



A Review of College Student in Physics Education: Type, Cause and Remediation Misconception

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Abstract: Misconceptions in physics education continue to pose significant challenges to meaningful learning among college students. This study aims to analyze the types, causes, and remediation strategies of physics misconceptions at the tertiary level through a systematic literature review. A total of 50 peer-reviewed articles published between 2019 and 2023 were selected from the Scopus database using bibliometric analysis tools, including Harzing's Publish or Perish and VosViewer. The review reveals five main types of student misconceptions: prejudice-based, non-scientific theories, conceptual misconceptions, vernacular misunderstandings, and factual errors. The most common causes include students' prior knowledge and ineffective instructional methods. The four-tier diagnostic test is found to be the most frequently used and effective tool in identifying misconceptions. Remediation strategies include conceptual change texts, simulation-based experiments, e-learning, and collaborative learning models. The study concludes that understanding and addressing misconceptions require both accurate diagnostic tools and innovative teaching strategies. This review contributes to physics education research by providing a comprehensive overview of misconception diagnostics and remediation approaches over the past five years.

Keywords: literature review; misconception; physics education; remediation

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INTRODUCTION

Misconceptions in physics are a persistent and complex issue that impedes students' conceptual understanding, even at the college level. Numerous studies have revealed that these misconceptions are not only prevalent but also deeply rooted, stable, and resistant to change (Hull et al., 2022; Kibirige & Mamashela, 2022; Kuczmann, 2017). As physics education aims to develop students' scientific reasoning and problem-solving skills, overcoming these erroneous beliefs becomes crucial for achieving meaningful learning outcomes in higher education. A preliminary review of recent empirical studies (2019–2023) confirms that misconceptions remain widespread among college students despite various instructional efforts. These studies have documented misunderstandings in fundamental topics, including mechanics, electricity, magnetism, and thermodynamics. While numerous diagnostic tools and teaching strategies have been proposed, the literature remains fragmented, with most studies focusing on a single topic or limited to school-level learners. This indicates a clear gap in research, as there is no comprehensive synthesis that categorizes the types of misconceptions among college students, explores their causes, maps the diagnostic tools used to uncover them, and identifies effective remediation strategies.

This study responds to that gap by conducting a systematic review of recent literature focused on misconceptions in undergraduate physics education. Specifically, it aims to: 1) classify the types of misconceptions that are prevalent among college physics students; 2) identify the root causes of these misconceptions; 3) analyze the diagnostic tools used to detect them; and (4) categorize the instructional strategies employed to remediate them. The scope of this review is limited to peer-reviewed journal articles published between 2019 and 2023, and these articles are categorized into measurable categories. By addressing these objectives, the review contributes to both theoretical understanding and instructional practice in physics education. To contextualize this issue more deeply, it is essential first to examine how students typically construct conceptual understanding. Students develop their understanding of scientific concepts not only through formal instruction but also through their everyday experiences and prior knowledge (Üce & Ceyhan, 2019; Shah, 2019). This prior knowledge can vary significantly among individuals and may not always align with scientifically accepted principles (Parwati & Suharta, 2020). When intuitive understanding based on daily phenomena contradicts formal physics explanations, students often form misconceptions, incorrect yet persistent mental models of scientific concepts. These misconceptions, once formed, are difficult to change. When students are introduced to new scientific facts that conflict with their existing ideas, they often experience

cognitive dissonance or confusion (Parwati & Suharta, 2020). In the absence of effective instructional interventions, this cognitive conflict can lead to disengagement, frustration, or even disinterest in learning complex physics topics (Chen et al., 2019; Franklin & Harrington, 2019). Even more concerning, misconceptions are not limited to primary or secondary education; they persist through college and are sometimes perpetuated by teachers who themselves hold inaccurate conceptions (Soeharto et al., 2019; Resbiantoro & Setiani, 2022). Physics education, in its ideal form, emphasizes inquiry-based learning and hands-on experience. Students are expected to bridge theory and practice through mathematical modeling and empirical investigation (Bao & Koenig, 2019; Volfson et al., 2020). However, in reality, many instructional settings over-rely on conceptual explanations without providing adequate concrete experiences (Suhandi et al., 2020). Despite efforts to introduce experimental activities and digital media to enhance engagement, many students still struggle with deeply ingrained misconceptions, suggesting that instructional design alone is insufficient unless paired with accurate diagnosis and targeted remediation.

