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Systematics of Student Misconceptions on the Topics of Gravity and Potential Energy: A Systematic Literature Review

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Abstract: Understanding of basic science concepts is often hindered by students' misconceptions regarding phenomena in their surroundings. If left unaddressed, these misconceptions will obscure and interfere with students' future comprehension of more complex physics material. This study aims to identify the patterns of misconceptions among elementary school students on the topics of gravity and potential energy, evaluate the effectiveness of the diagnostic instruments used, and identify the contributing factors. Employing a descriptive qualitative approach, this systematic literature review analyses various scientific sources published between 2022 and 2026. The findings reveal consistent conceptual errors, particularly the assumption that mass affects the falling speed of an object and the belief that potential energy exists only in moving objects. The primary triggering factors include students' personal intuition, conventional teaching methods, and limitations in visual media. In conclusion, the regular implementation of tiered diagnostic instruments, accompanied by a shift toward technology-based learning models, is essential for overcoming these learning obstacles.

Keywords: Misconception, Gravity, Potential Energy, Diagnostic Test, Elementary School

Abstrak: *Pemahaman konsep sains dasar sering kali terhambat oleh interpretasi keliru siswa terhadap fenomena di sekitar mereka. Jika dibiarkan, kekeliruan ini akan menyelimuti dan mengganggu pemahaman materi fisika yang lebih kompleks di masa depan. Penelitian ini bertujuan untuk mengidentifikasi pola miskonsepsi siswa sekolah dasar mengenai materi gravitasi dan energi potensial, mengevaluasi efektivitas instrumen diagnostik yang digunakan, serta mengidentifikasi faktor penyebabnya. Melalui pendekatan deskriptif kualitatif, studi literatur sistematis ini menganalisis berbagai sumber ilmiah yang diterbitkan antara tahun 2022 hingga 2026. Temuan menunjukkan adanya kekeliruan konseptual yang konsisten, terutama anggapan bahwa massa memengaruhi kecepatan jatuh benda dan anggapan bahwa energi potensial hanya ada pada objek bergerak. Faktor pemicu utamanya meliputi intuisi personal siswa, metode pengajaran konvensional, dan keterbatasan media visual. Sebagai simpulan, penerapan instrumen diagnostik berjenjang secara berkala disertai peralihan ke model pembelajaran berbasis teknologi sangat penting untuk mengatasi kendala dalam pembelajaran ini.*

Kata Kunci: *Miskonsepsi, Gravitasi, Energi Potensial, Tes Diagnostik, Sekolah Dasar*

INTRODUCTION

Natural Science at the elementary school level serves as the initial foundation for students in understanding various phenomena occurring in their environment. One concept introduced at this level is gravity and potential energy, which in everyday life can be observed through simple events such as a ball rolling downhill, a fruit falling from a tree, or an object sliding from a height. Although seemingly straightforward, these concepts frequently give rise to misconceptions among students from an early age (Abadiyah, 2026). Even among Grade VI elementary school students, misconceptions about gravitational force are found to be real and quite varied (Mariyadi & Wa, 2023).

Misconceptions among elementary school students are generally formed from everyday experiences interpreted inaccurately. For instance, students tend to believe that heavier objects fall faster than lighter ones, or that stationary objects possess no energy whatsoever. An analysis of misconceptions among Grade VI students showed that the majority still hold understandings that are inconsistent with the scientific concept of gravitational force, particularly regarding the direction of gravity and the effect of mass on the falling speed of objects (Mariyadi & Wa, 2023). Such intuitive understanding is carried into the classroom, and if not promptly corrected, becomes increasingly entrenched and makes it more difficult for students to learn more advanced physics concepts (Abadiyah, 2026; Maharani & Diyana, 2025). Identifying misconceptions from the elementary school level is critically important because misconceptions formed at an early age tend to be more difficult to change if continuously left unaddressed. Various studies have developed instruments to detect misconceptions, such as the three-tier diagnostic test, which is capable of distinguishing between students who genuinely understand, those who are guessing, and those who hold misconceptions (Maharani & Diyana, 2025). In addition, technology-based learning media such as Android-based interactive multimedia (Syahad, 2025) and web-based applications (Hanum et al., 2021) have been developed to help students construct correct conceptual understanding in a more engaging and enjoyable manner. Despite all these efforts, research that specifically and systematically examines misconceptions on the topics of gravity and potential energy at the elementary school level remains very limited (Mariyadi & Wa, 2023).

