JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

The Profile of Science Misconception Remediation Efforts: A Systematic Literature Review

Putu Nita Kusuma[1*], I Nyoman Suardana[1]

[1] Study Program of Science Education, Postgraduate Program, Universitas Pendidikan Ganesha, Singaraja, Indonesia.

Received: January 13, 2025
Revised: April 29, 2025
Accepted: May 25, 2025
Published: May 31, 2025

Corresponding Author:
Putu Nita Kusuma
putunitakusuma96@gmail.com

DOI: 10.29303/jppipa.v11i5.11201

Abstract: This study aims to describe: the trend of research on improving misconception in science (Physics, Chemistry, Biology), the remediated science concepts, the efforts to remediate science misconceptions. The research method used is systematic literature review (SLR) of the literature from 2019 to present (May 2025) on the Scopus, ERIC, and Google Scholar databases. So far, there has been no comprehensive review of integrated science misconception improvement in Physics, Chemistry, and Biology. The results showed that the trend of science misconception improvement from 2019 to present (May 2025) was mostly conducted in 2023 and was dominated by misconceptions at the high school level. The most remediated misconceptions are on the concept of Physics. The most applied efforts to remediate science misconceptions based on groups of media, models, strategies, methods, and learning approaches respectively are interactive media, conceptual change models, cognitive conflict strategies, refutation text methods, and multiple representative approaches. These remediation efforts can be integrated with each other to design more effective remediation techniques. These findings provide valuable insights for educators and researchers in designing more effective interventions to address science misconceptions at various levels of education, especially high school, and emphasize the importance of integrating various improvement efforts.

Keywords: Biology; Chemistry; Misconceptions; Physics; Remediation

Introduction

Every student has initial knowledge about something which is called preconception (Suparno, 2013). This initial knowledge will be the initial key to successful learning (Suparman et al., 2024) and become a basis for building subsequent new knowledge (Suma et al., 2019). Students interpret a concept personally into a conception (Suyono et al., 2023). The understanding of concept is very fundamental (Setemen et al., 2023). The inability of students to build a complete scientific conception can lead to a state of misconception. Misconceptions are defined as incorrect meanings, incorrect usage, incorrect classification of examples, and incorrect hierarchical relationships between concepts which is based on strong self-confidence (Gurel et al., 2017) and also known as cognitive disorder (Mariawan & Parwati, 2018).

Misconceptions occur in students at all levels, especially those with low analytical skills (Surmaini et al., 2021), and especially in science concepts (Hermita et al., 2024) which includes concepts of Physics, Chemistry, and Biology. Misconceptions that occur in students indicate low student understanding. The low level of students' understanding of science can be seen from the results of the analysis of PISA 2022, namely that most students in Indonesia are at level 2 and below, which is limited to only being able to explain scientific phenomena and draw conclusions from simple phenomena (OECD, 2023). The decline in PISA results in science is likely influenced by misconceptions among students.

How to Cite:
Kusuma, P. N., & Suardana, I. N. (2025). The Profile of Science Misconception Remediation Efforts: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 73–85. https://doi.org/10.29303/jppipa.v11i5.11201

Various forms of science in field of Physics, Chemistry, and Biology misconceptions have been revealed in various studies. Misconceptions are a serious problem in learning that not only affects one understanding of the material but will continue this wrong understanding to the next material (Juita et al., 2023). Misconceptions cause students to be lazy to learn (Resbiantoro et al., 2022; Rokhim et al., 2023), decline in learning outcomes (Maharani et al., 2019), and influences decision-making ability (Díaz et al., 2020; Putri et al., 2021). Misconceptions in Physics, Chemistry, and Biology subject come from various causes which are generally caused by intuition (Sudiatmika & Subagia, 2022), teacher (Kismiati & Hutasoit, 2024; Maknun & Marwiah, 2022; Margunayasa et al., 2021; Rahmadani et al., 2023; Redhana et al., 2018), context (Rahmadani et al., 2023), learning resources (Astuti et al., 2023; Maharani et al., 2019; Suhendi & Ardiansyah, 2021; Winarni et al., 2024) and abstract concepts (Sudiatmika & Subagia, 2022; Suhendi & Ardiansyah, 2021).

One of the characteristics of misconceptions is that they are resistant to change (Díaz et al., 2020; Parwati & Suharta, 2020). These indicate that remediation of students' misconceptions is important to be carried out as early as possible to prevent resistance from continuing into the next level of education (Hermita et al., 2024; Kismiati & Hutasoit, 2024), moreover, each individual can experience different misconceptions even on the same topic (Haidar et al., 2020).

Reducing misconceptions requires appropriate tools and strategies because conventional learning is not suitable for remediating misconceptions (Mimanah et al., 2020). In practice, teachers tend to ignore learners' alternative concepts (Redhana et al., 2017), so that misconceptions are not identified and not remediated properly. Because misconceptions are a serious problem, a comprehensive understanding of remediation efforts is important, therefore, to provide an in-depth understanding of this, a comprehensive literature review of integrated science misconception remediation efforts in Physics, Chemistry, and Biology is necessary to provide a comparison of interventions in each of the three science topics. Reviews of previous misconception remediation have been conducted but at limited by Islamiyah et al. (2022) on chemistry misconceptions; Ogundare et al. (2024) on biology misconceptions; Rahmadani et al. (2023) that reviewed the profile, causes, and remediation of biology misconceptions; Resbiantoro et al. (2022) that reviewed the profile, causes, and remediation of physics misconceptions; and Pebriani et al. (2024) that reviewed the remediation of impulse and momentum misconceptions. The reviews that have been done before have a limitation, namely targeting misconceptions in one field of science only so that it has not provided a comprehensive comparison of the suitability of remediation efforts for science topics in Physics, Chemistry, and Biology directly. So far, a review of science misconception remediation efforts in terms of physics, chemistry, and Biology subject simultaneously has never been done. As a step to fill this gap, the research was initiated to present misconception improvement efforts in terms of integrated science in Physics, Chemistry, and Biology as well as comprehensively. This review will contribute to the field of science education, especially to provide a comparison in curative way in overcoming students' science (Physics, Chemistry, and Biology) misconceptions. Based on the explanation that has been presented, this research aims to describe: the trend of research on improving misconception in science (Physics, Chemistry, Biology), the remediated science concepts, and the efforts to remediate science misconceptions.

