




Four-Tier Multirepresentation Diagnostic Test for Identifying Students' Misconception on Uniform Circular Motion

Lusia Andini , Maison, Jeliana Veronika Sirait

Universitas Jambi

Jl. Lintas Jambi - Muara Bulian No.KM. 15, Jambi Luar Kota, Muaro Jambi, Jambi, Indonesia

luisanaandini07@gmail.com  | DOI: <https://doi.org/10.37729/radiasi.v19i1.7499> |

Abstract

This study aims to analyze students' misconceptions on the topic of uniform circular motion using a four-tier diagnostic test based on multi-representation. The use of a four-tier diagnostic test based on multi-representation is expected to be able to identify students' misconceptions more deeply because it not only analyzes students' answers and reasons, but also the level of students' beliefs in various forms of representation, namely macroscopic, microscopic, symbolic, and graphic. This study used a quantitative descriptive method involving 100 high school students' who had studied the material of regular circular motion. Data were analyzed by grouping students' answers into five categories, namely scientific conception, misconception, lack of knowledge, false positive, and false negative. The results showed that the misconception category had the highest percentage of 37.17 percent, which indicates that students still have difficulty in connecting concepts to various forms of representation. Misconceptions were more common in macroscopic and symbolic representations, especially in understanding the direction of centripetal acceleration and the relationship between quantities in regular circular motion. These findings indicate that students' conceptual understanding has not been fully formed. Therefore, physics learning needs to integrate various forms of representation so that students' conceptual understanding becomes more comprehensive. However, this study is limited to descriptive analysis in one school so that the factors causing misconceptions have not been studied in depth.

Article Info:

Received:

10/03/2026

Revised:

24/04/2026

Accepted:

29/04/2026

Keywords: Four tier test; Misconception; Multirepresentation; Circular motion



1. Introduction

Physics learning at the secondary level aims to help students understand various phenomena in nature through scientific principles, concepts and laws of physics [1]. According to [2], understanding concepts is crucial in physics learning because these concepts serve as the foundation for students to explain natural phenomena and solve various physics problems. However, in practice, many students have difficulty grasping abstract physics concepts, resulting in understandings that often do not align with actual scientific concepts. Poor conceptual understanding can hinder students' ability to solve contextual problems and develop scientific reasoning [3]. The use of concepts that do not follow scientifically accepted concepts from experts or scientists is called misconception [4].

Misconceptions are closely related to differences in the level of students' conceptual understanding in capturing the material they receive [5]. Misconceptions can hinder students' from understanding related concepts and science as a whole [6]. Misconceptions can form before learning begins or even emerge after the learning process has taken place [7].

The problem of misconceptions in various fields of science, especially physics, has long been widely discussed by researchers from various places, where physics is a branch of natural science that discusses phenomena in everyday life [8]. The existence of this misconception will certainly hinder someone in the process of transferring new knowledge, thus preventing success in further learning activities [9]. According to [10], state that misconceptions are dangerous because they lead to incorrect thinking and feelings in understanding concepts, creating a barrier between the previously incorrect concept and the new concept being learned. If misconceptions are not immediately identified and corrected, they tend to persist over time and become part of students' thinking frameworks [11]. Misconceptions must be identified and corrected through learning so that students can understand the correct concepts [12]. If the misconception is critical, it can disrupt the student's subsequent knowledge development. Therefore, misconceptions experienced by students must be addressed immediately [13].

One of the physics topics that often causes misconceptions in students is uniform circular motion. Several studies show that students often have difficulty understanding the direction of centripetal acceleration, distinguishing linear velocity from angular velocity, and understanding the relationship between centripetal force and the motion of an object in a circular path. Students assume that centripetal acceleration is in the same direction as linear velocity, even though centripetal acceleration is directed towards the center of the circle [14]. According [15], several studies have shown that students still experience various misconceptions regarding uniform circular motion. For example, students assume the period is proportional to the number of rotations of an object and assume that the direction of centripetal acceleration is tangent to the path like the object's velocity, when in fact, centripetal acceleration is perpendicular to the velocity and toward the center of the circle. This situation indicates that misconceptions regarding circular motion are still a problem that must be addressed in the physics learning process.

