



Misconception in Physics Learning: A Systematic Review of the Research Trend, Misconception Profile, Diagnosis, and Remediation Strategies

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Abstract – Misconceptions in physics education continue to be a persistent challenge because they hinder meaningful learning, weaken conceptual understanding, and reduce students' ability to accurately interpret physical phenomena. Although research on this topic has grown over the past decade, the literature remains fragmented across different educational levels, physics topics, diagnostic approaches, and remediation strategies. This study aimed to provide an updated and structured overview of influential research on misconceptions in physics by analyzing research trends, misconception profiles, diagnostic tools, and remediation techniques. A citation-based systematic mapping review was conducted using the Scopus database. The search was limited to English-language journal articles and conference proceedings published between 2015 and 2024, with the top 100 records ranked by citation count screened, resulting in 74 studies included in the final analysis. The results show that research on misconceptions in physics primarily focuses on university and high school students, with classical mechanics the most studied topic, followed by electricity, magnetism, and wave-related concepts. In terms of diagnosis, four-tier diagnostic tests were the most frequently used instruments, followed by established concept inventories such as the Force Concept Inventory. Concerning remediation, diagnostic-based interventions, conceptual change strategies, and cognitive conflict-based learning were the most prominent approaches. However, a significant number of studies did not explicitly identify the causes of misconceptions or report clear remediation strategies. The novelty of this review lies in its integrative mapping of influential studies across multiple analytical dimensions within a single physics-specific framework. This research contributes to physics education by offering a structured reference for future work on diagnostic development, causal analysis, and the design of more context-sensitive instructional interventions.

Keywords: conceptual change; diagnostic assessment; misconceptions; physics education; systematic review

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I. INTRODUCTION

Misconceptions in physics remain a major concern in science education because they stem from well-founded alternative ideas that diverge from accepted scientific explanations and often hinder the development of an accurate understanding. In physics learning, students do not

approach formal instruction as blank slates; instead, they bring prior knowledge, everyday experiences, intuitive beliefs, and informal explanatory frameworks that influence how they interpret new information. When these existing ideas conflict with scientific concepts, students may develop or hold onto misconceptions that are hard to change through regular instruction. This issue has been extensively documented in physics education research, which consistently shows that students face persistent conceptual difficulties in key areas, including Newtonian mechanics, fluid mechanics, electricity and magnetism, and wave phenomena (Isra & Mufit, 2023; Atasoy & Ergin, 2017; Kaniawati et al., 2019; Diani et al., 2019; Maknun & Marwiah, 2022; Siong et al., 2023; Wheatley et al., 2021). These findings suggest that misconceptions are not just accidental learning errors but rather a recurring and structurally significant challenge in physics education.

The significance of misconceptions in physics lies not only in their frequency but also in their consequences for the quality of learning. Misconceptions can hinder meaningful learning by preventing students from integrating new knowledge into coherent conceptual frameworks. Students may memorize formulas or procedures while continuing to misunderstand the underlying physical principles, resulting in superficial achievement that does not reflect genuine conceptual change. This issue is particularly problematic in physics because many topics require the coordinated understanding of abstract representations, causal reasoning, and multilevel interpretations of phenomena. Previous studies have emphasized that misconceptions, when left unaddressed, tend to become resistant to subsequent instruction and may negatively influence problem-solving, transfer of learning, and sustained engagement with physics and other STEM disciplines (Astuti et al., 2023; Bessas et al., 2024; Maknun & Marwiah, 2022). For this reason, the identification, understanding, and remediation of misconceptions have become central to research in physics education.

An extensive body of scholarly literature indicates that misconceptions do not originate from a singular source, but rather from the interaction of multiple cognitive, instructional, and contextual factors. Students may develop incorrect notions based on everyday observations, incomplete prior knowledge, inappropriate analogical reasoning, or overgeneralized intuitions. Concurrently, classroom explanations, textbooks, visual aids, and assessment practices may inadvertently reinforce scientifically inaccurate understandings by oversimplifying complex concepts or failing to challenge students' pre-existing conceptions. Bouzid et al. (2024) contend that misconceptions may arise through students' intuitive beliefs, prior experiences, instructional design, learning materials, and assessment approaches, while Maison et al. (2022) further demonstrate that limited analytical reasoning skills and overconfidence can exacerbate misconceptions, particularly in abstract domains such as electric fields. This body of evidence

underscores that misconceptions should be regarded as a multifaceted educational phenomenon, necessitating equally nuanced diagnostic and pedagogical strategies.

Recent studies further indicate that misconceptions in physics are not only associated with students' prior knowledge and intuitive beliefs, but also with the ways concepts are represented and communicated through modern learning resources. For example, research has shown that conceptual difficulties remain persistent in abstract domains such as introductory quantum physics, where students often struggle to reconcile mathematical formalisms with physical interpretation (Bouchée et al., 2022). In addition, digital learning materials do not automatically reduce misconceptions; under certain conditions, even instructional explainer videos may create an illusion of understanding while reinforcing inaccurate conceptual interpretations when the scientific explanation is oversimplified or cognitively misaligned with learners' prior ideas (Kulgemeier & Wittwer, 2023). These findings reinforce the view that misconceptions in physics should be understood as a dynamic interaction among learners' prior conceptions, instructional representations, and the epistemic complexity of the subject matter itself.

The persistence of misconceptions across content domains and educational levels has spurred research in this area over the last decade. Physics misconception studies now include several major strands, such as profiling students' conceptual difficulties, developing diagnostic instruments, examining factors that contribute to misconception formation, and designing instructional strategies for remediation. This development indicates that the field has matured beyond merely documenting the existence of misconceptions and has moved toward more systematic efforts to measure, explain, and reduce them. Nonetheless, despite this expansion, the literature remains dispersed across diverse topics, populations, and methodological traditions. Research findings are often published in disciplinary and regional outlets, employ varying theoretical lenses, and use different forms of evidence, making it difficult to obtain a clear overview of how the field is evolving as a whole. Consequently, literature reviews have become increasingly important for organizing fragmented knowledge, identifying major patterns, and clarifying research gaps (Snyder, 2019).

Several review studies have attempted to synthesize relevant knowledge on misconceptions and their assessment. These studies have made important contributions by clarifying common student difficulties, compiling diagnostic approaches, and highlighting the importance of conceptual change in science learning. However, the existing review literature also shows several limitations. Some reviews concentrate on a specific category of diagnostic tools, such as four-tier diagnostic tests, thereby offering depth in one methodological area but not providing a broader map of the field (Çelikkanlı & Kızılcık, 2022). Other reviews discuss misconceptions in science education more generally, combining physics with other science domains, which is useful for

broad comparisons but may reduce the specificity needed to understand the distinct epistemic and pedagogical character of physics learning (Soeharto et al., 2019; Soeharto & Csapó, 2022). In addition, some previous reviews were based on literature published only up to 2020, limiting their ability to capture more recent developments in diagnostic design, research distribution, and remediation approaches (Resbiantoro et al., 2022). Taken together, these studies provide a valuable foundation, but they do not yet offer a sufficiently focused and updated mapping of influential research trajectories in physics misconception studies.