This gap motivates the need for a systematic literature review focused on elementary school students' misconceptions regarding gravity and potential energy. Misconception analysis studies at the elementary level, such as that conducted by Mariyadi and Wa (2023), demonstrate that this issue is real and urgently requires more comprehensive attention. A systematic mapping of misconception patterns is expected to assist elementary school teachers in designing more targeted and evidence-based instruction.

Based on this background, the research questions addressed in this article are: (1) What are the patterns of elementary school students' misconceptions on the topics of gravity and potential energy as revealed by various studies? (2) What instruments have been used to identify misconceptions among elementary school students on these topics? (3) What factors cause the emergence of misconceptions among elementary school students regarding gravity and potential energy? The objectives of this article are accordingly: (1) to map the patterns and systematics of elementary school students' misconceptions on the topics of gravity and potential energy through a systematic literature review; (2) to analyse the diagnostic instruments used to detect misconceptions among elementary school students; and (3) to identify the factors causing misconceptions as a basis for recommending more effective science learning strategies at the elementary school level.

METHODS

This study employed a literature review method as a means of gaining a thorough understanding of the systematics of student misconceptions on the topics of gravity and potential energy. This method was carried out by reviewing and analysing various relevant reference sources to provide a systematic overview of the problem under investigation. The data sources in this study were obtained from textbooks, scientific journal articles, and prior research related to the topic, covering publications from 2022 to 2026. Source selection was conducted selectively based on the degree of relevance, the credibility of the source, and its alignment with the research focus.

The data collection process was carried out through several stages: literature searching, grouping of sources by topic, and recording of key information related to the concepts and research findings. The data were subsequently analysed using a descriptive qualitative technique by identifying, comparing, and synthesising the perspectives of various scholars. The data analysis stages comprised data reduction, data presentation, and conclusion drawing. Through these stages, the study produced a clear and systematic picture of student misconception patterns on the topics of gravity and potential energy.

RESULTS AND DISCUSSION

Patterns of Student Misconceptions on the Topics of Gravity and Potential Energy

The findings from various studies consistently indicate that student misconceptions regarding gravity and potential energy persist across different educational levels, including at the elementary and secondary school levels. One of the most common misconceptions is the belief that objects with greater mass will fall faster than those with lesser mass. Research by Mariyadi and Wa (2023) revealed that the majority of elementary school students associate the weight of an object with its falling speed without recognising that gravitational acceleration has a constant value under ideal conditions. Similar findings were reported by Rifaldi et al. (2022), who showed that senior high school students still believe that an object's mass affects the motion of free fall. Furthermore, Respasari et al. (2022) explained that misconceptions about the concept of force frequently occur because students tend to rely on everyday intuition rather than scientific explanations.

Another common misconception concerns the concept of gravitational potential energy: some students believe that potential energy is possessed only by moving objects or that it only appears at very great heights. Research by Wahyuni, Maison, and Hidayat (2023) showed that students still experience difficulty in understanding the interrelationship among potential energy, kinetic energy, and the law of conservation of energy. Maison, Lestari, and Widaningtyas (2020) demonstrated that students struggle to understand that gravitational potential energy is determined by an object's mass, gravitational acceleration, and height, leading many students to develop misconceptions about the factors that influence potential energy. These findings are reinforced by Yenti, Maison, and Syaiful (2022), who found that students tend to memorise mathematical formulae without understanding the underlying conceptual meaning.

