Review of misconceptions in physics among Indonesian high school students: Diagnosis, causes, and remediation

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Abstract
Misconceptions in physics education pose significant challenges to student learning and conceptual understanding. This research aims to bridge gaps in understanding by systematically identifying and analyzing the diagnostics, causes, and remediation methods for misconceptions in physics among Indonesian high school students. Using a Systematic Literature Review (SLR) following the PRISMA method, 61 articles were selected from databases such as Scopus and Google Scholar, focusing on publications between 2019 and 2024. The results reveal that static fluids emerged as the most frequently studied topic in misconception research, with common issues including the misunderstanding of buoyancy and hydrostatic pressure. Diagnostic tools were dominated by four-tier tests, which offer high accuracy and ease of analysis compared to other methods. The findings also highlight that the primary causes of misconceptions are rooted in students' intuitive thinking and teaching methods. Computer simulations were identified as one of the most effective remediation strategies, often employed alongside conceptual change texts and laboratory-based approaches. This study consolidates existing research and provides actionable insights for educators by highlighting effective diagnostic tools and strategies to design targeted interventions, foster deeper conceptual understanding, and improve learning outcomes in physics education.

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1. Introduction

The constructivist approach emphasizes the critical role of active student engagement in building understanding by connecting new concepts to existing mental models based on personal experience (Novianti et al., 2023; Resbiantoro et al., 2022; Simatupang et al., 2023). The constructivist framework also highlights the potential for misconceptions to arise when students incorrectly categorize new concepts, leading to misunderstanding (Mellu & Langtang, 2023; Putri et al., 2022). Misconceptions are separated from a lack of knowledge or simple mistakes. Misconceptions is known as alternative conceptions, naive beliefs, naive ideas, children's ideas, conceptual difficulties, phenomenological primitives, or mental models (Gurel et al., 2015; Hidayatullah et al., 2020; Hull et al., 2021; Maison, Safitri, et al., 2020; Resbiantoro et al., 2022; Surtiana, Suhandi, Putri, et al., 2020). It is frequently resistant to change, causing cognitive conflict, frustration, and hindering academic progress (Resbiantoro et al., 2022; Sukarelawan et al., 2021; Zuwita & Mufit, 2023). It involves a complicated interaction of pre-existing notions, associative thinking, faulty intuitions, and students' cognitive development levels (Jumilah & Wasis, 2023; Mellu & Langtang, 2023; Sukarelawan et al., 2021). Factors contributing to misconceptions in learning include the diverse backgrounds of students and the methods employed by educators to present materials. For instance, reliance on rote learning methods may fail to address deeper conceptual issues, potentially reinforcing misunderstandings. If unaddressed, these misconceptions can result in imbalances in the learning process, with some groups achieving better understanding (Hunaidah et al., 2022; Juita et al., 2023; Surtiana, Suhandi, Samsudin, et al., 2020). In physics education, misconceptions refer to students' conceptualizations that contradict scientific models (Çelikkanlı & Kızılcık, 2022; Maknun & Marwiah, 2022).

Misconceptions can be identified using diagnostic tests. Diagnostic tools that can be used are interviews, concept maps, open-ended, practicum with questions and answers, class discussions, and multi-tier multiple-choice tests (Hidayatullah et al., 2020; Kamilah & Suwarna, 2016; Maison, Lestari,

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et al., 2020; Soeharto et al., 2019). These diagnostic tools have both advantages and disadvantages(Gurel et al., 2015)(Soeharto et al., 2019). Misconceptions must be identified and reduced as soon as possible because they can interfere with related concepts(Treagust, 2006). Misconceptions can persist in students' cognition even after they have completed their studies(Mufit et al., 2023). Misconceptions can be reduced through remedial learning(Islamiyah et al., 2022). Identifying misconceptions is crucial in designing effective learning strategies. Therefore, it is essential to understand the root cause of these misconceptions(Inggit et al., 2021). Teachers can adjust their teaching methods to effectively counteract this misunderstanding. For instance, if misconceptions result from the manner in which concepts are presented in textbooks or instructional materials, teachers can modify their instruction to deliver clearer and more scientifically accurate explanations(Resbiantoro et al., 2022). Incorporating modern technological tools, such as simulations or interactive digital resources, can further aid in addressing these challenges by providing dynamic and engaging learning experiences.