An additional limitation in the review landscape concerns the scope and analytical orientation of prior synthesis studies. Although some earlier reviews claim broad coverage, their comprehensiveness is often constrained by database selection, time window, or thematic emphasis. More importantly, few reviews have simultaneously examined research trends, types of misconceptions, diagnostic instruments, causal explanations, and remediation strategies within a single analytical framework. This is an important gap because these dimensions are closely interrelated. Research trends help reveal where scholarly attention is concentrated; misconception profiles indicate which concepts remain problematic; diagnostic tools determine how misconceptions are identified and interpreted; and remediation strategies show how research findings are translated into instructional practice. Without an integrative mapping of these dimensions, the field risks becoming fragmented, with insights remaining isolated within specific subtopics or methodological traditions. Therefore, there is a strong rationale for a review that not only summarizes findings but also explicitly clarifies its scope, analytical purpose, and contribution to the development of physics education research.

In response to this need, the present study adopts a citation-based systematic mapping review to analyze influential and field-shaping studies on misconceptions in physics education. A mapping approach is appropriate because the objective is not to estimate intervention effect sizes, but to categorize and interpret the structure of research activity within a diverse body of literature. Mapping reviews are particularly well-suited to broad questions because they are designed to describe, categorize, and organize the existing evidence base rather than to answer narrowly defined questions of effectiveness (James et al., 2016; Campbell et al., 2023). By focusing on influential studies indexed in Scopus, this review provides a structured overview of how misconceptions in physics are conceptualized, diagnosed, and addressed in secondary and tertiary education. The emphasis is therefore not on exhaustive inclusion of all available publications, but on identifying patterns that have shaped the direction of scholarship and that can inform future work in physics education research.

The positioning of this study is consequently both descriptive and analytical. Descriptively, it maps the research landscape of physics misconception studies by identifying publication trends,

dominant content areas, and the populations most frequently investigated. Analytically, it examines how the literature characterizes student misconceptions, what instruments are used to measure them, and what remediation approaches are proposed to reduce them. This dual orientation is important because the field requires not only the accumulation of studies but also a clearer organization of knowledge to support more coherent future research agendas. Through this approach, the review is expected to contribute to at least three aspects of the literature. First, it updates the overview of influential research on physics misconceptions using recent studies from 2015 to 2024. Second, it sharpens the focus specifically on physics education rather than science education in general. Third, it integrates multiple dimensions of analysis research trends, misconception profiles, measurement tools, and remediation strategies within one review framework. In doing so, the study aims to offer a more comprehensive reference for researchers, teacher educators, and practitioners interested in improving conceptual understanding in physics.

Based on this rationale, the study is designed to analyze the development of research on misconceptions in physics, the forms of misconceptions reported among students, the tools used to diagnose those misconceptions, and the remediation strategies discussed in the literature. These objectives are translated into four research questions that guide the review. First, how is the trend in physics misconception research? Second, how do misconceptions in physics concepts occur among students? Third, how are misconceptions in physics concepts measured? Fourth, what learning remediation strategies are used to reduce misconceptions in physics? By addressing these questions, the present review aims to provide a coherent and up-to-date map of influential scholarship in the field and to identify areas that remain insufficiently explored. Such a contribution is important for directing future studies toward stronger diagnostic precision, clearer causal analysis, and more evidence-informed intervention design in physics education.

II. METHODS

This study employed a citation-based systematic mapping review to identify, classify, and synthesize influential research patterns in studies on misconceptions in physics education. A systematic mapping review differs from a conventional systematic literature review in both purpose and analytical emphasis. Rather than aggregating effect sizes or determining the overall effectiveness of particular interventions, systematic mapping is intended to provide a structured overview of a research field by categorizing its major themes, methodological tendencies, and publication patterns (Petersen et al., 2008; Grant & Booth, 2009). This design was considered appropriate because research on misconceptions in physics is broad, methodologically heterogeneous, and distributed across multiple subtopics, including misconception profiling,

diagnostic instrument development, causal analysis, and remediation strategies. Accordingly, the mapping approach enabled this study to identify dominant directions in the literature and to highlight areas that remain underexplored.

To enhance transparency in the reporting of the search and screening process, this review adopted selected principles from the PRISMA 2020 framework. However, the study was not designed as a full PRISMA-compliant systematic review and did not include meta-analysis. Instead, PRISMA was used in a limited, functional sense to document the stages of study identification, screening, eligibility assessment, and final inclusion (Page et al., 2021). This selective use is consistent with the purpose of the present study, which is to map influential research patterns rather than to synthesize intervention effects or compare treatment outcomes statistically.

The literature search was conducted exclusively in the Scopus database. Scopus was selected because it provides broad coverage of international journals and conference proceedings and is widely used in review and bibliometric-informed studies to identify high-visibility publications in a given field. In the context of this study, the database was considered suitable because the purpose was to capture influential and field-shaping studies in physics misconception research rather than to obtain exhaustive coverage from all possible indexing sources. The search query used was “misconception” AND “physics” AND (“student” OR “learner”), applied to titles, abstracts, and keywords. To ensure relevance and comparability, the search was limited to publications issued between 2015 and 2024, written in English, and published as journal articles or conference proceedings. These criteria were established to capture recent developments in the field while maintaining consistency in document type and publication language.

Because the review was explicitly citation-based, the retrieved records were ranked by citation count in Scopus. From this ranking, the top 100 records were selected for initial screening. The use of citation-based sampling aligned with the study's analytical objective: to examine the literature with the strongest scholarly visibility and influence in shaping research trajectories on misconceptions in physics. In mapping and bibliometric-informed reviews, citation counts are frequently used as indicators of academic impact and field prominence, particularly when the intention is to identify dominant conceptual emphases, methodological norms, and widely recognized lines of inquiry (Donthu et al., 2021). Thus, the present study did not aim to represent all existing studies on physics misconceptions, but rather to focus on those publications that have significantly contributed to the development of the field.

Following the identification stage, the selected records underwent a relevance screening process. At this stage, each paper was examined to determine whether it explicitly addressed misconceptions in physics education and whether it aligned with the scope of the review. Articles

were retained only when their central focus was diagnosing, analyzing, profiling, or remediating misconceptions about physics concepts. Studies that did not directly concern misconceptions in physics learning were excluded from further analysis. Through this process, 74 articles were judged to be relevant and sufficiently aligned with the review objectives, and these papers constituted the final dataset for analysis. The overall procedure of article identification, screening, and selection is summarized in Figure 1, while detailed information on the included studies is presented in the Appendix.