Method

The method used in this research is Systematic Literature Review (SLR). SLR was chosen as the research method because it is appropriate to answer the research questions through literature study of various relevant articles in a scientific, systematic and comprehensive manner. Systematic Literature Review (SLR) is a systematic step in collecting, critically evaluating, integrating, and presenting the findings of various research results on research problems or topics (Pati & Lorusso, 2017). The SLR applies a series of steps in methodically reviewing a variety of relevant studies (Rivera et al., 2022). The SLR steps applied in this study adopted the SLR framework from Mengist et al. (2020) namely PSALSAR (Protocol, Search, Appraisal, Synthesis, Analysis, and Report). The PSALSAR framework was chosen because it can accommodate the overall objectives of this SLR research by providing detailed and systematic steps starting from the problem formulation stage, articles search, articles evaluation, synthesis and analysis of findings from each article, to the final stage of reporting the results of the review. The research steps are provided in Figure 1.

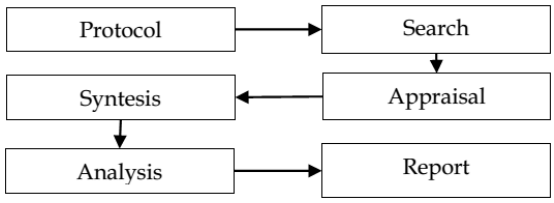

Figure 1. The research steps

Research Stage 1-Protocol

At this stage, the formulation of the research problem was carried out. The formulation of the research question is as follows:

RQ1. What is the trend of research on remediation of science (Physics, Chemistry, and Biology) misconceptions from 2019 to present (May 2025)?
RQ2. What are the science (Physics, Chemistry, and Biology) concept that are remediated?
RQ3. What efforts are implemented to remediate science (Physics, Chemistry, and Biology) misconceptions?

Research Stage 2-Search

This stage includes the article search strategy through the specified database and determining the inclusion criteria for eligible articles. The article search process in this study is sourced from the Scopus, ERIC, and Google Scholar databases. Scopus, ERIC, and Google Scholar databases were chosen because they contain accredited journals that are accessible to support this research. The articles search process uses the Publish or Perish application. The inclusion criteria for articles that will meet the eligible criteria are: the scope of the research article is the remediation of students' science misconceptions in science fileld as in Physics, Chemistry, and Biology; the publication year is from 2019 to present (May 2025); articles published in reputable international journals indexed by Scopus or national journals indexed by Sinta 1, Sinta 2, or Sinta 3; full-text and open access articles; article must be from journals and not in the form of conference proceedings/books/review articles/meta-analyses; and articles must be in English. All of these eligibility criteria are rationally arranged so that the research data analyzed is of high quality, valid, and accommodates the research objectives.

Research Stage 3-Appraisal

This stage includes determining eligible studies based on the established inclusion and quality assessment criteria. In the initial stage, an article search was conducted using the keywords "misconception remediation" and "misconception reduction". These keywords were used to obtain articles that specifically remediate misconceptions, and then the articles were sorted according to the research objectives, namely the scope of misconceptions in Science (Physics, Chemistry and Biology). The application of these keywords resulted in a total of 1,516 articles (665 articles from the ERIC database, 351 articles from the Scopus database, and 500 articles from the Google Scholar database). After eliminating duplicate articles, articles published before 2019, articles in the form of review articles, conference proceedings, books, and meta-analyses, the number of literatures was reduced to 1,401 which entered the title and abstract screening stage. After eliminating articles based on the suitability of the title and abstract, the number of articles was reduced to 101 articles which entered the full text reading stage. In the end, as much 36 articles were obtained that met the inclusion criteria and were used in this SLR. The stages of aticles selection are shown in the PRISMA diagram in Figure 2.

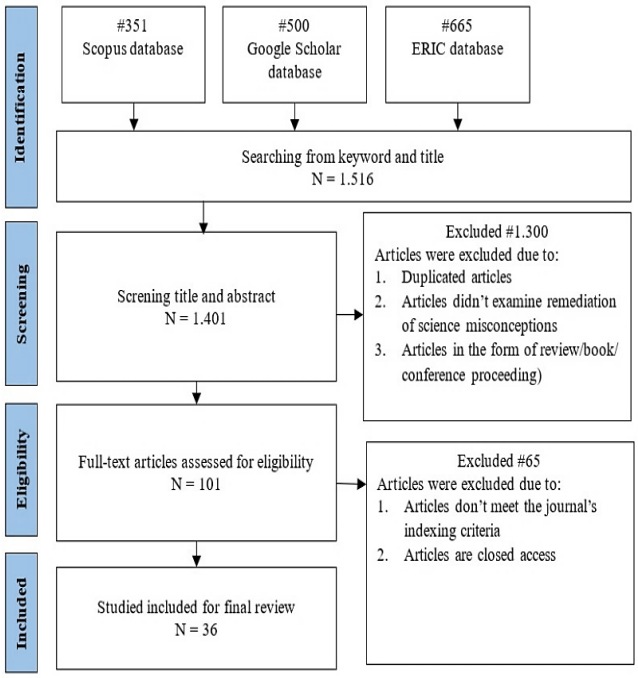

Figure 2. PRISMA diagram inspired by Mengist et al. (2020) and Moher et al. (2009)

At the Appraisal stage, researchers obtained 36 articles from reputable international journals and national journals published in the period 2019 to May 2025. A summary of the research articles that entered the synthesis stage is shown in Table 1.

Table 1. Article Screening Results used in Systematic Literature Review

Authors	Article code	Journal (Index)
Afriwardani et al. (2023)	A1	Jurnal Penelitian Pendidikan IPA (S2)
Akhsan et al. (2023)	A2	Jurnal Penelitian Pendidikan IPA (S2)
Anisah et al. (2023)	A3	Journal of Biology Education (S3)
Busyairi et al. (2021)	A4	Jurnal Penelitian Pendidikan IPA (S2)
Djudin (2021)	A5	Journal of Turkish Science Education (Q2)
Erna et al. (2021)	A6	Journal of Education and Learning (EduLearn) (S1)
Haidar et al. (2020)	A7	Jurnal Pendidikan IPA Indonesia (Q3)
Halim et al. (2020)	A8	Jurnal Penelitian dan Pengembangan Pendidikan Fisika (S2)
Halim et al. (2021)	A9	Education sciences (Q1)