Observations and interviews with physics teachers at SMA Negeri 1 Muaro Jambi indicate that students still face difficulties in applying the concept of uniform circular motion to solve problems involving the relationship between physical quantities and mathematical formulas. Teachers also stated that many students still experience difficulties in the areas of symbols, formulas, graphs, and physical phenomena in a single, complete concept. Furthermore, the process of identifying misconceptions conducted by teachers still tends to use verbal questions, so they are unable to reveal students' misconceptions in depth and systematically. This situation indicates a misalignment between students' conceptual understanding and their ability to apply those concepts to solve physics problems. In the learning process, the use of various types of representations has not been maximized, so students often understand concepts through only one presentation method. This situation results in students facing challenges when having to link verbal, symbolic, graphical representations, and physical phenomena in understanding the concept of uniform circular motion. Therefore, a multi-representation-based diagnostic tool is needed that can detect students' misconceptions more deeply.

To identify student misconceptions more accurately, a diagnostic instrument is needed that can deeply explore students' conceptual understanding. Diagnostic tests are used to identify students' conceptual errors, allowing teachers to identify areas of the material that are not yet fully understood. By administering diagnostic misconception tests to students, teachers can identify conceptual errors experienced by students [16]. The use of four-tier diagnostic tests is more effective in identifying misconceptions compared to other diagnostic tests because it can explore students' conceptual understanding more deeply by having a level of confidence in answer choices and reasons [17]. The two-tier diagnostic test is a development of the two-tier multiple choice test, where the first and third levels are used to measure students' understanding of concepts and reasons, while the second and fourth levels are used to measure students' level of confidence in the answers and reasons chosen [18].

This results in the test results obtained being more accurate compared to other test instruments in identifying student misconceptions [19]. The four-tier diagnostic test can identify students who have a good understanding of concepts, misconceptions and those who do not understand concepts [20].

In physics learning, understanding concepts cannot be seen from just one presentation method, but needs to be understood through various representations [21]. Multirepresentation ability is an ability that students must have, so that students can easily represent solutions to the problems they face [22]. Learning with a multirepresentation approach emphasizes various perspectives in the form of verbal representations, pictures, diagrams, tables, and graphs [23]. By using various forms of representation, such as macroscopic, submicroscopic, and symbolic, students can gain a deeper understanding of concepts [24]. With various forms of representation, students also demonstrate different problem-solving abilities. Learning will be effective and efficient if it is carried out using various representations [25]. Through a multirepresentation approach, it can be used to analyze students' conceptual understanding from various perspectives so that misconceptions experienced by students can be identified more clearly and comprehensively.

Various studies have examined misconceptions in uniform circular motion. However, most studies still use two-tier or three-tier diagnostic tests, thus failing to fully reveal the relationship between students' answers, reasons, and confidence levels. Furthermore, research integrating the four-tier diagnostic test with a multirepresentational approach in uniform circular motion is still limited. Therefore, this study was conducted to analyze students' misconceptions in depth using the four-tier multirepresentational diagnostic test and provide an overview of students' conceptual understanding profiles in uniform circular motion.

2. Methods

This study employed a quantitative descriptive method to identify and analyze students' misconceptions related to uniform circular motion. This method was used to explain students' conceptual understanding based on the results of a diagnostic test. This study was conducted at SMA Negeri 1 Muaro Jambi, involving students who had already studied uniform circular motion. The sample consisted of 100 students drawn from classes that had already studied this topic. The instrument used in this study was a four-level multi-representation diagnostic test designed to assess students' conceptual understanding and misconceptions. The test consists of four levels. The initial level includes questions that elicit concepts. The subsequent level relates to the level of confidence in answering the initial questions. The third level relates to the reasoning behind the answers given, while the fourth level measures students' confidence in choosing those reasons [26]. The use of a four-tier diagnostic test allows for more accurate identification of student misconceptions than conventional multiple-choice tests, as it considers students' answers, reasoning, and level of belief. The questions in this instrument are designed using a multirepresentational approach that includes macroscopic and microscopic images, symbols, and graphs. This multirepresentational approach is applied to evaluate students' conceptual understanding across various presentation formats, allowing for a more comprehensive and in-depth identification of student misconceptions.

Before being implemented in research, the instrument must first be validated by a subject matter expert to assess the suitability of the content, structure, and language aspects, as well as the instrument's ability to identify misconceptions. After the validation process, the instrument is revised based on input from the validator, then tested on a limited basis in one class. After completing the test, students are asked to complete a student response questionnaire using a Likert scale to evaluate the clarity of the questions, the use of language, and the instrument's ability to detect student misconceptions. Data from the questionnaire is analyzed as a percentage to determine students' responses to the instrument.