Several literature reviews on misconceptions have been published. Resbiantoro et al. (Resbiantoro et al., 2022) reviewed 72 international journal articles published from 2005 to 2020 to discuss the diagnosis methods, causes, and remediation of physics misconceptions at all levels around the world that were published between 2005 and 2020. They found that most articles aimed to diagnose and treat misunderstandings, with a focus on simulation-based experiments, collaborative learning, and other methods using diagnostic tools such as interviews, open-ended tests, multiple-choice tests, and others. Çelikkanlı & Kızılcık (Çelikkanlı & Kızılcık, 2022) focused on reviewing four-tier tests in physics education that were published between 2010-2022 at all levels worldwide. This study showed a growing interest in four-tier tests, increasingly used as diagnostic tools in misconception research, with most studies conducted in Indonesia. Soeharto et al. (Soeharto et al., 2019) reviewed 111 articles published from 2015 to 2019. This study revealed that physics had the most topics (33 topics) that often caused misconceptions in science learning compared to chemistry (12 topics) and biology (15 topics). Soeharto et al. (Soeharto et al., 2019) also revealed the most commonly used diagnostic tests include multi-tier tests (33.06%), multiple-choice tests (32.23%), and open-ended tests (23.97%) based on the reviewed articles. Dirman et al. (Dirman et al., 2022) conducted a literature review focusing on the comparison of four-tier and five-tier multiple-choice diagnostic tests for identifying student misconceptions in high school physics subjects. Based on 60 articles from 2017-2021, the use of four-level multiple choice (83.33%) and five-level multiple choice (16.67%). Putri et al. (Putri et al., 2022) focused on reviewing 50 articles about students' conceptual change in science education before the COVID-19 pandemic. Physics subjects have received more attention compared to other science domains, with most studies focusing on undergraduate students from various majors. Research on conceptual change has evolved from a solely cognitive perspective to include metacognitive aspects(Putri et al., 2022).

This research is different from previous research because it focuses specifically on physics misconceptions at the high school level in Indonesia and reviews literature sources in the form of national and international journal articles. By narrowing the focus to this demographic, this study aims to identify the basic physics topics, diagnostic tools, factors causing, and remediation of misconceptions for high school students and provide actionable insights for educators and policymakers to design effective interventions tailored to the Indonesian educational context.

2. Method

The study is a systematic literature review (SLR) on the misconceptions of physics among Indonesian high school students. A systematic literature review carefully gathers and analyzes research on a specific topic using transparent and replicable methods, unlike narrative reviews, which lack inclusion criteria and critical evaluation (Palmatier et al., 2018). It involves a well-planned process to reduce bias and eliminate irrelevant or low-quality studies, ensuring the reliability and validity of the findings (Linares-Espinós et al., 2018). This research provides an integrated and synthesized overview of the current state of knowledge in high school students' misconceptions, helping to understand the existing research landscape in Indonesia. It involves a structured approach to searching for, selecting, analyzing, and summarizing relevant research studies and articles from various sources (Torres-Carrion et al., 2018).

This research analyzed journal articles related to misconceptions in physics published from 2019 to 2024. The criteria for the articles of the journal were indexed by SINTA or Scopus, and a study was held in Indonesia with high school students as a sample. While Scopus-indexed journals are international, SINTA-indexed journals represent national journals in Indonesia, often published in Bahasa Indonesia. The inclusion of SINTA-indexed journals ensures that the study captures research directly relevant to the Indonesian education context. The time frame of 2019 to 2024 ensures that the analysis focuses on recent developments and current trends in understanding and addressing physics misconceptions in Indonesian secondary education.

Preferred reporting items for systematic reviews and meta-analyses (PRISMA) were used to ensure a transparent and structured approach to conducting and reporting the review process (Moher et al., 2009). The PRISMA flowchart for selecting relevant journals is illustrated in Figure 1. During the identification stage, 1,195 articles were retrieved from Scopus and Google Scholar using keywords such as "misconceptions in physics" and "miskonsepsi fisika." Duplicate articles and irrelevant sources, such as books, book chapters, and conference proceedings, were removed, leaving 933 articles for further screening. In the screening stage, the selection process ensured that only journal articles indexed in Scopus or SINTA were included. This step reduced the initial 933 articles to 479 articles that met the criteria of being indexed in reputable databases. From this reduced set, the abstracts of these 479 articles were reviewed to ensure alignment with the research objectives. Articles were excluded if they did not focus on physics studies, were not conducted in Indonesia, or were not related to high school students. As a result of this abstract screening process, 418 articles were excluded, leaving 61 articles for final inclusion.