Authors	Article code	Journal (Index)
Haryono et al. (2024)	A10	Jurnal Pendidikan IPA Indonesia (Q3)
Haryono et al. (2024)	A11	Jurnal Penelitian Pendidikan IPA (S2)
Hermita et al. (2024)	A12	Quality Assurance in Education (Q2)
Ibrahim et al. (2022)	A13	BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan (S2)
Jeharut et al. (2020)	A14	Jurnal Ilmu Pendidikan (JIP) (S2)
Mimanah et al. (2020)	A15	International Journal of Recent Educational Research (S2)
Makhrus et al. (2023)	A16	Jurnal Penelitian Pendidikan IPA (S2)
Maknun et al. (2022)	A17	Journal of Technical Education and Training (Q3)
Mufida et al. (2023)	A18	Jurnal Penelitian Pendidikan IPA (S2)
Mufit et al. (2023)	A19	Journal of Turkish Science Education (Q2)
Mukramah et al. (2023)	A20	Jurnal Penelitian Pendidikan IPA (S2)
Nasrudin et al. (2020)	A21	Jurnal Pendidikan IPA Indonesia (Q3)
Ningrum et al. (2022)	A22	Jurnal Penelitian Pendidikan IPA (S2)
Novita et al. (2024)	A23	Revista de Gestão Social e Ambiental (Q3)
Nurahman et al.(2022)	A24	Journal of Biology Education (S3)
Ozdemir (2022)	A25	Journal of Science Learning (S2)
Pardiyanto et al. (2021)	A26	Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education) (S2)
Rafika et al. (2023)	A27	Jurnal Penelitian Pendidikan IPA (S2)
Samsudin et al. (2024)	A28	Journal of Turkish Science Education (Q2)
Sani et al. (2025)	A29	Jurnal Penelitian Pendidikan IPA (S2)
Siong et al. (2023)	A30	Participatory Educational Research (PER) (Q3)
Syahrial et al. (2023)	A31	Journal Of the Serbian Chemical Society (Q3)
Taqwim et al. (2022)	A32	Jurnal Inovasi Pendidikan IPA (S2)
Virtayanti et al. (2020)	A33	JTK: Jurnal Tadris Kimiya (S2)
Weingartner et al.(2019)	A34	Contemporary Educational Psychology (Q1)
Winarni et al. (2024)	A35	Journal of Turkish Science Education (Q2)
Zulfira et al. (2024)	A36	Jurnal Penelitian Pendidikan IPA (S2)

Quality Assesment Criteria

Each data from the articles analyzed in this SLR study was evaluated using the following criteria based on the quality assessment (QA) questions as follows.

QA1. Do the studies clearly state the research problem and objectives?

QA2. Do the studies accommodate the entire meta data parameter required for data extraction?

Research Stage 4-Synthesis

This stage includes the data extraction stage from each study to produce discussions and conclusions. Specific parameters were set up for data extraction such as year of publication, research approach, participants, misconception remediation efforts, remediated Physics, Chemistry, and Biology concepts, results and findings of the article, as well as challenges and obstacles in implementing a remediation effort. The synthesized is presented in the form of diagrams and graphs as the final results.

Research Stage 5-Analysis

This stage includes evaluating the results of data synthesis into meaningful information by answering research questions in narrative form both qualitatively and quantitatively. The variables analyzed were trends in science (Physics, Chemistry, and Biology) misconception remediation research in terms of publication year, education level, topics remediated, and the effectiveness of each remediation effort.

Research Stage 6-Report

This stage includes a complete description of the research results and presenting the results in the form of a journal article.

Result and Discussion

Based on 36 articles synthesized and analyzed, the review results based on research trends by publication year, research subjects, topics that are remediated, and efforts applied to overcome misconceptions

Research Trends on Remediation of Science (Physics, Chemistry, Biology) Misconceptions in Term of Publication Year

The representation of science misconception remediation research based on publication year is shown in Figure 3. Figure 3 explains the trend in the number of publications of articles on the theme of remediation of science misconceptions from 2019 to present (May 2025). Based on the results of the synthesis, since 2019 to 2023 the number of articles on remediation of science misconceptions has increased. The highest increase was in 2020 and followed by 2023. The most reviewed articles were articles published in 2023. This is relevant because

2023 is the year after the Covid-19 pandemic so that stakeholders in the field of education are making efforts to restore the learning situation including remediate misconceptions as an impact of learning loss during the Covid-19 pandemic (Dewi & Wulandari, 2021). The number of publications on remediation of science misconceptions after 2023 experienced a significant decline, until May 2025 only one study was found to be fully accessible.

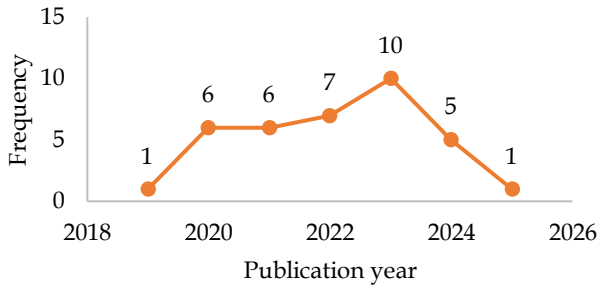

Figure 3. Research representation based on publication year

Research Trends on Remediation of Science (Physics, Chemistry, Biology) Misconceptions in Term of Research Subject

The synthesis results based on research subjects are shown in Figure 4.

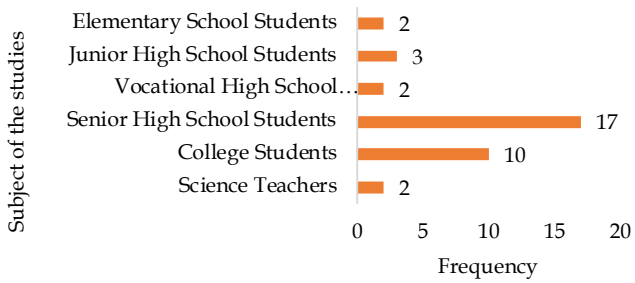

Figure 4. Subjects of science misconception remediation research

Based on the data in Figure 4, the subjects of remediation of Science (Physics, Chemistry, and Biology) misconceptions start from elementary school education levels to teachers in school. Remediation of misconceptions in elementary school students is carried out with a scaffolding-integrated inquiry learning model (Haidar et al., 2020) and inquiry learning media with flashcards (Mimanah et al., 2020). The remediation of misconceptions in junior high school students was conducted with the SSCS learning model (Taqwim et al., 2022), dry lab based augmented reality (Akhsan et al., 2023), and comic-based e-module (Mukramah et al., 2023). Misconception remediation in vocational high school subjects conducted with virtual anatomy system (Winarni et al., 2024) and conceptual change model based on virtual simulation media (Maknun & Marwiah, 2022)

Misconception remediation in senior high school student conducted with interactive e-books (Afriwardani et al., 2023), concept attainment learning model (Anisah & Saptono, 2023), refutation text with 3-2-1 reading strategy (Djudin, 2021), interactive e-module (Erna et al., 2021), 6e learning cycle integrated cognitive conflict (Jeharut et al., 2020), cognitive conflict-based learning (Ningrum et al., 2022), P2OC2R learning model (Nurahman & Susantini, 2022), generative learning strategy (Pardiyanto & Winarti, 2021), ISLE-based worksheet (Rafika et al., 2023), conceptual change model based on PDEODE*E task (Samsudin et al., 2024) concept cartoon-based worksheet (Siong et al., 2023), structured test-based worksheet (Virtayanti & Rohmah, 2020), interactive media based on VBA Excell Spreadsheet (Zulfira et al., 2024), computer simulation on refutation text (CoSiReT) (Mufida et al., 2023), e-learning based collaborative learning (Haryono et al., 2024; Haryono et al., 2024), and synectics learning model assisted by mind mapping (Sani et al., 2025).