Recognizing the persistence and impact of these misconceptions, various diagnostic instruments have been developed to detect and understand them. These tools include interviews, open-ended questions, multiple-choice items, and multitier tests that explore not just students' answers, but also their reasoning (Kaniawati et al., 2019; Resbiantoro & Setiani, 2022). While many of these instruments have been validated in previous studies, their use in college settings remains underexplored, particularly in terms of their effectiveness in identifying specific types of misconceptions and informing instruction. Additionally, four-tier diagnostic tests, although promising, have not been widely implemented at the undergraduate level. The novelty of this review lies in its integrative synthesis of misconceptions, diagnostic instruments, and remediation strategies specifically within the context of college physics education, an area that has been relatively neglected in past reviews. By connecting these three components and analyzing their interplay, this study provides a more holistic understanding of how to address conceptual difficulties in higher education, offering practical implications for curriculum development, teaching strategies, and future research.

METHODS

This study applied a Systematic Literature Review (SLR) following the PRISMA 2020 protocol (Page et al., 2021) and the systematic review framework proposed by Kitchenham (2004). The objective was to explore the types, causes, and remediation strategies of misconceptions in college-level physics education by synthesizing empirical research findings from the last five years (2019–2023). SLR was selected as a methodological approach due to its structured and transparent procedures that allow for comprehensive data collection, critical evaluation, and synthesis of available evidence to generate new insights for theory and practice in science education.

The review procedure followed three stages: Planning, Conducting, and Reporting, as outlined by Kitchenham (2004). In the planning stage, the research questions were formulated, and the Scopus database was identified as the main source due to its comprehensive indexing of peer-reviewed literature. Keyword strings such as "physics education", "misconception", "college students", and "remediation" were used with Boolean operators AND/OR. In the conducting stage, a total of 198 articles were initially identified. After duplicate removal and screening of titles and abstracts, 122 articles remained. Following full-text assessment based on inclusion/exclusion criteria, 50 eligible articles were retained for final analysis. The reporting stage involved thematic synthesis and visualization using bibliometric tools. The PRISMA flow diagram of the article selection process is provided in Figure 1.

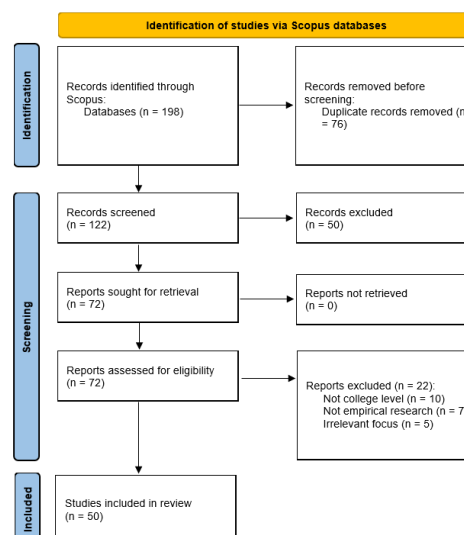


Figure 1. PRISMA Flow Diagram

Inclusion criteria were: 1) articles published between 2019 and 2023; 2) written in English; 3) focused on college students in physics education; and 4) empirically discussed misconceptions (types, causes, or remediation). Articles were excluded if they: 1) focused on elementary or high school level; 2) were not empirical (reviews, opinion pieces); or 3) lacked relevance to misconceptions in physics education. The article screening process followed the PRISMA four-stage structure: identification, screening, eligibility, and inclusion (Page et al., 2021). Data were extracted using a structured matrix adapted from Petticrew and Roberts (2008), containing key information: title, author, year, physics topic, research method, misconception type, cause, diagnostic tool, and remediation approach. Data were coded using thematic content analysis and organized into frequency tables and co-occurrence networks.

Quantitative analysis was performed using VOSviewer (van Eck & Waltman, 2010) to visualize trends in authorship, keyword co-occurrence, and citation networks. This provided insight into the intellectual structure of the field. Qualitative analysis classified misconceptions into five major categories: prejudice-based, non-scientific theories, conceptual misconceptions, vernacular misunderstandings, and factual errors. Causes were also coded thematically, including instructional strategies, prior knowledge, and teacher misconceptions. Remediation strategies were grouped into seven types: conceptual change texts, simulation-based experiments, learning strategies, e-learning, collaborative learning, model-based instruction, and laboratory experiments. The combination of both analyses provides a comprehensive map of diagnostic and instructional practices in the field.