If the percentage indicated a good rating, the instrument was not revised. The instrument deemed suitable was then administered to 100 students to identify and analyze student misconceptions about uniform circular motion. Instruments deemed to have met the requirements were then piloted on 100 students in a large-scale testing phase. The data obtained from the test were then analyzed to determine the instrument's validity and reliability. To test item validity, product-moment correlation analysis using Microsoft Excel and corrected item-total correlation analysis using SPSS were used. For reliability, the Cronbach's Alpha approach was used. The reliability test results showed a Cronbach's Alpha value of 0.807 for a total of 18 items, confirming the instrument's high reliability and readiness for application in research.

Data collection was conducted by administering a four-tier multi-representation diagnostic test to students who had studied the topic of uniform circular motion. Each question presented a concept in various forms of representation, including verbal, pictorial, symbolic, and graphical. A multi-representation approach was applied to explore students' conceptual understanding in greater depth while identifying potential misconceptions. Data obtained from students' answers were analyzed based on the combination of answers and their confidence levels at each tier of the four-tier diagnostic test. Students' conceptual understanding was grouped into five categories: scientific conception, misconception, lack of knowledge, false positive, and false negative. The percentage of each category was calculated using the following equation: According to [27], the category percentages are calculated using the formula:

$$P = \frac{f}{N} \times 100\%$$

with P as a percentage of the understanding category, f as the number of students in each category, and N as the total number of students. The results of this analysis are used to describe the profile of students' conceptual understanding and identify the forms of misconceptions that arise in each phenomenon and representation.

3. Results and Discussion

This section presents an analysis of students' conceptual understanding of uniform circular motion using the four-tier multirepresentation diagnostic test. The analysis was conducted to identify categories of students' conceptual understanding and the forms of misconceptions that emerged in each phenomenon presented in the instrument. The results indicate that students' conceptual understanding varied across phenomena and representations. Some students' demonstrated a consistent understanding of scientific concepts, but some students still experienced misconceptions and did not fully grasp the concepts. To provide a general overview of students' conceptual understanding profiles, the analysis was classified into five categories: conceptual understanding (Scientific Conception/ SC), misconception (Misconception/ MSC), false positives (FP), false negatives (FN), and lack of knowledge (Lack of Knowledge/ LK). This classification was obtained from a combination of students' answers to four questions: answer choices, level of confidence in the answers, reasons for the choices, and level of confidence in the reasons. Based on the data analysis using the four-tier diagnostic test, the distribution of student conceptual understanding categories included scientific conception, misconception, lack of knowledge, false positives, and false negatives. The percentage of each category is presented in Table 1.

Table 1. Percentage of Student Concept Understanding Categories

| No | Category | Percentage |
|----|-----------------------|------------|
| 1 | Scientific Conception | 24.39 % |
| 2 | Misconception | 37.17 % |
| 3 | Lack of Knowledge | 19.00 % |
| 4 | False Positif | 8.72 % |
| 5 | False Negatif | 10.11 % |

Based on Table 1, the misconception category has the highest percentage at 37.17%. These results indicate that most students' still have an understanding that is inconsistent with the scientific concept of uniform circular motion. The high percentage of misconceptions indicates that students still have difficulty understanding the relationships between concepts in uniform circular motion. These misconceptions can occur because students construct understanding based on everyday experiences that don't necessarily align with physics concepts. According to constructivism theory, students construct new knowledge based on prior knowledge. If this prior knowledge doesn't align with scientific concepts, students tend to maintain misconceptions even after learning. In circular motion, students often assume that an object moving in a circle will have acceleration in the same direction as its motion. However, in the concept of circular motion, the direction of centripetal acceleration is not in the same direction as the object's motion, but always points toward the center of the trajectory.

Furthermore, the abstract concept of uniform circular motion also contributes to students' difficulty understanding the relationships between physical quantities. Concepts such as centripetal acceleration, angular velocity, and the relationship between linear velocity and angular velocity require students to connect mathematical concepts with physical phenomena. When students are unable to connect these various conceptual representations, they tend to memorize formulas without understanding their physical meaning, making them more susceptible to misconceptions. The existence of false positive and false negative categories also indicates that students' confidence levels do not always align with the correctness of their answers. Some students answer correctly but provide incorrect reasoning, and others answer incorrectly but actually have reasoning that aligns with the scientific concept. These results demonstrate that students' conceptual understanding cannot be assessed solely on the final answer; they also need to analyze their reasoning and confidence levels. Therefore, using a four-tier diagnostic test is more effective in identifying misconceptions in depth than a traditional multiple-choice test. Further analysis of students' misconceptions based on phenomena and forms of representation is presented in Table 2 and Figure 1.