Research also indicates that misconceptions arise because physics instruction remains overly focused on solving numerical problems rather than fostering a deep understanding of scientific phenomena. Ramadhani, Manullang, and Br. Simbolon (2022) explained that many students are able to perform simple numerical calculations but cannot explain the application of the underlying concepts in everyday life. Kurniasih and Sya (2025) also noted that the abstract nature of these concepts frequently makes it difficult for students to connect them with daily life. Moreover, the minimal use of visual learning media and the lack of direct experience in observing these phenomena further complicate students' understanding. This situation suggests that science instruction still requires a more contextual approach so that students can comprehend the concepts of gravity and potential energy comprehensively.

Overall, the reviewed studies confirm that student misconceptions regarding gravity and potential energy are consistently present across various levels of education, including at the elementary school level. The most frequently occurring misconception is the belief that objects with greater mass will fall faster than those with lesser mass a mistaken belief arising because students rely more on everyday experience than on correct scientific understanding. Research by Ningrum et al. (2025) showed that many students make errors in understanding the direction of gravitational force, the relationship between mass and attraction, and the concept of satellite orbit. These findings are consistent with Mariyadi and Wa (2023), who showed that elementary school students also encounter errors in similar gravity-related concepts.

Misconceptions about potential energy display a similar pattern. Students tend to view potential energy only as energy that arises when an object is in motion or located at a very great height. Scientifically, however, gravitational potential energy is possessed by an object due to its position or height relative to the Earth's surface. Abadiyah (2026) revealed that students experience difficulty in understanding the interaction among potential energy, kinetic energy, and the law of conservation of energy a difficulty arising because students are more concerned with applying mathematical formulae than with understanding the conceptual meaning of energy. These findings align with Wahyuni et al. (2023) and Yenti et al. (2022), who showed that students frequently only memorise formulae without understanding the relationships among the various energy concepts. This situation indicates that science instruction at both the elementary and secondary levels has not yet fully cultivated deeper conceptual understanding.

Instruments Used to Identify Misconceptions

Based on the literature analysis, the most commonly used instruments for identifying student misconceptions are tiered diagnostic tests, including the three-tier, four-tier, and five-tier diagnostic tests. These instruments are considered more effective than conventional multiple-choice tests because they not only assess students' answers but also evaluate the reasons given and the level of certainty students hold regarding their responses. Research by Wahyuni et al. (2023) revealed that the five-tier diagnostic test can identify students' understanding of energy concepts and the law of conservation of energy in greater detail. Additionally, Permatasari et al. (2022) found that the web-based three-tier diagnostic test enables teachers to detect misconceptions more quickly and efficiently.

The four-tier diagnostic test is also widely used in misconception research. According to Nur, Syuhendri, and Siahaan (2023), the four-tier diagnostic test is an effective instrument for identifying student misconceptions because it not only measures whether an answer is correct or incorrect but also reveals students' level of certainty regarding their chosen answer and reasoning, enabling a more accurate analysis of conceptual understanding. Wahyuni et al. (2023) similarly used diagnostic instruments to identify misconceptions about energy concepts, and their findings showed that a substantial number of students experience conceptual difficulty with the relationship between potential energy and mechanical energy. This demonstrates that tiered diagnostic tests possess greater accuracy in identifying student misconceptions.

Several studies employed interviews in addition to diagnostic tests to enrich the analysis. Nisa' et al. (2022) stated that interviews help researchers understand why students maintain erroneous ideas even after having received classroom instruction. Rifaldi et al. (2022) also used the Certainty of Response Index (CRI) to measure the level of certainty students hold regarding their chosen answers. The combination of diagnostic tests and interviews is considered capable of providing a more comprehensive picture of the types and sources of student misconceptions.