RESULT AND DISCUSSION

The results of this study not only confirm the persistence of misconceptions in physics, particularly in the concepts of Newton's laws and electric circuits but also provide a deeper understanding of how these misconceptions arise and how they can be effectively addressed. The four-tier diagnostic test method employed in this study represents a significant innovation, especially when compared to the traditional two-tier tests that have been widely used in previous research. The four-tier method allows for a more nuanced identification of misconceptions, providing not only a diagnosis of the misconception itself but also the reasoning behind the students' incorrect beliefs. This methodological advancement offers a clearer picture of how students' misconceptions are constructed and maintained over time. In previous research, such as Fratiwi and Aminudin (2019), a more basic approach was used, focusing solely on identifying factual inaccuracies. However, this study's inclusion of reasoning behind misconceptions allows for targeted remediation strategies, something that earlier studies did not fully address. This distinction in methodology is a key contribution of this study to the field of physics education. To support the analysis, this study utilized VOSviewer to visualize research trends related to misconceptions in physics education. Figure 2 displays a visualization of misconceptions from the last five years, indicating that Newton's laws and electric circuits remain the most problematic areas for college students. In Figure 2, the visualization of misconceptions over the past five years, generated using VOSviewer, shows an ongoing trend in students' misunderstanding of fundamental physics concepts.

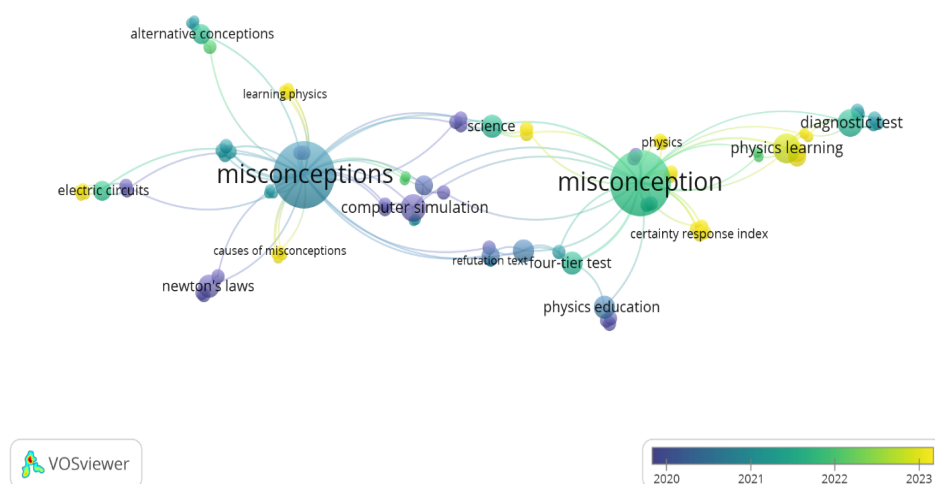


Figure 2. Misconceptions from The Last Five Years

The most persistent misconceptions identified in this study, such as the misapplication of Newton's first law and misunderstandings related to electric circuits, have been widely reported in past studies. However, unlike earlier research, this study goes a step further by incorporating computer simulations and interactive e-learning modules as part of the remediation process. This combination of diagnostic tools and technological interventions is a significant departure from the more traditional approaches used in the past, which typically

involved paper-based diagnostic tests and in-person instruction. By integrating digital tools, this research offers a more comprehensive approach to addressing misconceptions, particularly for concepts that are traditionally challenging for students to grasp.