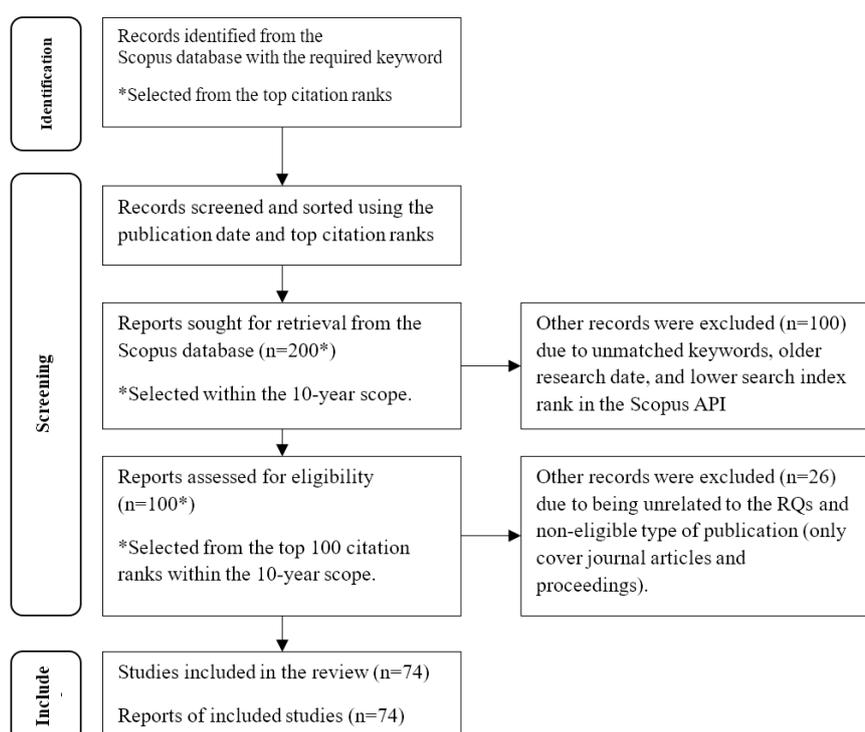


Figure 1. Flow diagram of the study identification, screening, eligibility, and inclusion process based on the adapted PRISMA framework

After the final set of studies was established, the included articles were organized into several layers of categorization to support systematic analysis. First, the studies were classified by publication type, namely journal articles and conference proceedings, in order to describe the main dissemination channels within the field. Second, the studies were grouped by research orientation. These categories included review studies, misconception profiling studies, measurement or diagnostic tool development studies, and studies focused on causes and remediation strategies. This classification was intended to reveal how the field is structured in terms of its dominant research purposes and to show whether the literature is more strongly oriented toward diagnosis, explanation, or pedagogical intervention.

The analysis also examined the research trends represented in the selected studies. This was done by identifying publication trends over time, the educational levels of the participant

groups, and the distribution of physics topics addressed in the literature. Participant groups were primarily distinguished between secondary/high school students and university students, with attention also given to studies involving junior-level learners where relevant. This aspect of the analysis helped clarify which student populations have received the most attention and where potential gaps remain. In addition, the reviewed studies were analyzed according to the physics concepts or domains investigated, enabling the review to identify content areas in which misconceptions have been most frequently studied.

To address the substantive focus of the review, the included papers were further analyzed in relation to the four research questions guiding the study. For RQ1, the analysis focused on research trends, including publication growth, source distribution, research type, and participant groups. For RQ2, the analysis examined how misconceptions in physics were reported to occur among students, including the forms of conceptual difficulty described in the literature and, where available, the causes or contributing factors identified by the studies. For RQ3, the review analyzed the diagnostic instruments used to measure misconceptions, including tiered diagnostic tests, concept inventories, qualitative approaches, and other measurement formats. For RQ4, the review examined remediation strategies proposed or implemented to reduce misconceptions in physics learning, including conceptual change approaches, cognitive conflict-based instruction, simulations, visual methods, and other pedagogical interventions. This question-based organization ensured that the mapping remained analytically aligned with the study's stated objectives.

In reviewing the diagnostic tools, attention was given not only to the type of instrument used but also to its reported design and application in the selected studies. This included identifying whether the literature relied on standardized concept inventories, researcher-developed tiered tests, open-ended assessments, interviews, or mixed diagnostic approaches. Similarly, in the analysis of remediation strategies, the review focused on the instructional methods reported in the literature and how these methods were positioned as attempts to reduce or correct student misconceptions. The purpose of this stage was not to statistically compare intervention effectiveness, but to map the range of strategies associated with misconception reduction in physics education research.

III. RESULTS

The results of this review are organized according to the four research questions that guided the study. Before addressing each question, the publication profiles of the selected studies are described to provide an overview of the sources included in the dataset. The final dataset

comprised 74 studies published across 33 journals and conference proceedings. Of these, 84% were journal articles, and 16% were conference proceedings. Among the identified sources, Physical Review Physics Education Research contributed the largest number of included studies, with 15 publications, accounting for approximately 20% of the dataset. The remaining studies were distributed across various international journals and proceedings, as detailed in the Appendix. The breakdown of publication types is illustrated in Figure 2.

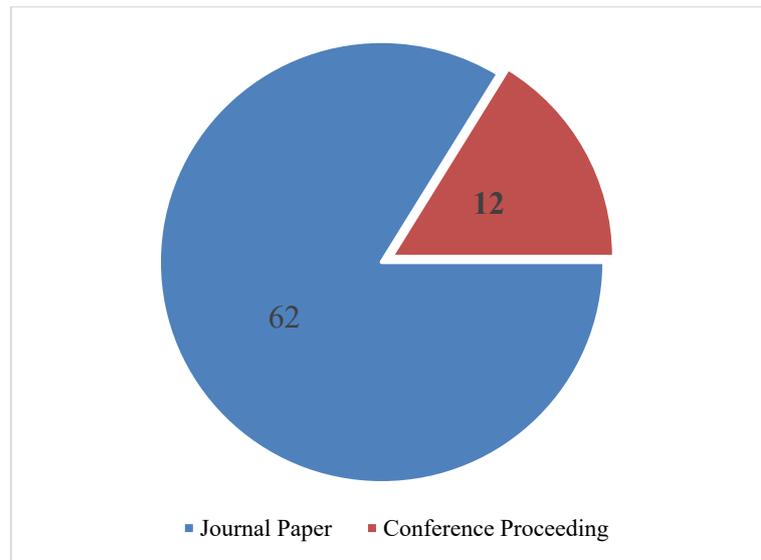


Figure 2. The publication types included in the study

RQ1: How is the trend in physics misconception research?