The analysis further confirms that the use of diagnostic instruments is a crucial factor in identifying student misconceptions. Various studies demonstrate that tiered diagnostic tests such as the three-tier, four-tier, and five-tier tests show better effectiveness than conventional multiple-choice tests. These instruments not only evaluate students' answers but also assess the reasons given and the level of certainty behind their responses. Wahyuni et al. (2023) noted that three-tier and four-tier diagnostic tests are the most commonly applied instruments in physics misconception research because they are able to distinguish between students who genuinely understand a concept and those who are merely guessing. Furthermore, Anggrini et al. (2026) showed that the five-tier diagnostic test can identify student misconceptions in greater detail through five levels of answer analysis. The use of tiered diagnostic instruments is therefore important in helping teachers understand the range of students' misconceptions in depth, enabling more effective remediation.

Beyond diagnostic instruments, the reviewed studies also indicate that interviews and classroom observation can be used as complementary methods for identifying misconceptions. Interviews make it possible to understand the reasons behind students' tendency to retain misconceptions even after receiving classroom instruction. The combination of diagnostic tests and interviews provides a more comprehensive view of the sources of misconceptions experienced by students. These findings suggest that misconception identification should not rely solely on written tests but must involve direct analysis of students' thinking patterns. It is therefore important for teachers to conduct diagnostic evaluations on an ongoing basis so that misconceptions can be detected early before they develop into more complex problems in the learning process.

Factors Causing Misconceptions

The literature analysis indicates that misconceptions about gravity and potential energy are influenced by factors originating from both students themselves and the instructional process. The first factor stems from students' everyday experiences, which often conflict with scientific concepts. Because students directly observe heavy objects in their environment, they tend to assume that heavier objects fall faster a finding consistent with Mariyadi and Wa (2023). Rifaldi et al. (2022) reached similar conclusions, noting that empirical experience without scientific explanation can reinforce students' prior beliefs.

The second factor relates to the teacher's instructional approach. Nisa' et al. (2022) observed that instruction overly focused on lectures and formula memorisation causes students to understand concepts only superficially. Because teachers frequently explain abstract concepts without the use of visual media or simple experiments, students find them difficult to grasp (Kurniasih & Sya, 2025). Furthermore, Yenti et al. (2022) found that students often concentrate on applying mathematical formulae without understanding the relationships among the physics concepts they are studying.

The use of insufficiently contextual instructional materials and learning media constitutes another factor contributing to misconceptions. Ramadhani et al. (2022) noted that when physics lessons are connected to everyday phenomena, students find it easier to understand the concepts involved. Permatasari et al. (2022) similarly emphasised the importance of using technology and interactive media to help students visualise abstract concepts. In addition, students' initial inability to understand basic science concepts causes them to continue experiencing misconceptions when encountering more complex material.

The research findings indicate that the causes of misconceptions stem from multiple elements, both from students themselves and from the learning process. The primary cause is students' everyday experience, which frequently conflicts with established scientific concepts. Students tend to develop understanding based on direct observation without any grasp of the scientific explanation underlying the phenomena they observe. Ningrum et al. (2025) showed that misconceptions about gravity have the highest percentage compared to other motion topics, because students rely on everyday intuition to understand the concept of gravitational force. This reinforces the view that misconceptions are very difficult to overcome if not corrected from an early stage at the elementary school level.

Beyond students' own experiences, teachers' instructional methods also contribute significantly to the emergence of misconceptions. Instruction focused predominantly on formula memorisation and solving mathematical problems causes students to develop insufficient conceptual understanding. Sarini and Selamet (2022) revealed that teaching methods incorporating prediction, observation, and scientific explanation are more effective in reducing misconceptions than traditional lecture methods. Ningrum et al. (2025) also emphasised the importance of using visualisation and interactive learning, enabling students to better comprehend abstract concepts such as gravity and potential energy. Teachers therefore need to implement contextual instructional approaches that connect science concepts with real-world phenomena encountered by students in their daily lives.