Table 2. Percentage of Misconceptions Based on Phenomena and Representation

| Phenomenon | Macroscopic | Microscopic | Symbolic | Graphical |
|------------|-------------|-------------|----------|-----------|
| 1 | 66 | 66 | 31 | - |
| 2 | 43 | - | 43 | 20 |
| 3 | 27 | - | 30 | 37 |
| 4 | 55 | 45 | 43 | 26 |
| 5 | 32 | 13 | - | 30 |
| 6 | 23 | 39 | - | - |

Information: The (-) sign indicates that the representation is not presented in the phenomenon.

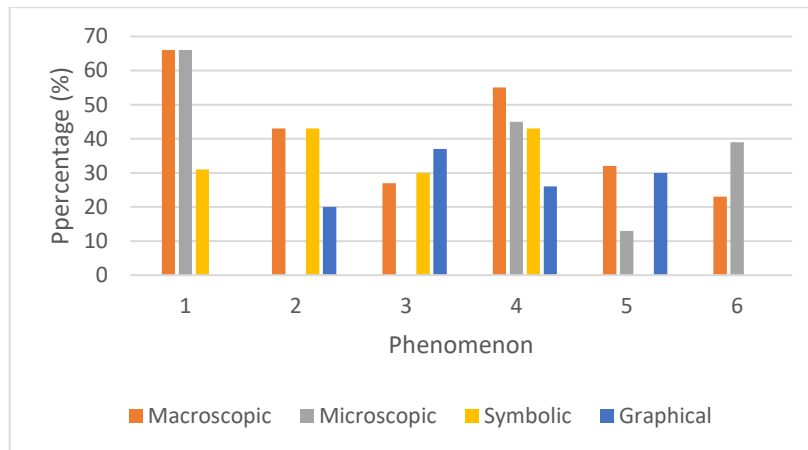


Figure 1. Percentage of Misconceptions Based on Phenomena and Representation

Based on Table 2 and Figure 1, it can be seen that the level of students' misconceptions varies across phenomena and types of representation. The missing data in several cells in Table 2 indicates that not all forms of representation are presented for each phenomenon. This is due to the instrument design, which selectively integrates representations according to the concept indicators being measured. Each phenomenon focuses on a specific representation deemed most relevant to uncovering students' understanding and misconceptions. Therefore, the absence of data on a particular representation does not indicate a lack of data, but rather represents part of the instrument development strategy.

The study results show that misunderstandings in macroscopic representations tend to be higher than in symbolic or graphical representations. This indicates that students' still face challenges in connecting physics concepts to real-life events. In the context of macroscopic representations, students' need to describe real-life phenomena using scientific concepts. However, many students' still rely on everyday understanding to explain these phenomena, such as assuming that when a string breaks, an object will bounce off its trajectory because of a force pushing the object outward. This understanding is evident in students' reasoning that the broken string causes the object to bounce in a certain direction. However, conceptually, an object does not experience a force pushing it outward; instead, the object maintains its linear velocity at the final point according to Newton's First Law. After the centripetal force is lost due to the string breaking, the object moves in a straight line tangent to a circular path.

In the submicroscopic realm, student misunderstandings regarding several phenomena are still relatively high. This indicates that students' still have difficulty imagining processes or interactions of physics concepts that cannot be directly observed. Students' find it easier to grasp concrete phenomena compared to conceptual explanations, which involve the direction of forces, particle interactions, or abstract visualizations of motion. This situation results in some students' being unable to connect microscopic representations with the circular motion phenomena that occur in real life. The inability to connect macroscopic phenomena with microscopic explanations results in inaccurate understanding. This is in line with Sukmawati's statement, which states that abstract concepts in physics require good visualization skills; otherwise, students are susceptible to misconceptions [28].

In symbolic representation, students' experience difficulty understanding the relationships between quantities and the use of mathematical equations. Many students' are unable to differentiate between angular velocity and linear velocity and do not yet understand the physical meaning of the equations used. This indicates that students' tend to memorize formulas without deeply understanding the concepts. In symbolic representation, students' experience difficulties in understanding the relationships between quantities and the use of mathematical equations.