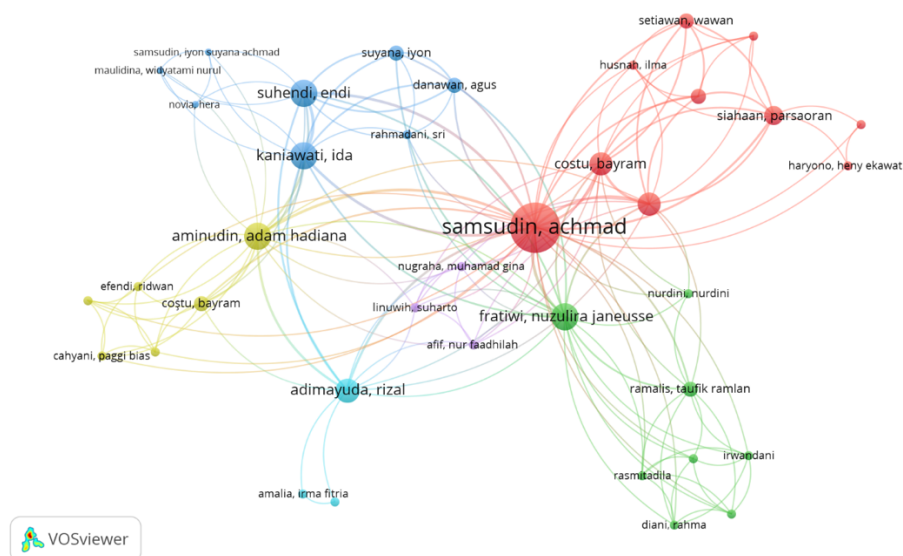


Figure 3. Researchers discussing misconceptions in the last five years

A complementary analysis is presented in Figure 3, which highlights collaboration networks of researchers working on physics misconceptions. Figure 3 offers further insight into the key contributors to the study of misconceptions over the last five years. The Vos Viewer network analysis highlights the prominent researchers, such as [Samsudin \(2021\)](#) and [Suhendi et al. \(2022\)](#), who have made significant contributions to understanding misconceptions in physics education. However, what sets this study apart is the innovative approach of combining four-tier diagnostic tests with digital remediation strategies. Previous studies have primarily focused on either diagnostic testing or technology-based interventions in isolation. This research fills a gap by integrating both approaches, offering a more holistic method for understanding and addressing misconceptions in physics. By showing the connections between diagnostic results and remedial activities, this study creates a more comprehensive framework for educators to follow when addressing misconceptions.

To deepen the understanding of what types of misconceptions emerge, students' misconceptions are characterized into five categories, namely: 1) prejudice, if it comes from life and personal experience; 2) non-scientific theories, if students' knowledge is obtained additional than from scientific sources; 3) conceptual misconceptions, if students' knowledge arises when put on confusing and wrong ideas based on scientific perceptions; 4) vernacular misconceptions, if students make mistakes in using arguments that have different meanings from scientific ideas; 5) factual misconceptions, if students' misconceptions occur early and are upheld into adulthood ([Kim et al., 2023](#)). Based on these five groups, there is a need for assessment tools that can be used to recognize or measure these misconceptions. Based on a review of all existing articles, it is evident that misconceptions can be categorized into five types: prejudice, non-scientific principles, conceptual misconceptions, vernacular misconceptions, and factual misconceptions ([Kim et al., 2023](#)).

Each type of misconception corresponds to different remediation strategies. For example, prejudice-based misconceptions are effectively addressed through simulation-based experiments that confront real-life experiences ([Park, 2019](#)). Conceptual misconceptions, which stem from the misapplication of scientific knowledge, are best remediated through conceptual change texts ([Suhendi et al., 2020](#); [Samsudin, 2023](#)). Vernacular misconceptions, related to misinterpretation of everyday language, respond well to collaborative learning ([Kaniawati et al., 2020](#)). This linkage between misconception types and remediation strategies, which is often missing in prior studies, is a critical contribution of this review. To identify these types of misconceptions, various diagnostic tools have been used in the literature over the past five years. The reviewers compiled data from trusted journals and identified several diagnostic tools to measure misconceptions over the last five years. There are several diagnostic tools used in research on misconceptions including interviews ([Resbiantoro & Setiani, 2020](#); [Pollard, 2021](#)), open-ended test ([Aminudin et al., 2019](#); [Adimayuda et al., 2020](#); [Fratiwi et al., 2020](#); [Nurdini et al., 2020](#); [Samsudin et al., 2021](#)), multiple-choice tests ([Hasanah, 2020](#); [Laliyo et al., 2021](#); [Kiray & Simsek, 2021](#)), two-tier tests ([Métoui, 2019](#); [Nasir, 2023](#); [Mufit & Fauzan, 2023](#)), three-tier tests ([Çoban & Mustafa, 2019](#); [Haryono et al., 2021](#); [Sakinah et al., 2023](#)), four-tier tests ([Kaniawati et al., 2019](#); [Laliyo et al., 2021](#); [Kiray & Simsek, 2021](#); [Resbiantoro & Setiani, 2022](#); [Önder & Kızılcık, 2022](#); [Istiyono et al., 2023](#)). Instead of listing the tools repeatedly, this information is now summarized in Table 1.