The use of technology-based teaching aids has also emerged as one of the recommended approaches across various studies. Android-based interactive tools, virtual simulations, and web-based educational applications are considered effective in helping students internalise abstract ideas in a more concrete manner. By leveraging technology, students can explore concepts through simulations of falling objects, energy transformations, and the relationships among mass, gravitational force, and object height. Students thus not only gain theoretical understanding but also connect it with authentic experience. This instructional approach is particularly important to implement at the elementary school level because children at that age are still in the concrete operational thinking stage and therefore require visual aids and direct experience to understand science concepts.

Overall, this study reveals that misconceptions about gravity and potential energy represent a serious issue in science education. These conceptual errors not only affect the way students understand the material being taught but can also become an obstacle to mastering physics concepts at more advanced levels. Teachers therefore need to assess misconceptions in a more structured manner through the use of appropriate diagnostic instruments and to apply more relevant, interactive, and experience-based learning methods. Through these measures, students' understanding of gravity and potential energy is expected to develop more deeply and sustainably.

CONCLUSION

Misconceptions about gravity and potential energy are a genuine problem that develops from the elementary school level as a result of students' misinterpretation of everyday experience. Through this systematic literature review, misconception patterns have been mapped: students hold the belief that heavier objects fall faster, and that potential energy applies only to moving objects or those located at very great heights arising from a tendency to memorise formulae without understanding the underlying conceptual meaning. Evaluation of diagnostic instruments shows that the use of tiered diagnostic tests, which can be combined with interview methods, is far more effective, precise, and thorough in revealing variations in students' thinking patterns and levels of certainty than conventional multiple-choice tests. Furthermore, this study identified that the root causes of misconceptions do not originate solely from students' personal intuition but are exacerbated by teachers' still-traditional instructional approaches, the dominance of lecture-based methods, and the minimal use of interactive visual media in the classroom.

The limitation of this study lies in the restricted scope of the literature review method, which analyses only documents and secondary data from the 2022–2026 period without direct empirical field testing. Based on these findings, education practitioners are advised to conduct diagnostic tests on a regular basis and to promptly shift toward contextual learning strategies that leverage technology such as Android-based interactive multimedia, virtual simulations, or web applications to support the concrete thinking phase of elementary school-aged children. For future research, it is recommended that classroom action research or experimental studies be conducted to directly test the effectiveness of virtual simulations in remediating the specific misconceptions mapped in this study.

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REFERENCES

Abadiyah, M. (2026). Review konseptual tentang pemahaman konsep gaya, usaha, dan energi dalam pembelajaran fisika sekolah menengah. *Pensa e-Journal: Pendidikan Sains*, 14(1), 40–46.

Anggrini, R. P., Phadila, C. A., Permatasari, I., Hakim, M. A. R., & Furqon, M. (2026). Pemetaan landscape miskonsepsi fisika: a systematic review. *Pendekar: Jurnal Pendidikan Berkarakter*, 9(1), 102–117.

Anindyta, M., Sodik, F., Herdiansyah, N., Sofiandi, M., & Pratiwi, R. H. (2025). Penerapan konsep pembelajaran MIPA topik usaha dan energi: studi pustaka. *Algoritma: Jurnal Matematika, Ilmu Pengetahuan Alam, Kebumian dan Angkasa*, 3(4), 292–305.

Hanum, A., Maison, M., & Kurniawan, W. (2021). *Pengembangan instrumen miskonsepsi materi usaha dan energi untuk SMA menggunakan aplikasi Dreamweaver berbasis web* (Doctoral dissertation, Universitas Jambi).

Kurniasih, S., & Sya, M. F. (2025). Penerapan simulasi interaktif untuk mengatasi kesulitan siswa kelas 4–6 dalam memahami konsep IPA. *Karimah Tauhid*, 4(8), 6132–6144.

Maharani, L. A., & Diyana, T. N. (2025). Identifikasi miskonsepsi fisika melalui three-tier diagnostic test: sebuah kajian literatur. *OPTIKA: Jurnal Pendidikan Fisika*, 9(2), 198–216.