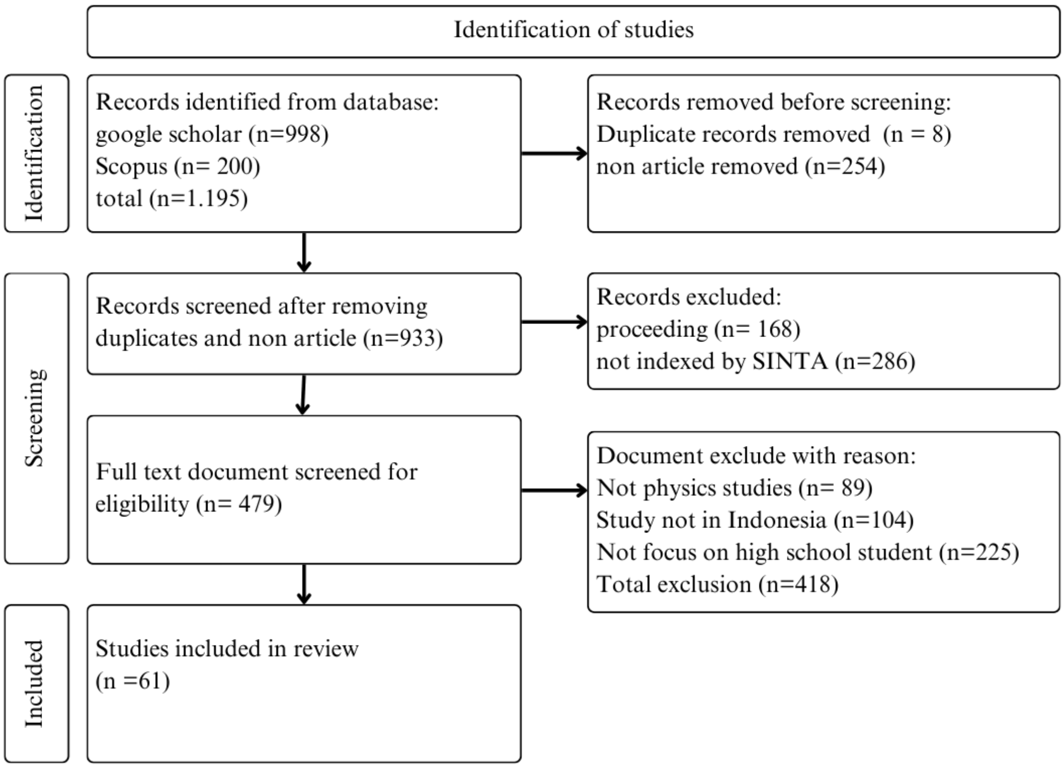

Figure 1. PRISMA flow chart

The PRISMA flowchart clearly and systematically documents the selection process, reducing bias and ensuring reliable findings by detailing the inclusion and exclusion process. Sixty-one selected articles were analyzed to extract key information: (1) frequently associated physics topics with misconceptions, (2) diagnostic tools for identifying misconceptions, (3) factors contributing to misconceptions, and (4) remediation strategies. Purposive sampling was used to select articles relevant to the research topic and compliant with predetermined criteria. The data collected were systematically coded and analyzed to identify patterns and trends in misconceptions, diagnostic tools, and remediation strategies. This approach ensures that findings are robust and reflect the current state of research in this field.

3. Results and Discussion

A total of 1.195 articles were found in Google Scholar and the Scopus database with the keywords “misconception in physics” and “miskonsepsi fisika” using Publish or Perish. In the identification articles, 8 duplicate articles and 254 articles categorized as books and book chapters were removed. Conference articles were excluded during the screening process. A total of 168 international and national proceedings articles were found in Google Scholar and Scopus databases. Various national journals were found in the Google Scholar database. Indexing also becomes a criterion to ensure that articles are qualified. Articles that focused on national journals indexed by SINTA were selected. After checking the journal index, 286 articles were not indexed by SINTA. During the abstract screening process, researchers found 418 articles that did not meet the inclusion criteria. Articles that were not physics studies were not in Indonesia and did not focus on high school students, as research samples were removed. Ultimately, 61 articles were included in this review.

3.1. Physics Topics Analyzed in Studies

Misconceptions in the cognitive structure of students can be compared to a disease, similar to how educators act as doctors who diagnose and treat the issues (Resbiantoro et al., 2022). To effectively address the problem, the educator must first diagnose the student's condition. How students categorize physics concepts can lead to misconceptions (Hull et al., 2021). When students hold onto misconceptions, they may face difficulties in problem-solving and overall academic achievement in physics (Soeharto & Csapó, 2022). Various topics in physics are misconceived at the high school level in Indonesia. Figure 2 shows the topics examined in the analyzed articles. The study of static fluid is the most extensively researched topic in physics, as evidenced by 10 dedicated articles. Common misconceptions regarding static fluids are that the causes of floating and sinking objects are solely dependent on mass or volume (Hunaidah et al., 2022; Inggit et al., 2021; Mellu & Langtang, 2023), pressure at a point is influenced by the cross-sectional area and volume of the fluid (Djudin, 2021; Harmania et al., 2020; Inggit et al., 2021; Maknun & Marwiah, 2022; Simamora et al., 2023; Surtiana et al., 2021), the hydrostatic pressure remains constant neglecting the fact that it varies linearly with depth due to the weight of the fluid above that point (Maknun & Marwiah, 2022). The second most researched topic was work and energy, with about seven articles. A common misconception is that potential energy depends on the shape of the trajectory (Maison, Lestari, et al., 2020; Samsudin et al., 2021).