Remediation of misconceptions in college students is carried out with the conceptual change model (CCM) (Makhrus et al., 2023), multiple representative approach (Busyairi et al., 2021), CCM based on hybrid learning, (Hermita et al., 2024), refutation text (Weingartner & Masnick, 2019), animated concept cartoon (Ozdemir, 2022), worksheet representation-metacognitive reinforcement CCM (Novita et al., 2024), teaching materials based on metacognitive skills (Nasrudin & Azizah, 2020), cognitive conflict based learning (Mufit et al., 2023), narrative feedback (Halim et al., 2021), and e-modules based on PhET simulation media (Halim et al., 2020). Remediation of misconceptions in elementary school science teacher was carried out with the P2OC2R learning model (Ibrahim & Sunanto, 2022b) and senior high school chemistry teachers with congnitive conflict interviews (Syahrial et al., 2023).

These results prove that misconceptions can occur in everyone and at all levels, even professional careers (Ogundare et al., 2024). Misconception remediation is mostly done on high school students and followed by college students. The high trend of misconception remediation in high school students and college students is because in these two subjects the level of misconceptions is getting higher due to the increasing complexity of the material, the accumulation of misconceptions from previous education levels that are resistant to change, long-lasting, and deeply rooted (Soeharto & Csapó, 2022). Based on this data, it can be said that misconception remediation has been carried from the lowest level of education, namely elementary school, even to the career level of a teacher. This is

supporting evidence that misconceptions are prone to persisting for a long time, are resistant and carried over to the next level of education (Haidar et al., 2020; Juita et al., 2023). Misconceptions experienced by teachers must be eliminated immediately because they cause a snowball effect which will increase the number of other people experiencing misconceptions (Ibrahim & Sunanto, 2022).

The Topics of Science (Physics, Chemistry, Biology) that are Remediated

Based on the synthesis results, there are various topics on Science (Physics, Chemistry, and Biology) that are given misconception remediation treatment. The topics that experienced misconceptions and were given remediation treatment are shown in Table 2.

Table 2. Topic Analyzed in Studies

Science Topics	Article Code	Science Field
Simple harmonic motion	A1	Physics
Solar system	A2	Physics
Blood circulatory system	A3	Biology
Straight motion	A4	Physics
Buoyancy concept	A5	Physics
Salt hydrolysis	A6	Chemistry
Light concept	A7, A15	Physics
Modern physics concept	A8	Physics
Free-fall motion	A9	Physics
Heat concept	A10, A11, A12	Physics
Living things, light, forces and celestial bodies	A13	Biology and Physics
Acid-base concept	A14, A22	Chemistry
Vibration and waves	A16	Physics
Transverse waves	A18	Physics
Static fluid concept	A17, A19, A29	Physics
Newton's law concept	A20, A26, A34	Physics
Energetic	A21	Chemistry
Chemical equilibrium	A23	Chemistry
Fungi	A24	Biology
Sentrifugal force	A25	Physics
Parabola motion	A27	Physics
Force concept	A28	Physics
Electricity concept	A30	Physics
Covalent bond	A31	Chemistry
Work and energy	A32	Physics
Stoikiometry	A33	Chemistry
Reproduction system	A35	Biology
Traveling wave	A36	Physics

Based on the remediated science concepts in Table 2, it can be seen that the dominant remediated Science concepts are in Physics namely 25 articles (69%), in Chemistry namely 7 articles (19%), in Biology namely 3 articles (8%), and in combination of Physcis and Biology only 1 article (3%). The results of the synthesis obtained that research on efforts to remediate science misconceptions from 2019 to present (May 2025) was dominated by the concept of Physics. This is in line with Soeharto et al. (2019) which found that the subject of Physics is the field of science study with the highest level of misconceptions experienced by students. This phenomenon is also supported by the many abstract concepts in the field of Physics which contribute to the high level of misconceptions (Sani et al., 2025).

Efforts to Remediate Science (Physics, Chemistry, Biology) Misconceptions

Based on the synthesis of 36 articles, there are several efforts implemented to remediate Science (Physcis, Chemistry, and Biology) misconceptions. There are stand-alone efforts and some are integrated with other techniques. Efforts to remediate Science misconceptions were categorized based on the application of learning approaches, learning strategies, learning models, learning methods and learning media as shown in Table 3.

Table 3. Efforts Applied to Remediate Science (Physics, Chemistry, and Biology) Misconceptions

Categories	Percentage (%)	Remediation efforts (Article code)
Applying learning approaches	3	Multiple-Representation approaches (A4)
Applying learning methods	11	Narrative feedback (A9)
		Refutation text (A34)
		Computer simulation on refutation text (CoSiReT) (A18)
		Refutation text- 3-2-1 reading strategy (A5)
Applying learning strategies	14	Generative learning strategy (A26)
		Cognitive conflict learning strategy (A19, A22)
		Cognitive conflict - 6e learning cycle (A14)
		Cognitive conflict - interview (A31)
Applying learning models	28	Conceptual Change Model (CCM) (A16
		CCM - virtual simulation (A17)
		CCM - hybrid, blended, and face-to-face learning (A12)
		CCM - PDEODE*E tasks (A28)
		Concept Attainment Model (CAM) (A3)
		Inquiry learning - scaffolding (A7)
		SSCS (Search, Solve, Create, and Share) model (A32)
		P2OC2R model (A13, A24)
		Synectics model - mind mapping (A29)
Applying learning media	44	Worksheet – structured test (A33)
		Worksheet – metacognitive skill (A21)
		Worksheet - Representation-Metacognitive Reinforcement CCM (A23)
		Worksheet - ISLE (Investigative Science Learning Environment) (A27)
		Worksheet – cartoon concept (A30)
		Interactive e-book (A1)
		Inquiry media - flashcard (A15)
		Animated concept cartoon (A25
		Visual Basic for Application (VBA) Excel Spreadsheet (A36)
		Media Virtual Anatomy System (VAS) (A35)
		Interactive e-module (A6)
		E-module - PhET simulation (A8)
		E-modul – comic (A20)
		E-learning collaborative-based learning (A10, A11)
		Dry lab - augmented reality (A2)

Based on Table 3, the three most widely applied efforts to remediate misconceptions consecutively are learning media, learning models and learning strategies. The other efforts that are least used are the learning approach. Learning media is the most widely applied effort. This is because media based on virtual experiments, simulations, and animations can strengthen the process of reconstructing scientific concepts (Mardana & Yasa, 2021). Physics misconceptions were overcome by applying multiple representative approach; refutation text and narrative feedback learning methods; generative learning strategy and cognitive conflict strategy; P2OC2R and CCM learning models integrated with virtual simulation, hybrid learning, and PDEODE*E tasks; synectics learning models; worksheets integrated with ISLE models, cartoon concepts; interactive media; and e-modules. Based on these, it can be said that the majority of learning media, learning models, learning strategies, learning methods, and learning approaches are suitable for overcoming Physics misconceptions.