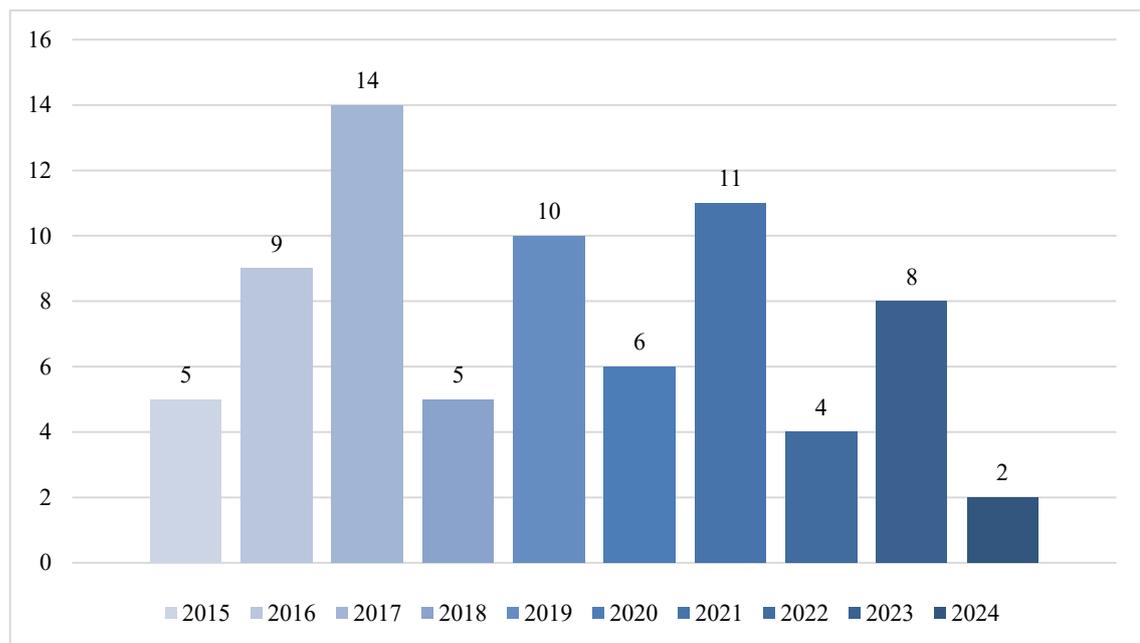


Figure 3. Number of publications throughout the years

The yearly distribution of publications indicates an overall increase in research on misconceptions in physics education across the review period. As shown in Figure 3, publications appeared across multiple years between 2015 and 2024, with a more pronounced concentration in the later years of the dataset. The geographical distribution of the reviewed studies, shown in Figure 4, also indicates that research on physics misconceptions has been conducted across multiple countries and regions.

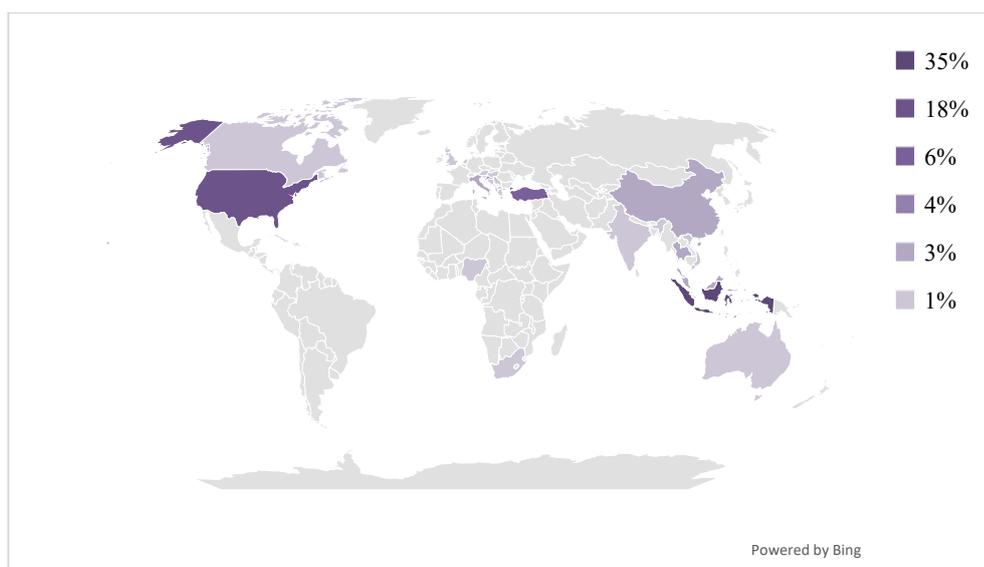


Figure 4. Misconception research counts based on location

When classified by research type, the reviewed studies were distributed into four categories: literature review, profiling report, measurement tool development, and cause and remediation strategies. As shown in Table 1, the largest proportion of studies fell into the cause and remediation strategies category, comprising 33 studies (45%). This was followed by measurement tool development (21 studies, 28%), profiling report (16 studies, 22%), and literature review (4 studies, 5%).

Table 1. The type of research in physics misconception studies

Type	Count	Percentage
Literature review	4	5%
Profiling report	16	22%
Measurement tool development	21	28%
Cause and remediation strategies	33	45%
Total	74	100%

The reviewed studies also varied in their participant groups. As shown in Table 2, university students were involved in 43 cases (52%), while high school students were involved in

36 cases (43%) and junior school students in 4 cases (5%). The total count in this table exceeds 74 because some studies involved more than one participant group.

Table 2. The type of student group proportion among the studies

Group*	Count	Percentage
Junior school	4	5%
High school	36	43%
University	43	52%
Total	83*	100%*

**Some research has more than one type of participant group*

In terms of topic coverage, the reviewed studies were concentrated in several main physics domains. Classical mechanics was the most frequently represented topic, with 26 studies (35%). This was followed by general physics (multi-topic) with 10 studies (13%), electricity and magnetism with 8 studies (11%), wave with 7 studies (11%), and quantum mechanics, fluid mechanics, and thermodynamics, each with 6 studies (8%). Smaller proportions were found in optics, with 3 studies (4%), and in advanced physics topics, including materials physics and computational physics, with 2 studies (3%). These distributions are summarized in Table 3.

Table 3. Physics topic reviewed for students' misconception research

Physics Topic	Count	Percentage
Classical mechanics	26	35%
General physics (multi-topic)	10	13%
wave	7	11%
Quantum mechanics	6	8%
Fluid mechanics	6	8%
Electricity and magnetism	8	11%
Thermodynamics	6	8%
Optics	3	4%
Advanced physics (materials physics, computational physics, etc.)	2	3%
Total	74	100%

RQ2: How does the misconception in physics concepts occur among the students?

The reviewed studies reported several causes of misconceptions, although not all articles explicitly identified causal factors. As shown in Table 4, the most frequently reported cause was instruction, which appeared in 6 studies. This was followed by an assessment in 4 studies. Videos and simulations were each reported in 2 studies. Other causes were reported only once each, namely preconceptions, materialistic thinking, students' own thinking, teaching, fragmented knowledge, and overconfidence.