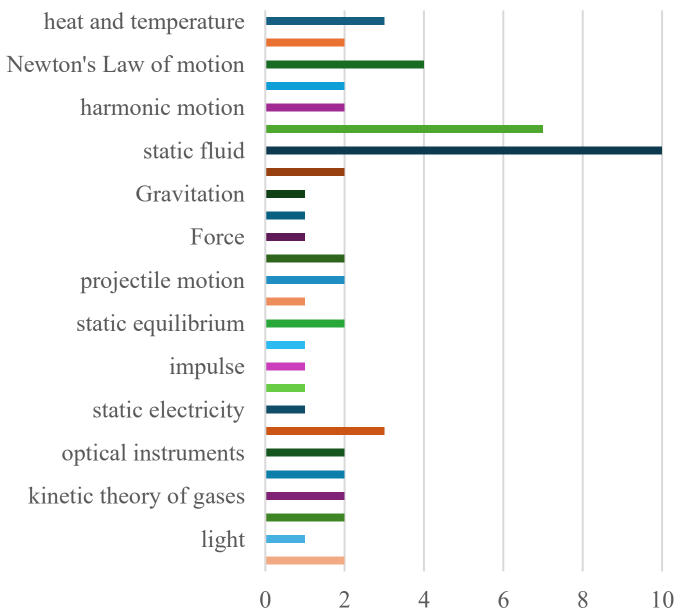

Figure 2. Physics material that is the topic of misconception research

Based on Figure 2, there is no research related to misconceptions on the topic of modern physics researched in Indonesia. In fact, it is very possible for misconceptions to occur on this topic (González de Arrieta, 2021; Hughes & Kersting, 2021). Misconceptions like the 'invisibility of length contraction' and 'time dilation' exist in special relativity (Hughes & Kersting, 2021). Some believe that passengers on a fast-moving train would experience time differently, but this is not true. The misconception persists that observing a clock on a moving object would show time slowing down, which is incorrect. Another common misunderstanding is that all observers see moving objects as length-contracted, which is a mistaken assumption.

3.2. Diagnostic tools

Diagnostic tests are crucial tools used in education to evaluate students' understanding of concepts and identify any misconceptions they may have (Jumilah & Wasis, 2023; Samsudin et al., 2021; Soeharto et al., 2019). Various forms of diagnostic instruments are available, including interviews, multiple-choice questions, open-ended questions, and multi-tier questions (Kamilah & Suwarna, 2016; Resbiantoro et al., 2022; Soeharto et al., 2019). It is important to note that each diagnostic test type has its advantages and disadvantages. Therefore, researchers or educators must adjust to the specific needs of each test (Soeharto et al., 2019). In this study, it was found that the diagnostic tests used by researchers were interviews and multi-tier tests with multiple-choice or open-ended types. Figure 3 shows the percentage of misconception diagnostic tool usage.

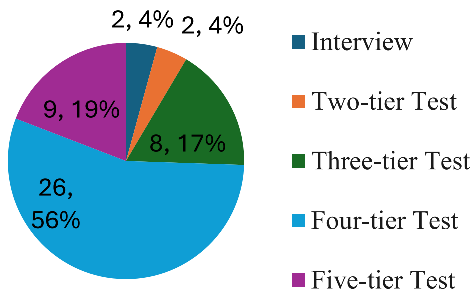

Figure 3. Misconception diagnostic tools

Interviews have long been used to identify misconceptions compared to multi-tier tests. Interviews in educational research are a powerful tool for uncovering misconceptions among students (Hestenes et al., 1992). Through interviews, researchers or teachers can probe deeper into students' understanding, identify any alternative frameworks or intuitive beliefs they may hold, and pinpoint specific misconceptions. It is important to note that interviews are a time-consuming process, yet they do not need to be repeated for every class, as misconceptions are universal (Çelikkanlı & Kızılcık, 2022; Hestenes et al., 1992; Kamilah & Suwarna, 2016; Resbiantoro et al., 2022). There were only two articles (2,5%) that used interviews. The interviews were conducted to gather more in-depth information about the misconceptions that high school students have regarding their conception (Maison, Lestari, et al., 2020; Ramadhani et al., 2022)