Chemistry misconceptions were overcome by applying interactive e-module media; worksheets integrated with CCM, metacognitive skills, and structured tests; and cognitive conflict strategies integrated with interviews and 6e learning cycle. Based on these, it can be said the application of learning strategies and learning media is suitable for overcoming Chemistry misconceptions. Biology misconceptions were overcome by applying the concept attainment model, P2OC2R model, and virtual anatomy simulation. based on these results, in can be said that the application of learning models and learning media is suitable for overcoming Biology misconceptions. In general, Physics, Chemistry and Biology misconception remediation studies have been able to overcome students' misconceptions with varying levels of reduction. The effectiveness of the most applied efforts is discussed through groups of learning media, learning models, learning strategies, learning methods, and learning approaches.

The most widely applied learning media group is interactive media (8 out of 16 studies). Various types of

interactive media were developed and applied to reduce misconceptions on various topics. Interactive media group including augmented reality-based dry lab that effectively reduces 45.16% of misconceptions on the topic of solar system (Akhsan et al., 2023). Interactive e-book that effectively reduces 11.00% misconceptions on the topic of simple harmonic motion (Afriwardani et al., 2023). Flashcard-based inquiry learning media that effectively reduces 70.00% of misconceptions on the topic of light (Mimanah et al., 2020). Animated concept cartoon that effectively reduces 15.80% of misconceptions on the topic of centrifugal force (Ozdemir, 2022). Interactive learning based on VBA (Visual Basic for Application) that is effective in reducing 60.00% of misconceptions on the topic of traveling waves (Zulfira et al., 2024), Virtual Anatomy System (VAS) that effectively reduces misconceptions with n-gain of 0.67 on the topic of reproduction system (Winarni et al., 2024), and e-learning collaborative based learning effectively reduce misconceptions by 58.45% (Haryono et al., 2024) and 26.5% (Haryono et al., 2024) on heat concept.

Learning models become the second highest effort applied to remediate Science misconceptions. The most applied learning model is the Conceptual Change Model (4 out of 10 learning models). CCM presents confusing phenomena and ends up proving that scientific conceptions can be used to solve problems that conflict with initial conceptions (Makhrus et al., 2023). CCM is effective in reducing 70.22% of misconceptions on the topic of vibration and waves (Makhrus et al., 2023). CCM-hybrid learning can reduce 90.32% of misconceptions on heat concept (Hermita et al., 2024). CCM can be integrated with other efforts such as CCM-Virtual PhET simulation able to reduce misconceptions on static fluid concept with an average score of 0.79 with a high category (Maknun & Marwiah, 2022); and CCM-PDEOD*E tasks that effectively reduce 34.50% misconceptions on force concept (Samsudin et al., 2024).

The third efforts that is most widely applied is learning strategies. The most widely applied learning strategy is the cognitive conflict strategy (3 out of 4 learning strategies). Cognitive conflict strategy accommodates misconceptions that conflict with scientific concepts to reconstruct new concept (Haryono et al., 2021). Cognitive conflict strategies effectively reduce 16.50% misconceptions on static fluid concept (Mufit et al., 2023). The results of another study found that the cognitive conflict strategy was effective in reducing 71.28% of misconceptions on acid-base concept (Ningrum et al., 2022) and cognitive conflict strategy-6e learning cycle are effective in reducing 14.00% of misconceptions also on acid-base concept (Jeharut et al., 2020). Cognitive conflict strategy applied in the form of interviews is effective in reducing 89.00% of misconceptions on the topic of covalent bonds (Syahrial et al., 2023). Although the cognitive conflict is effective for remediating misconceptions, there is one disadvantage that requires a relatively long time in synchronizing misconceptions (Parwati & Suharta, 2020).

The fourth efforts that is most widely applied is learning methods. The most widely used learning method is refutation text (3 out of 4 learning methods). Refutation texts remediate misconceptions with the help of texts that contain contradictory information and place misconceptions as a basis until dissatisfaction, cognitive imbalance, and cognitive conflict occur (Mufida et al., 2023). Refutation text integrated with the 3-2-1 reading strategy is effective in reducing 54.71% of misconceptions on Buoyancy concept (Djudin, 2021). Another study found that refutation text was effective in reducing 78.34% of misconceptions on Newton's law concept (Weingartner & Masnick, 2019). Refutation text can be integrated with computer simulation called CoSiReT that effectively reduces 80.75% of misconceptions on the topic of transverse waves (Mufida et al., 2023). Refutation texts involve an effective reading strategy in correcting misconceptions because reading strategies make learners realize understandings that are contrary to scientific concepts so that changes in conception occur (Suma et al., 2019).

The learning approach was the least implemented intervention (1 study), namely the multiple representative approach. The multi-representative approach can reduce misconceptions by facilitating the explanation of material in various forms such as words, visualization with pictures, equations, analogies, and graphs so that students' understanding becomes more comprehensive (Busyairi et al., 2021). This approach effectively reduced 55.76% of misconceptions on the topic of straight motion. It is in line that the multi-representative can improve understanding becomes more comprehensive and avoids misconceptions again (Suarsana et al., 2019). Misconception remediation efforts do not necessarily reduce the overall misconceptions. This can be seen from the percentage of the misconceptions reduction that none of the studies reached 100% reduction. Although the majority of studies did not explicitly or implicitly explain the challenges and obstacles in implementing misconception remediation efforts, some mentioned challenges in this effort. These challenges and obstacles include varying levels of reading and comprehension as well as students' disinterest in Physics (Djudin, 2021). Another challenge is the difficulty in making hypotheses, analyzing data, drawing conclusions, and difficulty in filling out the worksheet so that it takes a long time (Mimanah et al., 2020). The lack of success in remediating some of the misconceptions is also due to

the fact that it takes a relatively longer time to change misconceptions and misunderstandings into scientific conceptions (Nasrudin & Azizah, 2020; Syahrial et al., 2023). Implementing online remediation due to the Pandemic is also one of the challenges in remediating misconceptions (Taqwim et al., 2022). Despite these challenges and obstacles, all efforts to overcome misconceptions from the analyzed studies, most of the processes emphasize cognitive conflict which is an absolute requirement for reconstructing concepts from misconceptions to scientific concepts.