Many students' are unable to differentiate between angular velocity and linear velocity and do not yet understand the physical meaning of the equations used. This shows that students' tend to memorize formulas without understanding the concepts in depth. Students' are more likely to memorize formulas without understanding the meaning of each variable contained. This causes students' to be able to answer questions correctly, but cannot provide reasons in accordance with the explanation of the concept. This shows that students' understanding is still procedural, not conceptual. This condition is in line with the opinion of [29] who stated that students often use physics formulas mechanically without understanding the true conceptual relationship. Furthermore, there were numerous misconceptions about the graph categories for several phenomena. This indicates that students' ability to read and understand graphs is still lacking. Some students focused solely on the shape of the graph without understanding the relationship between the variables shown. This finding is also in line with previous research which stated that students often experience misconceptions in circular motion material, especially in understanding the direction of centripetal acceleration and interpreting graphs [30].

The results of this study indicate that students do not fully grasp concepts across various types of representations. They still face challenges in linking verbal, pictorial, symbolic, and graphical representations into a coherent concept. This emphasizes the importance of implementing multi-representation-based learning methods in physics teaching. If learning does not fully incorporate various forms of representation, students tend to only grasp concepts within a specific type of presentation, resulting in less in-depth understanding. However, this study has limitations: not all forms of representation appear in every phenomenon, resulting in some missing data. Furthermore, this study is only descriptive in nature, so it does not fully address the causes of misconceptions. Therefore, further research is recommended to develop learning methods or strategies that can reduce student misconceptions using a multi-representation approach.

4. Conclusion

This study aimed to analyze students' misconceptions regarding uniform circular motion using a four-tier multi-representation diagnostic test. The results showed that misconceptions remained very high in understanding the concept, as evidenced by the high percentage of categories and the discrepancies and inconsistencies between students' answers, explanations, and confidence levels. These errors emerged in various forms of representation: macroscopic, microscopic, symbolic, and graphic. These findings indicate that students still experience difficulty connecting everyday phenomena, conceptual visualizations, mathematical equations, and graphic interpretations into a comprehensive understanding. This study also revealed that the four-tier multi-representation diagnostic test was able to identify student misconceptions more accurately because it not only analyzed answers but also considered students' explanations and confidence levels. Therefore, this instrument can be used as an alternative diagnostic tool in physics teaching to help teachers more accurately identify student misconceptions. However, this study has limitations because it was conducted in only one school and used a quantitative descriptive method that did not sufficiently explore the factors causing misconceptions. Therefore, it is recommended that further research involve a larger sample size and develop multi-representation-based teaching strategies to help reduce student misconceptions. Furthermore, it is hoped that teachers can integrate various forms.

Acknowledgement

The authors would like to thank all parties who have supported the implementation of this research. Thanks are extended to the supervising lecturer who provided direction and guidance throughout the research process, and to the school administration of SMA Negeri 1 Muaro Jambi for granting permission and the opportunity to conduct the research. Thanks are also extended to the physics teacher who assisted in the data collection process, and to the students who participated as respondents in this research.