A substantial portion of the reviewed literature did not explicitly specify the cause of misconceptions. In total, 56 studies were categorized under unspecified or general causes, making this the largest category in Table 4.

Table 4. Causes of misconceptions according to the studies

Cause of misconception	Articles mentioned*	Count
Instruction	2, 4, 37, 40, 44, 47	6
Assessment	12, 22, 29, 66	4
Videos	9, 46	2
Simulations	33, 43	2
Preconceptions	11	1
Materialistic thinking	20	1
Students' own thinking	27	1
Teaching	3	1
Fragmented knowledge	39	1
Overconfidence	64	1
Unspecified or general causes	(All the other unspecified articles)	56

**) Article's numbering code reference can be reviewed in the appendix's table*

RQ3: How is the misconception in physics concepts measured?

A wide variety of diagnostic tools were used across the reviewed studies to identify and measure misconceptions in physics. As shown in Table 5, the most frequently used instrument was the four-tier diagnostic test, which appeared in 8 studies. The Force Concept Inventory (FCI) was the next most frequently used, appearing in 6 studies. Three-tier diagnostic tests, item response curves/models, and interviews/think-aloud protocols each appeared in 4 studies, while custom multiple-choice or open-ended tests appeared in 3 studies.

Several additional instruments appeared in smaller numbers. These included the five-tier diagnostic test, Force and Motion Conceptual Evaluation (FMCE), Field Conceptual Change Inventory (FCCI), Thermal Concept Evaluation (TCE), and network module analysis, each used in 2 studies. Other tools appeared once each, including the Photoelectric Effect Misconception Test (PEMT), Heat, Temperature and Internal Energy Diagnostic Test (HTIEDT), Action Concept Inventory (ACI), Kinetic Molecular Theory Concept Inventory, Sound Concept Inventory Instrument (SCII), DIRECT, Conceptual Survey of Electricity and Magnetism (CSEM), Energy and Momentum Conceptual Survey (EMCS), Simple Harmonic Motion Concept Test, and Pathfinder Network Analysis.

Overall, the reviewed studies employed both standardized concept inventories and researcher-developed diagnostic instruments, as well as qualitative and model-based approaches. The complete distribution of these tools is reported in Table 5.

Table 5. The Diagnostic tools used in measuring misconceptions in physics

Diagnostic tools	Articles mentioned*	Count
Four-tier diagnostic test	6, 12, 15, 21, 28, 29, 30, 56	8
Three-tier diagnostic test	22, 25, 51, 53	4
Five-tier diagnostic test	27, 38	2
Force concept inventory (FCI)	1, 18, 27, 50, 61, 64	6
Force and motion conceptual evaluation (FMCE)	26, 66	2
Field conceptual change inventory (FCCI)	23, 54	2
Photoelectric effect misconception test (PEMT)	63	1
Heat, temperature & internal energy diagnostic test (HTIEDT)	22	1
Action concept inventory (ACI)	41	1
Kinetic molecular theory concept inventory	19	1
Sound concept inventory instrument (SCII)	20	1
Determining and interpreting resistive electric circuit test (DIRECT)	58	1
Thermal concept evaluation (TCE)	37, 62	2
Conceptual survey of electricity & magnetism (CSEM)	67	1
Energy and momentum conceptual survey (EMCS)	13	1
Simple harmonic motion concept test	60	1
Custom multiple-choice or open-ended tests	17, 60, 65	3
Item response curves / models	26, 61, 66, 67	4
Interviews / think-aloud protocols	17, 19, 41, 65	4
Pathfinder network analysis	57	1
Network module analysis	18, 67	2

**) Article's numbering code reference can be reviewed in the appendix's table*

RQ4: What are the learning remediation strategies to reduce misconceptions in physics?

The reviewed studies reported a range of remediation strategies, as summarized in Table 6. The most frequently identified category was diagnostic-based intervention using three-tier, four-tier, or five-tier tools, which appeared in 11 studies. The conceptual change approach was reported in 7 studies, while cognitive conflict-based learning and simulations/virtual simulations each appeared in 6 studies.

Several other strategies were reported less frequently. Visual representation, interactive instruction (PDEODE, ALBICI), network/item response analysis, and interview/think-aloud protocols each appeared in 3 to 4 studies. Strategies reported in 2 studies included cartoon worksheets, reflection activities, project-based learning, and feedback (narrative/formative). Strategies reported in 1 study each included Think-Pair-Share, concept mapping, ethno-STEM/local wisdom, and inquiry-based learning.

In addition, 40 studies were categorized as unspecified or no clear strategy, indicating that no explicit remediation strategy was clearly identified in those articles. The full distribution of remediation strategies is presented in **Table 6**.

Table 6. Misconceptions remediation strategy according to the studies

Remediation strategy	Articles mentioned*	Count
Cognitive conflict-based learning	2, 37, 43, 44, 45, 68	6
Conceptual change approach	13, 23, 35, 45, 54, 55, 56	7
Diagnostic (3-tier, 4-tier, 5-tier)	6, 12, 15, 21, 22, 25, 27, 28, 29, 30, 56	11
Think-pair-share	13	1
Cartoon worksheets	7, 58	2
Visual representation	11, 17, 60	3
Simulations/virtual simulations	9, 14, 33, 46, 48, 68	6
Interactive instruction (pdeode, albici)	23, 54, 56	3
Reflection activities	57, 64	2
Concept mapping	5	1
Ethno-stem / local wisdom	40	1
Project-based learning	4, 40	2
Interview / think-aloud protocols	17, 19, 41, 65	4
Feedback (narrative / formative)	24, 48	2
Inquiry-based learning	64	1
Network / item response analysis	18, 61, 66, 67	4
Unspecified or no clear strategy	(All the other unspecified articles)	40

**) Article's numbering code reference can be reviewed in the appendix's table*

IV. DISCUSSION

The findings of this review indicate that research on misconceptions in physics has become increasingly visible and methodologically diversified over the last decade. The upward trend in publications suggests that misconceptions are no longer treated as isolated classroom errors but rather as a central issue in physics education that affects conceptual understanding, assessment design, and instructional intervention. This trend is consistent with the broader recognition in the literature that misconceptions obstruct meaningful learning and hinder students' ability to organize scientific ideas into coherent conceptual structures (Astuti et al., 2023). It also aligns with evidence that misconceptions tend to persist when they are not explicitly challenged, thereby affecting problem-solving ability, transfer, and long-term engagement with physics learning (Maknun & Marwiah, 2022). In this sense, the observed growth in publication output can be interpreted as a response to the enduring educational significance of misconceptions rather than merely an expansion of a niche research area. The distribution of studies across multiple countries further reinforces the view that misconceptions in physics represent a global educational concern, although the intensity of research activity likely remains shaped by differences in curriculum

structures, teacher preparation systems, and the maturity of physics education research communities.