Conclusion

Misconceptions are a barrier in scientific learning and difficult to change, so efforts to remediate misconceptions are necessary. Based on the review, the research trend of Science (Physics, Chemistry, and Biology) misconception remediation efforts from 2019 to present (May 2025) was mostly conducted in 2023 and was dominated by misconceptions at the high school level. The most remediated misconceptions are on the concept of Physics, because there are many abstract concepts that require direct proof activities. The most applied efforts to remediate misconceptions are learning media, this is because learning media can be packaged interactively to strengthen the process of reconstructing scientific concepts. The order of the most applied efforts based on groups of media, models, strategies, methods, and learning approaches consecutively are interactive media, conceptual change model, cognitive conflict learning strategy, refutation text method, and the least applied is the multiple representative approach. All of these misconception remediation efforts can be integrated with each other to design more effective improvement efforts. The limitation of this study is that not all studies explain the obstacles in efforts to correct misconceptions, so the analysis of challenges and obstacles has not described the situation of all the studies analyzed. Recommendations for future research are that in addition to explaining the steps and results of misconception reduction, it is also important to explain the challenges and obstacles in implementing a misconception remediation effort.

Acknowledgments
The authors are grateful to Jurnal Penelitian Pendidikan IPA for publishing this article.

Author Contributions
P. N. K conducting research; I N. S reviewed the manuscript. All authors have read and approved the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest in writing this article.

References

Afriwardani, P., Jumadi, & Pribadi, F. O. (2023). Development of interactive physics e-book to reduce student misconception. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2018–2024. https://doi.org/10.29303/jppipa.v9i4.1854

Akhsan, H., Yusup, M., Ariska, M., Husna, T., & Sari, D. K. (2023). Effectiveness of dry lab based augmented reality to overcome the misconceptions of students on solar system and eclipse learning topics. *Jurnal Penelitian Pendidikan IPA*, *9*(Special Issue), 37–43. https://doi.org/10.29303/jppipa.v9ispecialissue.6198

Anisah, C. N., & Saptono, S. (2023). Implementation of the concept attainment learning model to increase independence and reduce misconceptions of MA students on the circulatory system learning material. *Journal of Biology Education*, *12*(2), 217–229. https://doi.org/10.15294/jbe.v12i2.70164

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

Busyairi, A., Doyan, A., Harjono, A., Sutrio, & Gunada, I. W. (2021). Implementation of multiple-representation approaches based on e-module to reduce misconceptions of prospective physics teachers during the covid-19 pandemic. *Jurnal Penelitian Pendidikan IPA*, *7*(Special Issue), 158–167. https://doi.org/10.29303/jppipa.v7ispecialissue.970

Dewi, E. P., & Wulandari, F. (2021). Identification of misconceptions in science learning during the covid-19 pandemic using the CRI (certainty of response index) method for primary school students. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 145–150. https://doi.org/10.29303/jppipa.v7ispecialissue.876

Díaz, C. V., Bustamante, K., Pinto, L., & Cofré, H. (2020). Exploring Chilean seventh grade students' conceptions of Earth dynamics before and after model- and inquiry-based instruction. *Journal of Geoscience Education*, *68*(4), 360–370. https://doi.org/10.1080/10899995.2020.1725406

Djudin, T. (2021). Promoting students' conceptual change by integrating the 3-2-1 reading technique with refutation text in the physics learning of

buoyancy. *Journal of Turkish Science Education*, *18*(2), 290–303. https://doi.org/10.36681/tused.2021.66

Erna, M., Anwar, L., & Mazidah. (2021). Interactive e-module using zoom cloud meeting platform to reduce misconceptions on salt hydrolysis material. *Journal of Education and Learning (EduLearn)*, *15*(2), 283–290. https://doi.org/10.11591/edulearn.v15i2.18460

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2017). Development and Application af A Four-Tier Test to Assess Pre-Service Physics Teachers' Misconceptions about Geometrical Optics. *Research in Science and Technological Education*, *35*(2), 238–260. https://doi.org/10.1080/02635143.2017.1310094

Haidar, D. A., Yuliati, L., & Handayanto, S. K. (2020). The effect of inquiry learning with scaffolding on misconception of light material among fourth-grade students. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 540–553. https://doi.org/10.15294/jpii.v9i4.22973

Halim, A., Mahzum, E., Yacob, M., Irwandi, I., & Halim, L. (2021). The impact of narrative feedback, e-learning modules and realistic video and the reduction of misconception. *Education Sciences*, *11*(4), 1–14. https://doi.org/10.3390/educsci11040158

Halim, A., Soewarno, S., Elmi, E., Zainuddin, Z., Huda, I., & Irwandi, I. (2020). The Impact of the E-Learning Module on Remediation of Misconceptions in Modern Physics Courses. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *6*(2), 203–216. https://doi.org/10.21009/1.06207

Haryono, H. E., Aini, K. N., Samsudin, A., & Siahaan, P. (2021). Reducing the students' misconceptions on the theory of heat through cognitive conflict instruction (CCI). *AIP Conference Proceedings*, *2330*, 050001. https://doi.org/10.1063/5.0043400

Haryono, H. E., Jatmiko, B., Prahani, B. K., Zayyadi, M., Kaniawati, I., & Kurtulus, M. A. (2024). E-learning-based collaborative as an effort to reduce high school student' misconception of heat. *Jurnal Pendidikan IPA Indonesia*, *13*(4), 538–550. https://doi.org/10.15294/jpii.v13i4.13222

Haryono, H. E., Zayyadi, M., Marzuqi, I., & Kaniawati, I. (2024). The effectiveness of collaborative e-learning-based learning in reducing student misconceptions on heat in east java high schools during merdeka belajar. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4543–4550. https://doi.org/10.29303/jppipa.v10i8.8179

Hermita, N., Erlisnawati, Alim, J. A., Putra, Z. H., Mahartika, I., & Sulistiyo, U. (2024). Hybrid learning, blended learning or face-to-face learning: which one is more effective in remediating misconception? *Quality Assurance in Education*, *32*(1), 64–78. https://doi.org/10.1108/QAE-02-2023-0019

Ibrahim, M., & Sunanto. (2022a). Identification and remediation of science misconceptions in elementary school teachers using the P2OC2R model. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *4*(3), 343–350. https://doi.org/10.20527/bino.v4i3.14359

Islamiyah, K. K., Rahayu, S., & Dasna, I. W. (2022). The Effectiveness of Remediation Learning Strategy in Reducing Misconceptions on Chemistry: A Systematic Review. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *7*(1), 63–77. https://doi.org/10.24042/tadris.v7i1.11140

Jeharut, R. R. K., Subandi, S., & Habiddin, H. (2020). Learning cycle-6e and cognitive conflict strategies: The remedial learning to overcome misconceptions. *Jurnal Ilmu Pendidikan*, *26*(1), 29–38. https://doi.org/10.17977/um048v26i1p29-38