References

- [1] N. Amalisholeha, J. Rokhmat, and I. W. Gunada, "Analisis Kesulitan Belajar Peserta Didik pada Pembelajaran Fisika di SMAN 1 Kediri Analysis of Students' Learning Difficulties in Learning Physics at SMAN 1 Kediri," *Empiricism J.*, vol. 4, no. 2, pp. 356–364, 2023.
- [2] M. A. S. I Ketut Mahardika¹, Sri Handono², Ernasari⁶, Hilma Alifatur Rofida⁵, Fatimatus Zahro⁵, "Hakikat Fisika Sebagai Pilar Kehidupan," *J. Pendidik. Ilm. Transform.*, vol. 7, no. 12, pp. 30–34, 2023.
- [3] R. R. Rifai, "Pemahaman Konsep Termodinamika pada Siswa Kelas XI SMA Negeri 2 Kota Ternate," *J. Pembelajaran Sains Fis. Kuantum*, vol. 6, no. 1, pp. 393–400, 2025.
- [4] N. I. Rizkita and F. Mufit, "Analisis Pemahaman Konsep dan Sikap Siswa Terhadap Belajar Fisika Pada Materi Hukum Newton Tentang Gerak," *J. Eksakta Pendidik.*, vol. 6, no. 2, pp. 233–242, 2022, doi: 10.24036/jep/vol6-iss2/599.
- [5] W. Edy Purwanto, "Representasi Miskonsepsi Peserta Didik pada Materi Suhu dan Kalor," *Papua J. Phys. Educ.*, vol. 01, no. 01, 2020.
- [6] D. Sugiharto, H. P. Wulandari, S. E. Sururiyatul, P. T. Indah, K. Merdeka, and T. Diagnostik, "Analisis Miskonsepsi pada Materi Fisika dalam Pembelajaran IPA Kurikulum Merdeka pada Tingkat Sekolah Menengah Pertama," *J. Dunia Pendidik.*, vol. 5, no. 5, pp. 1821–1832, 2025.
- [7] S. Rahma and U. Mulawarman, "Analisis Miskonsepsi Siswa pada Materi Larutan Penyangga Melalui Tes Diagnostik CRI : Studi Kasus di SMAN 2 Muara Badak," *CHEDS J. Chem. , Educ. , Sci.*, vol. 9, no. 2, pp. 154–162, 2025.
- [8] M. Maison, N. Lestari, and A. Widaningtyas, "Identifikasi Miskonsepsi Siswa Pada Materi Usaha Dan Energi," *J. Penelit. Pendidik. IPA*, vol. 6, no. 1, pp. 32–39, 2020, doi: 10.29303/jppipa.v6i1.314.
- [9] M. Rozaq and S. Prihatiningtyas, "Analisis Miskonsepsi Mahasiswa Pada Matakuliah Fisika Teknik Untuk Rekayasa Otomotif Melalui Pembelajaran Berbasis Kasus," *J. V-Mac*, vol. 10, no. 1, pp. 1–7, 2025.
- [10] R. I. Izza, N. Nurhamidah, and E. Elvinawati, "Analisis Miskonsepsi Siswa Menggunakan Tes Diagnostik Esai Berbantuan Cri (Certainty of Response Index) Pada Pokok Bahasan Asam Basa," *Alotrop, J. Pendidik. dan Ilmu Kim.*, vol. 5, no. 1, pp. 55–63, 2021, doi: 10.33369/atp.v5i1.16487.
- [11] B. W. Talita Rizki Setianisa, Mamat Ruhimat, "Pengembangan Instrumen Four-Tier Diagnostic Test untuk Mengidentifikasi Miskonsepsi pada Materi Dinamika Litosfer Di SMA Kabupaten Cianjur," *Sosio-Didaktika Social Sci. Educ. J.*, vol. 12, no. 1, pp. 21–40, 2025.
- [12] R. N. K. Mellu and D. Langtang, "Profil Miskonsepsi Peserta Didik Pada Materi Kinematika Gerak Dan Fluida Statis," *JPF (Jurnal Pendidik. Fis. FKIP UM Metro*, vol. 11, no. 2, pp. 170–184, 2023.
- [13] D. Yolenta, L. Sutrisno, and Haratua, "Deskripsi Miskonsepsi Siswa SMA Kecamatan Kapuas Tentang Gerak Melingkar Beraturan Menggunakan Three-Tier Test," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 4, no. 3, pp. 1–7, 2020.
- [14] A. H. Daud and A. Hatibe, "Miskonsepsi Gerak Melingkar Siswa Students' Misconception on Circular Motion," *J. Kreat. Online*, vol. 9, no. 3, pp. 83–89, 2021, [Online]. Available: <http://jurnal.fkip.untad.ac.id/index.php/jko>