A second important pattern concerns the distribution of research types, in which studies on causes and remediation strategies formed the largest category, followed by diagnostic tool development and profiling studies. At one level, this pattern is encouraging because it suggests that the field is not limited to describing misconceptions but is increasingly oriented toward addressing them instructionally. However, this distribution also reveals a structural tension in the literature. Although many studies are classified under causes and remediation, the review found that a substantial proportion of the included articles did not explicitly report the causes of misconceptions. This discrepancy is methodologically significant because it suggests that the field often moves rapidly from detection to intervention without sufficiently examining the conceptual, cognitive, or contextual mechanisms through which misconceptions develop and persist. That pattern supports the argument raised in the Introduction that misconceptions emerge through multiple pathways, including prior experience, intuitive beliefs, instructional design, learning materials, and assessment practices (Bouزيد et al., 2024). It is also compatible with findings that limited critical thinking and overconfidence may intensify conceptual error, particularly in abstract domains such as electric fields (Maison et al., 2022). Taken together, the present review suggests that future research would benefit from stronger theoretical integration, especially through perspectives that explain not only what students misunderstand, but why those misunderstandings remain stable under instruction.

The participant distribution likewise reveals an important orientation in the field. Most studies focused on university and high school students, while junior-level learners were only minimally represented. This pattern is understandable because many of the concepts most frequently associated with misconceptions, such as mechanics, electricity, and thermodynamics, are more explicitly taught and formally assessed at secondary and tertiary levels. Nevertheless, the imbalance has important implications. If misconceptions are shaped by prior knowledge and intuitive reasoning before formal instruction is fully consolidated, then the relative absence of studies at earlier levels means that the field may be underexamining the formative stages of conceptual development. Since misconceptions often become resistant to later instruction, the lack of attention to younger learners may limit opportunities for early identification and preventive intervention. The review therefore strengthens the argument that future research should not only continue to investigate misconceptions in advanced contexts, but also examine how these ideas first emerge, stabilize, and evolve across earlier stages of science learning. Such a shift would contribute to a more developmental understanding of misconceptions in physics education.

The dominance of classical mechanics as the most frequently investigated topic is another notable finding with both pedagogical and epistemic implications. This dominance likely reflects the foundational role of mechanics in physics curricula and the fact that it involves concepts such as force, motion, acceleration, and Newtonian interactions that are especially vulnerable to conflict with everyday intuition. Prior studies cited in the manuscript have likewise documented persistent misconceptions in Newtonian mechanics and related domains (Atasoy & Ergin, 2017; Kaniawati et al., 2019). From an educational perspective, this concentration is understandable because mechanics often serves as the conceptual entry point to formal physics learning. At the same time, the relative underrepresentation of advanced topics such as computational physics, materials physics, and other higher-level areas suggests that the literature remains weighted toward foundational content. This may indicate either that misconceptions in advanced topics are less frequently studied or that they are more difficult to diagnose systematically due to greater abstraction, smaller target populations, or less standardized measurement tools. In either case, the imbalance suggests that the current evidence base may be strongest where curriculum traditions and concept inventories are already well-established, whereas emerging or specialized physics domains remain less visible in misconception research.

One of the most consequential findings of this review is the limited explicit reporting of the causes of misconceptions. Although instruction and assessment were the most frequently mentioned causes among studies that identified them, the overwhelming prevalence of unspecified causes points to a persistent analytical gap in the field. This matters because misconceptions are not merely observable incorrect answers; they are cognitive constructions shaped by how students interpret experience, represent knowledge, and respond to classroom discourse. This finding is also consistent with more recent evidence suggesting that the persistence of misconceptions is strongly related to underlying cognitive processes that are not always directly visible in conventional assessment. Wen et al. (2024), for example, showed that students may continue to experience interference from scientifically incorrect intuitions even when they can produce correct formal answers, indicating that misconception persistence can involve both inhibitory control and conceptual understanding. This perspective helps explain why the explicit causes of misconceptions are often underreported in the literature: the mechanisms may be cognitively complex and not easily captured through surface-level diagnostic measures alone. If studies identify misconceptions without examining whether they arise from preconceptions, fragmented knowledge structures, misleading representations, or weaknesses in reasoning, then remediation efforts risk remaining surface-level. This concern is directly aligned with the literature in the manuscript, which shows that misconceptions can emerge from instructional design, assessment practices, prior experience, intuitive beliefs, and low analytical

reasoning (Bouzid et al., 2024; Maison et al., 2022). The present review, therefore, offers an important clarification: the field has made substantial progress in diagnosing misconceptions, but it remains less mature at explaining their origins in a theoretically explicit way. A stronger causal orientation would improve not only the explanatory power of future research but also the design of interventions that target underlying mechanisms rather than only their manifestations.

The review also shows a clear methodological development in the measurement of misconceptions. The prominence of four-tier diagnostic tests, followed by three-tier tests and established concept inventories such as the Force Concept Inventory, indicates that the field increasingly values instruments that go beyond right-or-wrong responses. This trend is important because misconceptions cannot be fully understood through accuracy scores alone; they require evidence about confidence, reasoning, and the structure of students' conceptions. The literature cited in the manuscript supports this movement, particularly the review by Çelikkanlı and Kızılcık (2022), which highlights the growing role of four-tier tests in physics education, and studies such as Kaniawati et al. (2019) and Diani et al. (2019), which demonstrate how tiered formats can reveal specific alternative conceptions in Newtonian mechanics and fluid concepts. At the same time, the continued use of interviews, think-aloud protocols, and item response approaches suggests that the field recognizes the limits of relying on a single diagnostic paradigm. The growing emphasis on more refined diagnostic approaches is also supported by recent work on the structure of misconceptions, using network-based and module analysis methods. Wells et al. (2019) demonstrated that misconceptions measured through the Force Concept Inventory may form patterned conceptual structures rather than isolated incorrect ideas, while Wells et al. (2020) reported similar structural patterns in the Force and Motion Conceptual Evaluation. This suggests that students' misconceptions are often interconnected rather than independent, and that identifying such relationships may provide a stronger basis for targeted remediation than item-by-item analysis alone. This trend is also consistent with the continued refinement of diagnostic assessment design in physics education, including the development of structured two-tier instruments intended to capture both answer accuracy and the reasoning underlying students' conceptual choices in topics such as electric circuits (Ivanjek et al., 2021). The mixed use of standardized inventories and researcher-developed tools reflects methodological diversification but also raises an important challenge for comparability. As instruments become more context-specific and topic-specific, the field gains diagnostic sensitivity while potentially losing cross-study consistency. This tension is a sign of maturation, yet it also indicates the need for stronger validation practices and clearer reporting standards in future misconception measurement research.