Multi-tier tests are assessment tools that consist of multiple layers or tiers, each serving a specific purpose in evaluating student understanding and misconceptions (Resbiantoro et al., 2022; Soeharto & Csapó, 2022). This study includes a variety of multi-tier tests, including two-tier tests, three-tier tests, four-tier tests, and five-tier tests. Two-tier test are designed by Treagust to assess students' misconceptions (Kiray & Simsek, 2021)(Tsui & Treagust, 2010). The two-tier test was utilized by only two articles (2,5%) in diagnosing misconceptions in AC circuits. (Hasanah, 2020) and Buoyancy (Djudin, 2021). A student's response was considered correct only if they correctly identified both the content knowledge in the first tier and the reason for the first tier in the second tier (Hasanah, 2020). This approach minimized the chances of obtaining a correct answer through guessing, as the probability of guessing correctly was very low (Tsui & Treagust, 2010). Unfortunately, the two-tier test presents difficulties in differentiating between the absence of knowledge and misconceptions among the participants (Kamilah & Suwarna, 2016; Resbiantoro et al., 2022; Soeharto et al., 2019).

To address these limitations, a third tier was added (Resbiantoro et al., 2022), (Kamilah & Suwarna, 2016). This third tier required respondents to indicate their confidence in the answers provided in the first two tiers. By including a confidence scale, researchers aimed to enhance the diagnostic accuracy of the test (Gurel et al., 2015; Hestenes et al., 1992; Kiray & Simsek, 2021;

Soeharto et al., 2019; Treagust, 2006). At the second tier, students may create their own ideas, so blank options are added to prevent arbitrary choices and encourage thoughtful responses (Gurel et al., 2015). In the review results, 17% of articles used the three-tier test as a diagnostic tool. In the articles analyzed, the three-tier test was employed as an instrument to determine the profile or identify misconceptions about a concept (Erlangga et al., 2021, 2021; Fauziah & Darvina, 2019, 2019; Hidayatullah et al., 2020, 2020; Ramadhani et al., 2022; Rizki & Setyarsih, 2022, 2022). Furthermore, it is also used as a diagnostic tool to ensure the success of misconception remediation treatment (Maknun & Marwiah, 2022, 2022; Mufit et al., 2023; Zuwita & Mufit, 2023, 2023). Nevertheless, no three-tier test instrument development was found in the articles analyzed. The application of three-tier tests may present certain challenges in accurately converting confidence levels into meaningful data, which could potentially affect the interpretation of student misconceptions(Soeharto et al., 2019). The lack of clarity in determining whether confidence relates to the first-tier or second-tier answers can pose challenges in accurately identifying misconceptions (Çelikkanlı & Kızılcık, 2022).

Four-tier have been introduced to address limitations of three-tier tests related to underestimating lack of knowledge and overestimating misconceptions (Gurel et al., 2015)(Kiray & Simsek, 2021). In four-tier tests, there are four distinct layers of content, confidence for content answer, reason, and confidence for reason (Çelikkanlı & Kızılcık, 2022; Gurel et al., 2015; Istiyono et al., 2023; Jumilah & Wasis, 2023; Kiray & Simsek, 2021). In four-tier tests, students' confidence levels in both main and reasoning tiers impact the determination of lack of knowledge, providing a more nuanced assessment. The four-tier test is the most frequently employed diagnostic tool, accounting for 56% of all instances. Of the 26 articles that employed the four-tier test, 12 sought to develop an instrument. This indicates that the four-tier test is the trend of misconception diagnostic instruments used at the high school level in Indonesia. One disadvantage of four-tier tests is that they are time-consuming to administer, which makes them less suitable for use in achievement assessments due to the additional time required for administration (Gurel et al., 2015), (Soeharto et al., 2019). Additionally, the complexity of four-tier tests, particularly in providing a range of possible student responses, can lead to challenges in interpreting results accurately (Gurel et al., 2015), (Soeharto et al., 2019).

The five-tier test followed in second place, with a diagnostic usage rate of 19%. The structure of the five-tier test is like a four-tier test with the addition of one-tier. The fifth-tier question in a five-tier diagnostic test is typically a drawing question, which means it requires the test-taker to draw or sketch something in response (Çelikkanlı & Kızılcık, 2022). There is also another version that adds questions related to the source of information or conclusions to the fifth-tier question (Juita et al., 2023). Five-tier tests, such as other multi-tier tests, face challenges in data analysis because they have many possible answer combinations. Some researchers overcome this by making the test computer-based so that it can be analyzed automatically. Kamilah & Suwarna (Kamilah & Suwarna, 2016) developed a digital three-tier test that was distributed using Google Forms, and answers were analyzed using Excel software. Simatupang et al. (Simatupang et al., 2023) developed a website-based five-tier test so that the results of the analysis can be immediately known by the teachers.