Table 1. Types of Diagnostic Tools Used by Researchers for 5 Years

Diagnostic Tool	Researchers
Open-ended tests	(Aminudin et al., 2019); (Adimayuda et al., 2020); (Fratiwi et al., 2020); (Nurdini et al., 2020); (Erceg et al., 2021); (Fakudze, 2021); (Samsudin et al., 2021); (Yildirim & Baran, 2021); (Hernandez et al., 2022); (Resbiantoro & Setiani, 2022)
Interviews	(Volfson et al., 2020); (Erceg et al., 2021); (Pollard, 2021); (Hidayat et al., 2022); (Rahmawati et al., 2022); (Resbiantoro & Setiani, 2022); (Quezada-Espinoza et al., 2023)
Multiple-choice tests	(Adimayuda et al., 2020); (Djudin, 2021); (Erceg et al., 2021); (Hasanah, 2020); (Laliyo et al., 2021); (Kiray & Simsek, 2021); (Balta et al., 2022); (Rahmawati et al., 2022); (Llinás & Márquez, 2023); (Isra & Mufit, 2023); (Istiyono et al., 2023); (Mufit & Fauzan, 2023)
Two-tier tests	(Métoui, 2019); (Suhandi et al., 2020); (Kaniawati et al., 2021); (Rahmawati et al., 2022); (Istiyono et al., 2023); (Nasir, 2023); (Mufit & Fauzan, 2023)
Three-tier tests	(Çoban & Mustafa, 2019); (Haryono et al., 2021); (Kaniawati et al., 2021); (Isra & Mufit, 2023); (Sakinah et al., 2023)
Four-tier tests	(Kaniawati et al., 2019); (Kaniawati et al., 2020); (Suhandi et al., 2020); (Laliyo et al., 2021); (Kaniawati et al., 2021); (Kiray & Simsek, 2021); (Resbiantoro & Setiani, 2022); (Önder & Kızılçık, 2022); (Astuti et al., 2023); (Istiyono et al., 2023)

According to research conducted over the last five years, the four-tier diagnostic test is more widely used than other diagnostic tests. This is a change that future researchers can implement to utilize the four-tier test in addressing misconceptions. It must also be adapted to an approach or method that fits the discussion on a particular concept. Additionally, this study offers a critical comparison of these tools. Interviews offer depth but are challenging to scale; multiple-choice tests are efficient but lack depth in reasoning; and two-tier tests offer content-reasoning pairs but lack confidence data. The four-tier test addresses these issues by integrating justification and confidence, making it the most robust for comprehensively identifying misconceptions.

Other discoveries mention that investigators' efforts on educator factors and teaching approaches are causes of misconceptions. Both factors are expenses that can be enhanced to eliminate misconceptions (Resbiantoro & Setiani, 2022). In the prescribed learning concept, educators are obligated to implement training methods that present scientific descriptions to students (Neidorf et al., 2020; Rashidov & Rasulov, 2020). There are some difficulties associated with these two factors, as identified in this review. Some educators lack insight into the misconceptions of their students, so they focus on education without attempting to apply the conceptual change method (Moodley & Gaigher, 2019; Achor & Abuh, 2020). One factor that often causes student misconceptions is the traditional or lecture-based learning method given by the teacher (Kaniawati et al., 2020).

