis of Junior High School Student in Lareh Sago Halaban Distrit on Vibration, Wave and Sound Materials Using the Four Tier Test Instrument. Jurnal Penelitian Pendidikan IPA, 10(10), 8197-8208.

Newton, P. M. (2020). How common is belief in the learning styles neuromyth, and does it matter? A pragmatic systematic review. Frontiers in Education, 51.

Özmen, Z. M. (2022). Enhancing pre-service mathematics teachers understanding of sampling distributions with conceptual change texts. Journal of Pedagogical Research, 6(1), 110-130.

Pebriani, N. B. (2024). Analysis of Students' Misconceptions on Electrochemistry Material using the Four-Tier Diagnostic Test Instrument. Jurnal Pendidikan Sains Indonesia, 12(4), 757-768.

Prinz, A. K. (2022). Refuting student teachers' misconceptions about multimedia learning. Instructional Science, 50(1), 89-110.

Rahmadani, U. S. (2023). Systematic Review of Misconceptions in Kinematics: Identification, Causes, and Remediation. Jurnal Penelitian Pendidikan IPA, 9(12), 1274-1283.

Salimpour, S. B.-G. (2021). The gateway science: A review of astronomy in the OECD school curricula, including China and South Africa. Research in Science Education, 51, 975-996.

Sari, D. R. (2023). Students' Misconceptions and the Causes on Straight Motion Materials Using Six-Tier Multiple Choice. Jurnal Penelitian Pendidikan IPA, 9(4), 1987-1995.

Sri, W. S. (2023). Identification of Prospective Chemistry Teachers' Misconceptions When Practicing Basic Teaching Skills and Their Correction Through Cognitive Conflict Strategies. Jurnal pendidikan sains Indonesia, 11(2), 318-332.

Tarisalia, F. S. (2020). Studi pustaka miskonsepsi siswa dalam konsep gerak lurus, gerak parabola, dan gerak melingkar. Jurnal Kependidikan Betara, 1(4), 208-217.

Turner, K. H. (2024). Around the world in electrochemistry: a review of the electrochemistry curriculum in high schools. Journal of Solid State Electrochemistry, 28(3), 1361-1374.

Umardianti, U. S. (2023). Does Educational Background Affect Understanding of Science Concepts? Case Study of Prospective Elementary School Teachers. Jurnal Penelitian Pendidikan IPA, 9(8), 5798-5805.

Wu, M. T. (2024). Evaluating Students' Conceptual Understanding of Isomers Based on a Four-Tier Diagnostic Tool in Upper Secondary Schools. International Journal of Science and Mathematics Education, 1-41.

Zulfira, R. H. (2024). The Effect of Interactive Learning Media Using Visual Basic for Application Excel Spreadsheet to Reduce Misconception in Physics Learning. Jurnal Penelitian Pendidikan IPA, 10(1), 28-36.