There is no longer any use of multiple-choice diagnostic tests consisting of only one level or referred to as simple multiple-choice. In contrast to the findings of Soeharto's SLR conducted in 2019, the trend analysis of the utilisation of diagnostic tests from the preceding two SLR articles indicated that the prevalence of simple multiple-choice was on the rise (Soeharto et al., 2019). The use of multiple-choice questions is a common practice in educational assessments. This is because multiple choices can be quickly administered, easily scored objectively, and used efficiently for a large group of students (Resbiantoro et al., 2022; Tsui & Treagust, 2010).

3.3. Causes Misconception

The causes of misconception are numerous and complex. According to the literature review by Resbiantoro et al.(Resbiantoro et al., 2022), a variety of elements can contribute to misconceptions, including students, the language used, teachers, teaching characteristics, teaching methods, materials, reference books, and students' daily experiences. Widiyatmoko & Shimizu(Widiyatmoko & Shimizu, 2018) also said there are four primary factors that significantly influence students' misconceptions in science education that are everyday experiences, language use, teachers, and textbooks. In this study, several articles discussed the causes of misconceptions. Figure 4 illustrates the number of articles that mention these causal factors.

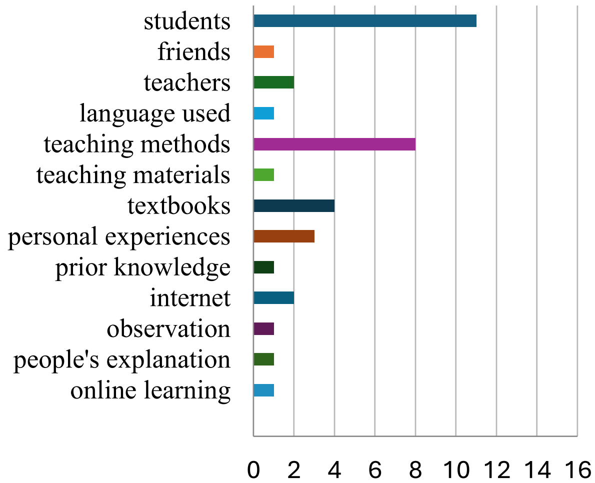

Figure 4. Causes of Misconceptions

11 articles reveal that the factors that cause misconceptions are in the students themselves. Simamora's research (Simamora, 2023) on static fluid shows that the source cause of misconceptions comes more from the student's own thinking. Researchers categorised lack of comprehensive understanding (Entino et al., 2021; Jumilah & Wasis, 2023), differences in mental structures(Inggit et al., 2021; Jumilah & Wasis, 2023), students' incorrect intuition (Fauziah & Darvina, 2019; Royani & Setyarsih, 2022), low learning interest (Entino et al., 2021), humanistic thinking (Royani & Setyarsih, 2022), assosiative thingking (Royani & Setyarsih, 2022), and wrong reasoning (Rizki & Setyarsih, 2022; Royani & Setyarsih, 2022) as student factors. Teaching methods are the second highest factor, with a value around 8 articles. Teaching method to explain physics topics prone to forming misconceptions (Inggit et al., 2021), (Jannah et al., 2022). According to Ramadhani et al. (Ramadhani et al., 2022) students frequently respond to statements that involve calculations, which can cause confusion and make it difficult for them to comprehend statements presented in the form of stories.

More specifically, online learning methods significantly contribute to misconceptions about elasticity (Rizki & Setyarsih, 2022). The absence of prepared infrastructure and direct feedback in some online learning environments leads to these misconceptions (Munastiwi et al., 2022). Additionally, the internet itself is identified as a factor causing misconceptions (Salmadhia et al., 2021). Although the internet can be a vast source of information, if not used wisely, it can become a source of misconceptions. Relevant research indicates that low digital literacy can cause students to misunderstand the information they find online (Carnesia & Mufit, 2024). Previous research shows that teachers' competence in explaining concepts and addressing students' questions is crucial in avoiding misconceptions (Inggit et al., 2021; Respasari et al., 2022; Suhandi, Samsudin, et al., 2020). Inappropriate teacher explanations can also make students experience misconceptions (Salmadhia et al., 2021) (Jannah et al., 2022). Teachers' lack of knowledge or even misconceptions that teachers have can be passed on to students(Admoko & Suliyanah, 2023). Learning resources such as textbooks can also have misconceptions (Fajar Saputri et al., 2016; Khoiri et al., 2017; Nurdiansyah et al., 2018). In order to become one of the factors contributing to misconceptions, (Jannah et al., 2022; Salmadhia et al., 2021). Personal experiences can also play a significant role to misconceptions. For instance, personal experiences that differ from classroom teachings can cause confusion and misconceptions (Dea Alifia Fitri et al., 2023; Mufida et al., 2023; Surtiana, Suhandi, Putri, et al., 2020).