The impact and contribution of this study to the field of physics education are evident in its combination of diagnostic tools with technology-driven remediation strategies. This combination has shown promise in reducing misconceptions and providing more efficient and personalized feedback to students. While prior studies, such as those conducted by Suhendi et al. (2022), have emphasized the importance of simulations in helping students visualize abstract concepts, this study takes it a step further by combining the four-tier diagnostic tool with targeted e-learning platforms. The integration of these two strategies enables a more tailored approach to meet each student's specific needs. This personalized remediation has been shown to improve learning outcomes, particularly for students who struggle to understand the underlying principles of Newton's laws and electric circuits. Additionally, the use of these diagnostic tools provides valuable data that can inform future teaching practices, making it easier to identify areas that require further attention in the curriculum. To strengthen this linkage, the author also categorizes remediation strategies into seven approaches: Simulation-Based Experiment, Conceptual Change Text, Learning Models, Learning Strategies, E-Learning, Collaborative Learning, and Model-Based Teaching. From Table 2, it can be seen that the most used remediation method is E-learning, highlighting the growing interest in integrating interactive multimedia to address persistent misconceptions (Samsudin et al., 2021; Samsudin et al., 2022).

Table 2. Types of Remediation Strategies Used by Researchers for 5 Years

Remediation Strategy	Researchers
Simulation-Based Experiment	(Park, 2019)
Conceptual Change Text	(Suhandi et al., 2020); (Surtiana et al., 2020); (Samsudin, 2023)
Learning Model	(Halim et al., 2021); (Chen et al., 2019); (Haryono et al., 2021)
Learning Strategies	(Astuti et al., 2020); (Hasanah, 2020); (Parwati & Suharta, 2020); (Samsudin et al., 2021)
E-Learning	(Halim et al., 2021)
Collaborative Learning	(Kaniawati et al., 2020); (Mufit & Fauzan, 2023)
Model-Based Teaching	(Moodley & Gaigher, 2019); (Kiray & Simsek, 2021)
Laboratory Experiment	(Kulgemeyer & Wittwer, 2023)

In addition to the methodological advancements, the impact of this research is clear in its potential to influence future studies on diagnostic assessments and remediation strategies in physics education. By demonstrating the effectiveness of combining diagnostic testing with interactive learning modules, this research opens up new possibilities for enhancing teaching practices and improving student learning outcomes in physics. Future studies could explore how these methods can be applied to other areas of science education, such as chemistry and biology, to test further their effectiveness in reducing misconceptions across different scientific domains. Moreover, the findings from this study can inform the development of adaptive learning technologies that automatically adjust the content and difficulty of remediation tasks based on individual student performance, thereby providing even more personalized learning experiences.

In summary, the results of this study provide new insights into the persistent nature of misconceptions in physics, offering a more detailed understanding of how these misconceptions form and how they can be effectively addressed using modern diagnostic tools and digital remediation. The novelty of combining four-tier diagnostic tests with interactive e-learning modules and computer simulations marks a significant advancement over previous approaches. The study's findings are expected to contribute to the development of more effective teaching strategies and assessment tools that can be applied in physics education and beyond, ultimately improving student comprehension of key scientific concepts. The author suggests that readers and future researchers continuously refer to the most recent studies in the field of physics education to stay updated on emerging patterns and remediation strategies for misconceptions. While this review provides a comprehensive overview based on literature from 2019 to 2023, it may have limitations in scope or interpretation. Therefore, future research is encouraged to expand, refine, and validate these findings using broader datasets, updated methodologies, or new perspectives to strengthen further efforts in addressing misconceptions in physics education.

CONCLUSION

This systematic literature review examined 50 peer-reviewed articles published between 2019 and 2023 in the Scopus database to identify the types, causes, diagnostic tools, and remediation strategies related to misconceptions in physics education at the tertiary level. The most dominant misconceptions found were conceptual and vernacular, typically rooted in students' prior knowledge and reinforced by conventional instructional methods. Among the various diagnostic instruments, the four-tier test emerged as the most comprehensive, capable of capturing both student responses and their underlying reasoning. Effective remediation strategies included conceptual change texts, simulation-based learning, e-learning platforms, and collaborative learning models. For educators and lecturers, the results highlight the importance of selecting diagnostic tools that assess not only content accuracy but also cognitive reasoning, and of aligning instructional strategies with the specific nature of student misconceptions to improve learning outcomes. Applying these findings in higher education settings can support the design of more responsive and conceptually driven instruction. However, it is important to note that the scope of this review is limited to Scopus-indexed, English-language articles published within the last five years and therefore may not encompass all relevant literature. Future studies should consider broader databases and empirical validation to substantiate these findings further and extend their applicability.

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