The pattern of remediation strategies reported in the reviewed studies further reinforces the interpretation that physics misconceptions are increasingly intervention-oriented but remain uneven in instructional specificity. Diagnostic-driven interventions, conceptual change approaches, cognitive conflict-based learning, and simulations were among the most frequently reported strategies. This distribution is theoretically consistent with misconceptions as robust prior conceptions that require explicit confrontation, restructuring, and conceptual reorganization rather than simple repetition of content. Conceptual change approaches are especially relevant in this regard because they are designed to replace or reorganize existing conceptions when learners encounter more plausible, intelligible, and fruitful scientific explanations. The prominence of this approach is also supported by recent intervention studies showing that instruction explicitly designed to challenge and reconstruct students' prior ideas can improve conceptual understanding in learning about electricity (Taslidere & Yildirim, 2023). Likewise, cognitive conflict-based learning is pedagogically appropriate when students need to recognize inadequacies in their existing explanations before they are willing to revise them. The use of simulations and visual representations is also understandable, particularly for abstract or invisible processes in physics, where students may struggle to form accurate mental models from verbal explanation alone. Previous studies in the manuscript support these directions, including Maknun and Marwiah (2022) on conceptual change in static fluids and Siong et al. (2023) on the use of concept cartoons for electricity concepts. These interventions suggest that effective remediation often depends on combining diagnosis with instructional designs that make students' thinking visible and challenge it productively.

At the same time, the large number of studies without a clearly reported remediation strategy indicates that the field still faces a gap between diagnosis and pedagogical application. This is a critical issue because identifying misconceptions, while essential, does not by itself improve learning outcomes. A literature base that is rich in detection but thinner in clearly articulated intervention logic risks limiting its practical value for classroom teaching. A related implication concerns teacher capacity to recognize and interpret student misconceptions accurately. Recent research on preservice teachers' diagnostic competence suggests that identifying misconceptions in physics is not a trivial task and requires both content knowledge and the ability to analyze student thinking in a conceptually precise manner (Timothy et al., 2023). This indicates that improvements in diagnostic tools should ideally be accompanied by attention to teacher diagnostic competence, because the usefulness of any instrument ultimately depends on how its results are interpreted and translated into instructional action. The finding that only one study in the reviewed set incorporated an ethno-STEM or local wisdom approach is also noteworthy. It suggests that culturally responsive and contextually grounded remediation remains

marginal, despite the fact that students interpret physics ideas through everyday experience and locally shaped understandings. In settings where contextual relevance matters for engagement and meaning-making, the scarcity of such approaches indicates an underdeveloped line of inquiry rather than a settled conclusion about their value. The present review, therefore, contributes not only a map of dominant strategies but also an identification of what remains peripheral in the field, namely, context-sensitive, culturally grounded, and explicitly theory-based intervention designs.

Viewed as a whole, the findings position this review as a contribution that extends prior review work in three meaningful ways. First, it updates the map of influential research on misconceptions using studies from 2015 to 2024, thereby addressing the limited temporal coverage of earlier reviews, such as [Resbiantoro et al. \(2022\)](#). Second, it maintains a specific focus on physics education rather than merging physics with broader discussions of science education, which helps preserve disciplinary precision in interpreting patterns of misconceptions. Third, it brings together, within a single analytical framework, the trends, participant profiles, topic distributions, causal reporting, diagnostic tools, and remediation strategies that are often discussed separately in earlier literature. This integrative perspective is important because the field's fragmentation has made it difficult to see how these dimensions relate to one another. By mapping them together, the review clarifies that progress in physics misconception research has been substantial, but uneven: diagnostic sophistication has advanced, intervention ideas have expanded, and publication output has increased, yet causal explanation, early-level coverage, advanced-topic coverage, and context-sensitive remediation remain comparatively underdeveloped.

V. CONCLUSION

This study provides a citation-based systematic mapping review of influential research on misconceptions in physics education and shows that misconceptions remain a persistent and widespread issue across the field. The reviewed literature indicates that research has grown over time and is concentrated primarily on university and high school students, with classical mechanics emerging as the most frequently studied topic, followed by electricity and magnetism, waves, thermodynamics, and several other core domains. The findings also show that diagnostic practices in the field have become increasingly sophisticated, with four-tier and three-tier diagnostic tests, as well as established concept inventories, playing a prominent role in identifying students' misconceptions. In addition, the review demonstrates that remediation efforts are most commonly associated with diagnostic-based interventions, conceptual change approaches,

cognitive conflict-based learning, simulations, and other visual or interactive instructional strategies. At the same time, the study reveals an important imbalance in the literature, as a large proportion of the reviewed studies do not explicitly explain the causes of misconceptions and many do not report clearly defined remediation strategies, indicating that diagnostic advancement has outpaced explanatory depth and instructional specification in the field.

This study also has several limitations that should be acknowledged. The review relied exclusively on the Scopus database and included only English-language publications, so relevant studies indexed elsewhere or published in other languages may not have been captured. In addition, the citation-based selection strategy, while appropriate for identifying influential and field-shaping research, may underrepresent newer studies that have not yet accumulated substantial citations. These limitations mean that the review should be interpreted as a structured map of influential research trajectories rather than a fully exhaustive account of all studies of misconceptions in physics education. Despite these constraints, the study contributes to the field by offering an updated and integrated overview of research trends, misconception profiles, diagnostic tools, and remediation strategies within a single analytical framework focused specifically on physics education. Based on these findings, future research should place greater emphasis on uncovering the cognitive, instructional, and contextual causes of misconceptions, expanding investigation to earlier educational levels and less-studied physics topics, strengthening the validation and innovation of diagnostic instruments, and designing intervention studies that are both empirically tested and contextually grounded. In this regard, the present review provides a useful reference for researchers, teacher educators, and practitioners seeking to develop more theoretically informed and instructionally effective responses to misconceptions in physics learning.

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REFERENCES

- Astuti, I. A. D., Bhakti, Y. B., Prasetya, R., & Zulherman. (2023). Android-based 4-tier physics test app to identify student misconception profiles. *International Journal of Evaluation and Research in Education*, 12(3), 1356–1363. <https://doi.org/10.11591/ijere.v12i3.25536>