3.4. Remediations Misconception

Research has shown that misconceptions related to physics can be challenging to overcome and may inhibit students from grasping more advanced physics concepts if not addressed early on through focused instruction (Neidorf, 2020; Soeharto & Csapó, 2022). Soeharto & Csapó (Soeharto & Csapó, 2022) found that students in grades 10, 11, and 12 had significant differences in the level of misconceptions, indicating that they may encounter more challenges in understanding complex science concepts due to entrenched misconceptions. In this study, several ways to remediate misconceptions are presented in Figure 5.

Computer simulations were the most common method used to remediate misconceptions. Computer simulation is always combined with other remediation methods or strategies. A total of eight articles used computer simulations to maximize remediation (Fratiwi et al., 2020; Kaniawati et al., 2020, 2021; Mufida et al., 2023; Samsudin et al., 2020, 2022; Surtiana et al., 2021; Surtiana, Suhandi, Putri, et al., 2020). Computer simulations, such as PhET simulations, are tools that help students learn about complex scientific concepts by creating virtual models of real-world phenomena (Sulisworo et al., 2019). By engaging with these simulations, students are exposed to new ways of understanding and explaining complex phenomena, helping to dispel misconceptions that may arise from traditional learning methods (Sulisworo et al., 2019).

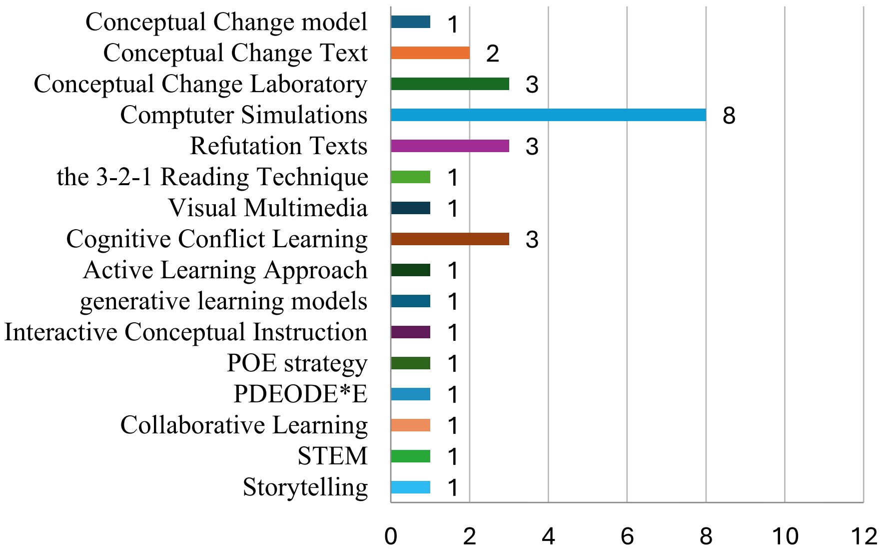

Figure 5. Remediation of misconception

The Conceptual Change Laboratory (CCLab) was applied to three articles. CCLab was developed by Suhandi et al.(Suhandi, Surtiana, et al., 2020). The key idea is to utilize laboratory sessions to correct students' misconceptions and enhance their conceptual understanding. Surtiana contends that laboratory activities benefit students by allowing them to develop and refine their own concepts through extensive exploratory tasks(Surtiana, Suhandi, Samsudin, et al., 2020). The use of CCLab to address misconceptions about the parallel electric circuit concept, the hydrostatic pressure concept and the boiling concept was effective (Suhandi, Surtiana, et al., 2020; Surtiana et al., 2021; Surtiana, Suhandi, Putri, et al., 2020). CCLab consists of five stages of laboratory activities designed to facilitate conceptual change among high school students (Suhandi, Surtiana, et al., 2020). The first stage of the CCLab model involves introducing the subject and identifying students' initial misconceptions. The second stage includes activities that challenge these preconceptions and prompt students to reassess their understanding. The third stage provides new information and explanations to help form an accurate conceptual framework. The fourth stage allows students to apply their new knowledge through hands-on experiments and practical activities. The final stage assesses students' comprehension through evaluations or tests to gauge the effectiveness of the conceptual change process. Three articles showed that cognitive conflict learning is effective in remediating misconceptions(Mufit et al., 2020; Pratama et al., 2021; Zuwita & Mufit, 2023). Zuwita and Mufit(Zuwita & Mufit, 2023) used the cognitive conflict-based learning model assisted by interactive multimedia to remediate the concept of sound and light waves. Cognitive conflict learning can be integrated into teaching materials using interactive E-modules(Pratama et al., 2021). Cognitive conflict learning involves three main phases: the preliminary phase introduces anomalies related to the concepts, the conflict presentation phase highlights students' misconceptions, and the conflict resolution phase allows students to identify correct concepts(Mufit et al., 2020).