Juita, Z., Sundari, P. D., Sari, S. Y., & Rahim, F. R. (2023). Identification of Physics Misconceptions Using Five-tier Diagnostic Test: Newton's Law of Gravitation Context. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 5954–5963. https://doi.org/10.29303/jppipa.v9i8.3147

Kismiati, D. A., & Hutasoit, L. R. (2024). Teacher misconceptions: A phenomenon of the lack of knowledge in science subjects. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3493–3500. https://doi.org/10.29303/jppipa.v10i6.7226

Maharani, L., Rahayu, D. I., Amaliah, E., Rahayu, R., & Saregar, A. (2019). Diagnostic test with four-Tier in physics learning: case of misconception in newton's law material. *Journal of Physics: Conference Series*, *1155*(1). https://doi.org/10.1088/1742-6596/1155/1/012022

Makhrus, M., Susilawati, Wahyudi, Hikmawati, & Sahidu, H. (2023). Reducing misconceptions on the concept of vibration and waves with CCM CCA to improve creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10108–10114. https://doi.org/10.29303/jppipa.v9i11.5204

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

Mardana, I. B. P., & Yasa, P. (2021). Pengaruh model belajar eksperential berbantuan eksperimen virtuil dalam pembelajaran fisika terhadap miskonsepsi siswa. *Jurnal Pendidikan Fisika Undiksha*, *11*(1), 66–74. https://doi.org/10.23887/jjpf.v11i1.47251

Margunayasa, I. G., Dantes, N., Marhaeni, A. A. I. N., & Suastra, I. W. (2021). Reducing misconceptions of elementary school students through guided inquiry learning. *Jurnal Ilmiah Sekolah Dasar*, *5*(4), 729–736. https://doi.org/10.23887/jisd.v5i4.40388

Mariawan, I. M., & Parwati, N. N. (2018). Types of junior high school students errors in science problem solving. *Journal of Physics: Conference Series*, *1040*(1), 1–6. https://doi.org/10.1088/1742-6596/1040/1/012039

Mengist, W., Soromessa, T., & Legese, G. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX*, *7*, 1–11. https://doi.org/10.1016/j.scitotenv.2019.134581

Mimanah, I. I. A., Suryanti, & Suprapto, N. (2020). Development of an inquiry-based science learning material using flash card to reduce misconception of elementary school students. *IJORER : International Journal of Recent Educational Research*, *1*(2), 178–190. https://doi.org/10.46245/ijorer.v1i2.35

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. In *BMJ (Online)* (pp. 1–336). https://doi.org/10.1136/bmj.b2535

Mufida, S. N., Samsudin, A., Suhendi, E., Kaniawati, I., & Novia, H. (2023). CoSiReT: Innovation of ReT (refutation texts) to reduce students' misconceptions concerning transverse waves. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9363–9371. https://doi.org/10.29303/jppipa.v9i11.4544

Mufit, F., Festiyed, Fauzan, A., & Lufri. (2023). The effect of cognitive conflict-based learning (CCBL) model on remediation of misconceptions. *Journal of Turkish Science Education*, *20*(1), 26–49. https://doi.org/10.36681/tused.2023.003

Mukramah, W. A. N., Halim, A., Winarni, S., Yusrizal, Safrida, Jannah, M., & Wahyuni, A. (2023). Effect of using comic-based e-module assisted by the flipbook maker for remediation of newton's law misconceptions. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6384–6392. https://doi.org/10.29303/jppipa.v9i8.4389

Nasrudin, H., & Azizah, U. (2020). Overcoming misconception in energetic topics through implementation of metacognitive skills-based instructional material: A case study in student of chemistry department, Universitas Negeri Surabaya. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 125–134. https://doi.org/10.15294/jpii.v9i1.21630

Ningrum, L. S., Drastisianti, A., Setiowati, H., & Pratiwi, R. (2022). Effectiveness of cognitive conflict-based chemistry learning in reducing students' misconceptions of acid-base materials. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2131–2135. https://doi.org/10.29303/jppipa.v8i4.2092

Novita, D., Suyono, S., & Sutoyo, S. (2024). Analysis of interview results on the remediation process of the dynamic equilibrium concept with the representatio-metacognitive reinforcement conceptual change model (R-MR CCM). *Revista de Gestao Social e Ambiental*, *18*(5), 1–19. https://doi.org/10.24857/rgsa.v18n5-163

Nurahman, A. A., & Susantini, E. (2022). Analysis and remediation of student misconceptions using P2OC2R-based learning model on fungi materials in senior high school. *Journal of Biology Education*, *11*(2), 220–231. https://doi.org/10.15294/jbe.v11i2.56477

OECD. (2023). *PISA 2022 Result: Factsheets Indonesia*. OECD Publishing. Retrieved from https://oecdch.art/a40de1dbaf/C108.

Ogundare, A. A., Bello, G., Gabriel Ademakinwa, A., & Sulaiman, M. M. (2024). Remediating Students' Misconception in biology: A review. *Custech International Journal of Education*, *1*(2), 122–134. Retrieved from http://custechijoe.org.ng

Ozdemir, E. (2022). Animated concept cartoons as a starter for cognitive conflict in online science learning: A case of circular motion. *Journal of Science Learning*, *5*(2), 242–249. https://doi.org/10.17509/jsl.v5i2.41191

Pardiyanto, E., & Winarti. (2021). Generative learning strategy assisted by flash animation to remediate students' misconceptions on newton's law of gravity. *Jurnal Pendidikan Sains Indonesia*, *9*(2), 201–216. https://doi.org/10.24815/jpsi.v9i2.18926

Parwati, N. N., & Suharta, I. G. P. (2020). Effectiveness of the implementation of cognitive conflict strategy assisted by e-service learning to reduce students' mathematical misconceptions. *International Journal of Emerging Technologies in Learning*, *15*(11), 102–118. https://doi.org/10.3991/ijet.v15i11.11802

Pati, D., & Lorusso, L. N. (2017). How to write a systematic review of the literature. *Health Environments Research and Design Journal*, *20*(10), 1–30. https://doi.org/10.1177/1937586717747384

Pebriani, T. U., Mufit, F., Hidayati, & Sari, S. Y. (2024). Systematic review: misconception and remediation on momentum and Impulse. *Pillar of Physics Education*, *17*(2), 85–98. https://doi.org/10.24036/15637171074

Putri, K. L., Suhandi, A., Samsudin, A., & Surtiana, Y. (2021). The development of virtual conceptual change laboratory (VCCLab) for conception reconstruction through lab virtual activity. *Journal of Physics: Conference Series*, *1806*(1).

https://doi.org/10.1088/1742-6596/1806/1/012015

Rafika, D., Rajibussalim, Zaini, N., Yusrizal, & Syukri, M. (2023). ISLE-based learning media development using PhET imulation to reduce misconceptions on parabola motion materials. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10001–10009. https://doi.org/10.29303/jppipa.v9i11.4520