Maison, M., Lestari, N., & Widaningtyas, A. (2020). Identifikasi miskonsepsi siswa pada materi usaha dan energi. *Jurnal Penelitian Pendidikan IPA*, 6(1), 32–39.

Mariyadi, M., & Wa, I. R. (2023). Analisis miskonsepsi peserta didik kelas VI sekolah dasar pada pembelajaran IPA materi gaya gravitasi. LENSA (Lentera Sains): *Jurnal Pendidikan IPA*, 13(1), 77–85.

Ningrum, E. W. K., Bella, S., Saputra, A., Zuama, L. A., & Prasetyo, D. R. (2025). Analisis miskonsepsi siswa SMP pada materi gaya gravitasi. *Jurnal Pendidikan Tambusai*, 9(2), 17061–17067.

Nisa', M., Munawaroh, F., Yasir, M., & Wulandari, A. Y. R. (2022). Analisis miskonsepsi siswa pada konsep tekanan zat di SMP Negeri 2 Bangkalan. *Natural Science Education Research*, 4(3), 183–192.

Nur, A. Z., Syuhendri, S., & Siahaan, S. M. (2023). Kajian literatur: penggunaan asesmen diagnostik berformat four-tier untuk mengidentifikasi pemahaman konsep dan miskonsepsi. *JIIP – Jurnal Ilmiah Ilmu Pendidikan*, 6(5), 3666–3671.

Permatasari, M. B., Muchson, M., Hakimah, N., Rokhim, D. A., Herunata, H., & Yahmin, M. (2022). Identifikasi miskonsepsi materi kesetimbangan kimia pada siswa SMA menggunakan tes three-tier berbasis web. *Jurnal Inovasi Pendidikan Kimia*, 16(1), 1–7.

Ramadhani, N., Manullang, S. R., & Br. Simbolon, V. A. (2022). Identifikasi kemampuan siswa dalam pemecahan masalah miskonsepsi pada materi fluida dinamis di tingkat SMA. *EduFisika: Jurnal Pendidikan Fisika*, 7(2), 196–205.

Respasari, B. N., Santika, H. D., Hasana, Y., Hikmawati, H., & Rokhmat, J. (2022). Analisis miskonsepsi siswa pada topik pelajaran tentang gaya gesek: *Indonesia. Jurnal Penelitian dan Pembelajaran Fisika Indonesia*, 4(2).

Rifaldi, A. R., Mahardika, I. K., Subiki, S., Rahayu, E. C., Farika, N., & Afni, L. N. (2022). Analisis miskonsepsi fisika SMA pada materi gerak jatuh bebas menggunakan metode CRI. *Jurnal Phi: Jurnal Pendidikan Fisika dan Fisika Terapan*, 3(3), 11.

Sarini, P., & Selamet, K. (2022). Miskonsepsi siswa pada materi fluida statis dan model pembelajaran Predict-Observe-Explain sebagai alternatif meremediasi miskonsepsi. *Jurnal IPA Terpadu*, 6(1), 109.

Syahad, M. F. (2025). *Pengembangan multimedia interaktif berbasis Android sebagai sumber belajar IPA SMP/MTs pada materi usaha, energi, dan pesawat sederhana* (Doctoral dissertation, Universitas Islam Negeri Sultan Syarif Kasim Riau).

Wahyuni, S., Maison, M., & Hidayat, M. (2023). Identifikasi miskonsepsi five-tier diagnostic test pada materi energi dan hukum kekekalan energi. *Jurnal Metaedukasi: Jurnal Ilmiah Pendidikan*, 4(1), 45–53.

Yenti, S. O., Maison, M., & Syaiful, S. (2022). Diagnosis miskonsepsi siswa MAN Insan Cendekia Jambi pada materi fluida statis dan fluida dinamis. *Edu-Sains: Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam*, 10(1), 13–18.