- [15] R. C. Habellia, H. T. Maria, and M. M. S. Hidayatullah, "Pengembangan two tier diagnostik test untuk mendeteksi miskonsepsi siswa sma pada materi gerak," *J. Pendidik. Inform. dan Sains*, vol. 10, no. 2, pp. 195–201, 2021, doi: 10.31571/saintek.v10i2.3222.
- [16] J. dan Supardiyono, "Kelayakan Instrumen Tes Diagnostik Miskonsepsi Berformat Four-Tier Untuk Mengungkap Miskonsepsi Siswa Pada Materi Hukum Newton," *IPF Inov. Pendidik. Fis.*, vol. 09, no. 02, pp. 293–300, 2020.
- [17] S. Nurlita and W. K. Sari, "Pengembangan Four-Tier Diagnostic Test Berbasis Keterampilan Proses Sains Untuk Mengidentifikasi Miskonsepsi Pada Materi Redoks," *J. Nat. Sci. Learn. Vol.*, vol. 02, no. 02, pp. 90–103, 2023.
- [18] I. S. Caleon and R. Subramaniam, "Do Students Know What They Know and What They Don't Know? Using a Four-Tier Diagnostic Test to Assess the Nature of Students' Alternative Conceptions," *Res Sci*, vol. 40, pp. 313–337, 2010, doi: 10.1007/s11165-009-9122-4.
- [19] N. Amaliyah, "Implementasi Pendekatan Pembelajaran Berbasis Kearifan Lokal Dalam Meningkatkan Minat Belajar Siswa Di MTs Miftahus Sudur Campor Proppo," vol. 2, no. 3, 2023.
- [20] E. B. Gumilar, "Problematika Pembelajaran Ipa Pada Kurikulum Merdeka Di Sekolah Dasar / Madrasah Ibtidaiyah," *J. Ilm. Pedagog.*, vol. 2, no. 1, p. 129, 2023.
- [21] O. Ate, P. Parno, and N. Munfaridah, "Multirepresentation in Physics Learning Research: A Content Analysis Review of Trends, Opportunities, and Challenges," *J. Sci. Educ. Res.*, vol. 9, no. 1, pp. 32–42, 2025, doi: 10.21831/jser.v9i1.72954.
- [22] S. Mariatul, W. P. Hadi, A. Yuniasti, R. Wulandari, D. Bagus, and R. Astid, "Analisis Kemampuan Multirepresentasi Siswa Berdasarkan Gaya Belajar Vak Materi Suhu dan Kalor," *J. Nat. Sci. Educ. Res.*, vol. 6, no. 2, pp. 39–54, 2023.
- [23] P. S. B. Alvin Ridwan Suparman, Ana Setiani, "Pengembangan Bahan Ajar Interaktif Materi Peluang Dengan Pendekatan Multirepresentasi," *J. Peka (Pendidikan Mat.)*, vol. 09, no. 01, pp. 181–186, 2025, doi: 10.37150/d7ekvn20.Copyright.
- [24] G. Rahmad Adi Putra, Nofri Yuhelman and Program, "Efektivitas Media Pembelajaran Terintegrasi Augmented Reality Materi Asam Basa Fase F Terhadap Hasil Belajar Peserta Didik," *J. Ris. Pendidik. Kim. (JRPK)*, vol. 15, no. 2, pp. 140–151, 2025.
- [25] D. Rahmawati and W. Setyarsih, "Kajian Literatur Pembelajaran Multirepresentasi pada Materi Fisika Tingkat SMA," *IPF Inov. Pendidik. Fis.*, vol. 10, no. 2, pp. 1–10, 2021, doi: 10.26740/ipf.v10n2.p1-10.
- [26] A. Rusilowati, T. Darsono, F. O. Sekarningtias, and Q. Fariyani, "Development of A Four-Tier E-Diagnostic Test on The Topic of Momentum to Measure and Reduce Student Misconception," *J. Pendidik. Fis. Indones.* 20, vol. 20, no. December, pp. 173–187, 2024, doi: 10.15294/jpfi.v20i2.
- [27] R. A. Niken Dwi Putri, Khairil Arif, Rani Oktavia, "Analysis of Students' Profile Using Four Tier Test Instrument on Temperature , Heat , and Thermal Expansion Topics in Junior High School," *JUPI (Jurnal IPA dan Pembelajaran IPA)*, vol. 9, no. 3, pp. 953–968, 2025.
- [28] W. Sukmawati, "Jurnal Inovasi Pendidikan IPA Analisis level makroskopis , mikroskopis dan simbolik mahasiswa dalam memahami elektrokimia Analysis of macroscopic , microscopic and symbolic levels of students in," *J. Inov. Pendidik. IPA*, vol. 5, no. 2, pp. 195–204, 2019.
- [29] Jumran, "Bagaimana Siswa Memahami Penggunaan Rumus Dalam Penyelesaian Kasus Fisika," *Sci. Educ. Res. Journal2*, vol. 2, no. 1, pp. 15–23, 2023.
- [30] D. Apriyani, J. Sirait, and M. M. Syarif, "Analisis Konsepsi Peserta Didik Dalam Menyelesaikan Soal Gerak Melingkar Beraturan Menggunakan Tes Diagnostik," *JPPK J. Pendidik. dan Pembelajaran*, vol. 12, no. 7, pp. 1805–1814, 2023, doi: 10.26418/jppk.v12i7.67507.