Rahmadani, U., Sundari, P. D., Hidayati, H., & Dewi, W. S. (2023). Systematic review of misconceptions in kinematics: identification, causes, and remediation. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 1274–1283. https://doi.org/10.29303/jppipa.v9i12.4956

Redhana, I. W., Sudria, I. B. N., Hidayat, I., & Merta, L. M. (2017). Identification of chemistry learning problem viewed from conceptual change model. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 356–364. https://doi.org/10.15294/jpii.v6i1.9594

Redhana, I. W., Sudria, I. B. N., Suardana, I. N., Suja, I. W., & Handayani, N. K. N. (2018). Identification of chemistry teaching problems of a prospective teacher: A case study on chemistry teaching. *Journal of Physics: Conference Series*, *1040*(1), 1–7. https://doi.org/10.1088/1742-6596/1040/1/012022

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://doi.org/10.36681/tused.2022.128

Rivera, A. C., Ochoa, W., Larrinaga, F., & Lasa, G. (2022). How-to conduct a systematic literature review: A quick guide for computer science research. *MethodsX*, *9*, 1–12. https://doi.org/10.1016/j.compind.2022.103730

Rokhim, D. A., Widarti, H. R., & Sutrisno, S. (2023). Five-Tier Diagnostic Test Instrument Validation on Reaction Rate Materials: To Identify the Causes of Misconception and Student Representation. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1380–1385. https://doi.org/10.29303/jppipa.v9i3.2952

Samsudin, A., Zulfikar, A., Saepuzaman, D., Suhandi, A., Aminudin, A. H., Supriyadi, S., & Coştu, B. (2024). Correcting grade 11 students' misconceptions of the concept of force through the conceptual change model (CCM) with PDEODE*E tasks. *Journal of Turkish Science Education*, *21*(2), 212–231. https://doi.org/10.36681/tused.2024.012

Sani, N. K., Darmadi, I. W., Nurgan, & Kamaluddin. (2025). The impact of synectics learning model implementation with mind mapping assignments on reducing misconceptions and enhancing students' cognitive learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 835–841. https://doi.org/10.29303/jppipa.v11i1.9274

Setemen, K., Sudirtha, I. G., & Widiana, I. W. (2023). The effectiveness of study, explore, implement, evaluate e-learning model based on project-based learning on the students conceptual understanding and learning agility. *Journal of Technology and Science Education*, *13*(3), 583–596. https://doi.org/10.3926/jotse.1624

Siong, L. C., Tyug, O. Y., Phang, F. A., & Pusppanathan, 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

Soeharto, 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

Soeharto, S., & Csapó, B. (2022). Exploring Indonesian student misconceptions in science concepts. *Heliyon*, *8*(9), 1. https://doi.org/10.1016/j.heliyon.2022.e10720

Suarsana, I. M., Mahayukti, G. A., Sudarma, I. K., & Pujawan, A. A. G. S. (2019). The effect of interactive mathematics learning media toward mathematical conceptual understanding on probability of hearing-impaired students. *Journal of Physics: Conference Series*, *1165*(1). https://doi.org/10.1088/1742-6596/1165/1/012021

Sudiatmika, A. A. I. A. R., & Subagia, I. W. (2022). Profil Miskonsepsi Mahasiswa Prodi S2 Pendidikan IPA pada Materi Optik menggunakan Tes Diagnostik Four Tier Test. *Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya*, *16*(2), 45–52. https://doi.org/10.23887/wms.v16i2.41118

Suhendi, H. Y., & Ardiansyah, R. (2021). Development of HATRADI : a four tier test for diagnostic student misconception in heat transfer concept. *Journal of Physics: Conference Series*, *1918*(2). https://doi.org/10.1088/1742-6596/1918/2/022015

Suma, K., Sadia, I. W., & Pujani, N. M. (2019). Effect of physics module based on activity and conceptual change text on students' conception of static electricity. *Journal of Physics: Conference Series*, *1321*(3). https://doi.org/10.1088/1742-6596/1321/3/032072

Suparman, A. R., Rohaeti, E., & Wening, S. (2024). Development of Computer-Based Chemical Five-Tier Diagnostic Test Instruments: A Generalized Partial Credit Model. *Journal on Efficiency and*

Responsibility in Education and Science, *17*(1), 92–106. https://doi.org/10.7160/eriesj.2024.170108

Suparno, P. (2013). *Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika*. Gramedia Widiasarana Indonesia.

Surmaini, Syafe'I, I., & Diani, R. (2021). An analysis of students' physics misconceptions in online learning using the four-tier diagnostic test with certainty of response index (CRI). *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012099

Suyono, S., Aini, K., & Sanjaya, I. G. M. (2023). The Effectiveness of The Six Tier Diagnostic Test (STDT) Instrument in Viewed from Empirical Validity to Identify Student's Misconceptions in Chemical Equilibrium Materials. *IJORER : International Journal of Recent Educational Research*, *4*(6), 827–836. https://doi.org/10.46245/ijorer.v4i6.413

Syahrial, S., Ilmah, M., Yahmin, Y., Munzil, M., & Muntholib, M. (2023). Remediation of chemistry teachers' misconceptions about covalent bonding using cognitive conflict interviews: A case study. *Journal of the Serbian Chemical Society*, *88*(2), 211–221. https://doi.org/10.2298/JSC220117073S

Taqwim, M. A., Sunarno, W., & Ramli, M. (2022). Remediation using SSCS model for reducing misconceptions about work and energy. *Jurnal Inovasi Pendidikan IPA*, *8*(2), 210–223. https://doi.org/10.21831/jipi.v8i2.49343

Virtayanti, I. A., & Rohmah, R. S. (2020). Effectiveness of structured-worksheet use to reduce student misconceptions in stoichiometry. *JTK (Jurnal Tadris Kimiya)*, *5*(2), 195–203. https://doi.org/10.15575/jtk.v5i2.9873

Weingartner, K. M., & Masnick, A. M. (2019). Refutation texts: Implying the refutation of a scientific misconception can facilitate knowledge revision. *Contemporary Educational Psychology*, *58*, 138–148. https://doi.org/10.1016/j.cedpsych.2019.03.004

Winarni, D. S., Pratama, A., Marianti, A., & Siroj, M. B. (2024). The effect of using a virtual anatomy system of student misconceptions on reproductive system. *Journal of Turkish Science Education*, *21*(4), 723–731. https://doi.org/10.36681/tused.2024.039

Zulfira, R., Halim, A., Khaldun, I., Mahzum, E., Nazar, M., & Kasli, E. (2024). Effect of interactive learning media using visual basic for application excel spreadsheet to reduce misconception in physics learning. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 28–36. https://doi.org/10.29303/jppipa.v10i1.6387