- Atasoy, Ş., & Ergin, S. (2017). The effect of concept cartoon-embedded worksheets on grade 9 students' conceptual understanding of Newton's laws of motion. *Research in Science & Technological Education*, 35(1), 58–73. <https://doi.org/10.1080/02635143.2016.1248926>
- Bessas, N., Tzanaki, E., Vavougiou, D., & Plagianakos, V. P. (2024). Diagnosing students' misconception in hydrostatic pressure through a 4-tier test. *Heliyon*, 10(23), 1-19. <https://doi.org/10.1016/j.heliyon.2024.e40425>
- Bouchée, T., de Putter-Smits, L., Thurlings, M., & Pepin, B. (2022). Towards a better understanding of conceptual difficulties in introductory quantum physics courses. *Studies in Science Education*, 58(2), 183-202. <https://doi.org/10.1080/03057267.2021.1963579>
- Bouziid, T., Darhmaoui, H., & Kaddari, F. (2024). Force and motion misconceptions in Moroccan high school science majors: Insights from video game activity. *Research in Science & Technological Education*, 43(4), 1247-1268. <https://doi.org/10.1080/02635143.2024.2428618>
- Campbell, F., Tricco, A. C., Munn, Z., Pollock, D., Saran, A., Sutton, A., White, H., & Khalil, H. (2023). Mapping reviews, scoping reviews, and evidence and gap maps (EGMs): The same but different—the “Big Picture” review family. *Systematic Reviews*, 12(45), 1-8. <https://doi.org/10.1186/s13643-023-02178-5>
- Çelikkanlı, N. Ö., & Kızılcık, H. Ş. (2022). A review of studies about four-tier diagnostic tests in physics education. *Journal of Turkish Science Education*, 19(4), 1291–1311. <https://doi.org/10.36681/tused.2022.175>
- Diani, R., Alfin, J., Anggraeni, Y. M., Mustari, M., & Fujiani, D. (2019). Four-tier diagnostic test with certainty of response index on the concepts of fluid. *Journal of Physics: Conference Series*, 1155(1), 1-9. <https://doi.org/10.1088/1742-6596/1155/1/012078>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, 26(2), 91–108. <https://doi.org/10.1111/j.1471-1842.2009.00848.x>
- Isra, R. A., & Mufit, F. (2023). Students' conceptual understanding and causes of misconceptions on Newton's law. *International Journal of Evaluation and Research in Education*, 12(4), 1914–1924. <https://doi.org/10.11591/ijere.v12i4.25568>
- Ivanjek, L., Morris, L., Schubatzky, T., Hopf, M., Burde, J. P., Haagen-Schützenhöfer, C., Dopatka, L., Spatz, V., & Wilhelm, T. (2021). Development of a two-tier instrument on simple electric circuits. *Physical Review Physics Education Research*, 17(2), 1-15. <https://doi.org/10.1103/PhysRevPhysEducRes.17.020123>
- James, K. L., Randall, N. P., & Haddaway, N. R. (2016). A methodology for systematic mapping in environmental sciences. *Environmental Evidence*, 5(7), 1-13. <https://doi.org/10.1186/s13750-016-0059-6>

- Kaniawati, I., Fratiwi, N. J., Danawan, A., Suyana, I., Samsudin, A., & Suhendi, E. (2019). Analyzing students' misconceptions about Newton's laws through Four-Tier Newtonian Test (FTNT). *Journal of Turkish Science Education*, 16(1), 110–122. <https://www.tused.org/index.php/tused/article/view/224>
- Kulgemeyer, C., & Wittwer, J. (2023). Misconceptions in physics explainer videos and the illusion of understanding: An experimental study. *International Journal of Science and Mathematics Education*, 21, 417–437. <https://doi.org/10.1007/s10763-022-10265-7>
- Maison, M., Hidayat, M., Kurniawan, D. A., Yolviansyah, F., Sandra, R. O., & Iqbal, M. (2022). How critical thinking skills influence misconception in electric field. *International Journal of Educational Methodology*, 8(2), 377–390. <https://doi.org/10.12973/ijem.8.2.377>
- Maknun, J., & Marwiah, M. (2022). Remediation of misconceptions vocational high school students on the concept of static fluids using the conceptual change model. *Journal of Technical Education and Training*, 14(2), 49–56. <https://doi.org/10.30880/jtet.2022.14.02.005>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, 10(89), 1-11. <https://doi.org/10.1186/s13643-021-01626-4>
- Petersen, K., Feldt, R., Mujtaba, S., & Mattsson, M. (2008). Systematic mapping studies in software engineering. In *Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering (EASE)*, 12, 1–10. <https://doi.org/10.14236/ewic/ease2008.8>
- Resbiantoro, G., Setiani, R., & Dwikoranto. (2022). A review of misconception in physics: The diagnosis, causes, and remediation. *Journal of Turkish Science Education*, 19(2), 403–427. <https://www.tused.org/index.php/tused/article/view/924>
- Siong, L. C., Tyug, O. Y., Phang, F. A., & Puspanathan, J. (2023). The use of concept cartoons in overcoming the misconception in electricity concepts. *Participatory Educational Research*, 10(1), 310–329. <https://doi.org/10.17275/per.23.17.10.1>
- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 104, 333–339. <https://doi.org/10.1016/j.jbusres.2019.07.039>
- Soeharto, S., & Csapó, B. (2022). Exploring Indonesian student misconceptions in science concepts. *Heliyon*, 8(9), 1-10. <https://doi.org/10.1016/j.heliyon.2022.e10720>
- Soeharto, S., Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, 8(2), 247–266. <https://doi.org/10.15294/jpii.v8i2.18649>
- Taslidere, E., & Yildirim, B. (2023). Effect of conceptual change-oriented instruction on students' conceptual understanding and attitudes towards simple electricity. *International Journal of Science and Mathematics Education*, 21, 1567–1589. <https://doi.org/10.1007/s10763-022-10319-w>

- Timothy, V., Watzka, B., Stadler, M., Girwidz, R., & Fischer, F. (2023). Fostering preservice teachers' diagnostic competence in identifying students' misconceptions in physics. *International Journal of Science and Mathematics Education*, 21, 1685–1702. <https://doi.org/10.1007/s10763-022-10311-4>
- Wells, J., Henderson, R., Stewart, J., Stewart, G., Yang, J., & Traxler, A. (2019). Exploring the structure of misconceptions in the Force Concept Inventory with modified module analysis. *Physical Review Physics Education Research*, 15(2), 1-18. <https://doi.org/10.1103/PhysRevPhysEducRes.15.020122>
- Wells, J., Henderson, R., Traxler, A., Miller, P., & Stewart, J. (2020). Exploring the structure of misconceptions in the Force and Motion Conceptual Evaluation with modified module analysis. *Physical Review Physics Education Research*, 16(1), 1-16. <https://doi.org/10.1103/PhysRevPhysEducRes.16.010121>
- Wen, Y., Lin, J., Ming, Y., Zhang, J., Wu, X., Bao, L., Yu, K., & Xiao, Y. (2024). Role of inhibition in overcoming interferences of misconception under similar feature saliency: An eye-tracking study of the projectile motion problem. *Physical Review Physics Education Research*, 20(2), 1-21. <https://doi.org/10.1103/PhysRevPhysEducRes.20.020121>
- Wheatley, C., Wells, J., Henderson, R., & Stewart, J. (2021). Applying module analysis to the Conceptual Survey of Electricity and Magnetism. *Physical Review Physics Education Research*, 17(1), 1-18. <https://doi.org/10.1103/PhysRevPhysEducRes.17.010102>