Innovation of Refutational text used in three articles to correct misconceptions. Refutational texts have three main components: a description of commonly held alternative concepts, a statement refuting these misconceptions, and the scientifically accepted conception presented(Fratiwi et al., 2020). Djudin (Djudin, 2021) effectively used the 3-2-1 reading technique with refutation text to address misconceptions about buoyancy. Fratiwi et al. (Fratiwi et al., 2020) and Mufida et al.(Mufida et al., 2023) add a computer simulation for investigation or observation to the Refutational text. Technology can enhance refutational text by incorporating videos, animations, and simulations.

3.5. Implications for Physics Education

The findings of this study have significant implications for physics education, particularly in the Indonesian context. Misconceptions were found to be widespread across almost all high school physics topics, requiring proactive measures from educators. The identification of static fluids as the most common topic associated with misconceptions highlights the need for targeted interventions in this area. Physics educators can develop contextually relevant teaching materials and employ active learning strategies, such as simulations and experiments, to address these misconceptions effectively. For instance, the use of computer simulations, including computer simulations, and innovative strategies like the Conceptual Change Laboratory (CCLab) and refutation texts, have shown promising results in reducing misconceptions. Teachers should be trained to incorporate these methods into their classrooms.

The predominance of four-tier tests as diagnostic tools highlights their effectiveness in identifying misconceptions with high accuracy. Research indicates that these tests can distinguish between misconceptions and a lack of knowledge, making them invaluable for assessing students' conceptual understanding. Physics educators are encouraged to adopt these tools in their assessments, enabling early identification and timely remediation of misconceptions. Additionally, more research is needed on the development of diagnostic tools for less frequently studied topics, such as modern physics, to ensure comprehensive coverage.

The study also underscores the importance of addressing the root causes of misconceptions, including student factors and teaching methods. Conceptual change-based instructional approaches, such as inquiry-based learning and collaborative problem-solving, can help students reconstruct their mental models in alignment with scientific principles. Teachers should align students' everyday experiences with formal physics concepts to promote a deeper understanding. Furthermore, the critical evaluation of teaching materials, including textbooks and online resources, is essential to ensure they do not propagate misconceptions.

The review reveals widespread misconceptions among Indonesian high school students, emphasizing the importance of preventing and correcting these misconceptions. This study highlights effective methods for identifying and addressing these misconceptions, such as targeted interventions and innovative diagnostic tools. However, it is limited by excluding research-verified tools and methods that are not published in SINTA or Scopus-indexed journals from 2019 to 2024. Teachers must develop strategies to explain concepts clearly and answer students' questions effectively in both traditional and online settings. Continuous professional development programs should focus on enhancing teachers' content knowledge and pedagogical skills, equipping them to address misconceptions in classrooms and digital environments.

These findings emphasize the need for a multi-faceted approach to addressing misconceptions in physics education. Efforts should involve curriculum development, teacher training, and the design of effective learning environments to improve physics education and prevent the persistence of misconceptions among students. Further research is needed to create innovative diagnostic tools and remediation methods, enhancing Indonesian students' understanding of complex physics concepts.

4. Conclusion

After conducting a thorough review and analysis, multiple conclusions can be inferred. The physics topic most addressed in research of misconceptions is static fluids. The four-tier test is the most frequently used tool in misconception research. It is more accurate than CRI, two-tier test, or three-tier test, also the analysis is easier than five-tier test. Misconceptions arise from multiple sources, such as students, peers, teachers, language, textbooks, prior knowledge, and teaching methods. The primary contributors are the students and the teaching methods used. Misconception remediation employs various strategies, such as conceptual change texts, conceptual change laboratories, computer simulations, cognitive conflict strategies, and model-based teaching. Computer simulations are commonly employed to address misconceptions, often in conjunction with conceptual change laboratories, refutation texts, and model-based teaching to enhance effectiveness.

Author Contributions

DK contributed to conceptualization, design of methodology, data curation, manuscript writing, original draft and finishing. BM contributed to collecting articles and manuscript writing. LA and AS contributed to validating and supervising the project for this publication. All the authors have read and approved the final manuscript.

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