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Misconceptions, Diagnostic Instruments Used and Their Causes in Chemistry Learning: Literature Review

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Abstract: This study aims to analyze and provide an overview of the micsconceptions experienced by students, the diagnostic instruments used and their causes in chemistry learning. The research method used was literature review. The research data consisted of 20 relevant national and international articles in the range of 2019-2025. The articles selected have similar topics of discussion regarding misconception analysis in chemistry learning. The results showed that the research on misconceptions in chemistry learning mostly frequently found in the concept of acid-base and salt hydrolysis, reaction rates and chemical equilibrium, thermochemistry, and chemical bonding. The diagnostic instruments used include two-tier tests, three-tier tests, four-tier tests, five-tier tests, questionnaires, multiple-choice questions and interviews. Factors causing misconceptions are due to internal and external factors. Internal factors include the discrepancy between students' preconceptions and experts' knowledge concepts, while external factors include learning methods and teaching materials used by teachers. In addition, there is no significant difference between the instrument used and the misconceptions found across countries. So that the trend of misconception research is a study that deserves to continue to be developed and researched

Keywords: Causes of misconceptions; Chemistry learning; Diagnostic instruments; Misconceptions

Introduction

Misconception is a state of one's conceptual understanding where there is an error or inconsistency between the concept and scientific understanding (Allen, 2019; Türkoguz, 2020; Üce et al., 2019). Misconceptions occur when a person's knowledge does not match the knowledge of experts. Misconceptions are defined as inaccurate understanding of a concept, inappropriate and incorrect use of concepts, giving classifications of incorrect examples, there is a confusion of concepts against an incorrect concept hierarchy (Soeharto et al., 2019). Misconceptions can take the form of misunderstanding basic concepts, errors in interpreting a concept, and errors in connecting various concepts with related ideas and theories. Misconceptions that occur can be stored in students' cognitive structures of for a long period of time so that it affects the construction of further concept knowledge. This misconception is often a crucial problem, especially in subjects like chemistry.

Chemistry is a branch of science that studies matter, structure, properties, changes and chemical reactions. Chemical representations include macroscopic, submicroscopic, and symbolic. This makes most of the scope of chemistry studies abstract, making chemistry a subject that tends to be difficult for students to understand. Research conducted by Alfitrah et al. (2021) shows that macroscopic to submicroscopic representations are more easily understood by students than symbolic to submicroscopic, macroscopic to symbolic and submicroscopic to symbolic representations. Gkitzia et al. (2020) stated that students' inability to translate one form of representation to

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another is one of the causes of misconceptions in chemistry learning. Research by Shaafi et al. (2025) found that misconceptions exhibt the highest prevalence, namely the universal indicator of strong alkali (71.70%), the calculation related concentrations of acids ad bases (69.30%), and procedural steps for preparing a solution with a specified concentration using the dilution method (65.80%). Research by Rosyidah et al. (2024) found that a profile of misconceptions about thermochemical materials consisting of system and environment sub-concepts, types of systems, endothermic and exothermic reactions, types of enthalpy, as well as changes in reaction enthalpy. About 15.00% of students understood the concept, 31% had misconceptions, and 54% did not understand.

Analysis of misconceptions regarding chemistry learning has been carried out by many researchers, including on the topic of reaction rates and chemical equilibrium (Harahap et al., 2021; Jusniar et al., 2020b; Riddle et al., 2023), the concept of acid base and salt hydrolysis (Horvat et al., 2021; Mubarak et al., 2020; Ningrum et al., 2022; Nurmaya et al., 2021; Yunitasari et al., 2019), thermochemistry (Habiddin et al., 2023; Sihaloho et al., 2021), Chemical bonding (Etokeren et al., 2022; Prodjosantoso et al., 2019; Sari et al., 2023; Setiawan et al., 2020), Atomic concept (Kaya, 2023; Reina et al., 2023). Misconception analysis requires instruments that can be used to reveal the location and causes of misconceptions in depth and detail. Misconception diagnosis instruments include multiple choice, two-tier test, three-tier test, four-tier test, and five-tier test. Valid instruments are essential for identifying misconceptions and helping reduce them. Therefore, it is important to analyze students' misconceptions, the diagnostic instruments used, and their causes.

Based on the background explanation above, this research is important to introduce a novel perpective by analyzing and providing an overview of research trends regarding misconceptions experienced by students, the diagnostic instruments used and their causes in chemistry learning. So that the following research questions are obtained: What is the definition of misconception according to experts? What are the trends of misconception diagnostic instruments used? What are the causes of student misconceptions in chemistry learning in the 2019-2023? and How do misconceptions of chemistry learning in Indonesia and some other countries compare?

Method

This research is a literature study (Hamilton et al., 2021) by reviewing national and international articles that are relevant to the topic of misconceptions in chemistry learning, the diagnostic instruments used, and the causes of miscoceptions. The research data used are articles published in national and international journals in the range of 2019-2025. Data collection is carried out indirectly and in the form of secondary data. Data were analyzed using data analysis techniques from Miles and Huberman which consisted of data reduction, data display, and conclusion drawing/verification data such as Figure 1. Data Reduction has the meaning of summarizing, choosing the main things, focusing on the things that are important, and looking for patterns and themes. It was carried out after collecting data. Data Display is a collection of information that has been arranged, which provides the possibility to draw conclusions and take further action. It is carried out in the form of brief descriptions, flowchart charts and so on. Then, conclusion drawing or verifiying is the last step in the process of data analysis, drawing conclusions is done by finding the meaning of the data that has been presented.

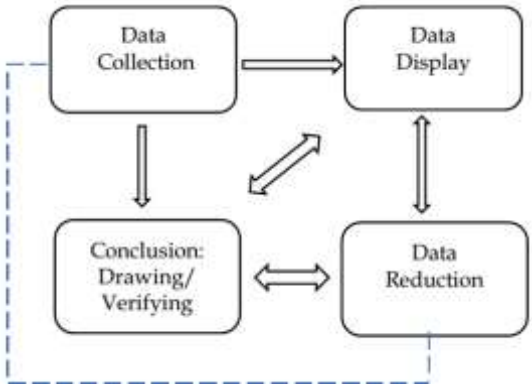

Figure 1. Miles and Huberman data analysis chart

Result and Discussion

The research data is the result of analyzing of national and international research articles relevant to the topic of misconceptions in chemistry learning. The research data are presented in Table 1. The research articles used are articles published in the range of 2019-2025.

Table 1. Relevant Research of Misconceptions on Chemistry Learning

Article Title	Authors	Diagnostic Instrument	Research Results
The Misconceptions Diagnosis on Ionic and Covalent Bonds Concepts with Three Tier Diagnostic Tests	Prodjosantoso et al. (2019)	Three-tier	Students' misconceptions on ionic and covalent bonding material with high (19.05%), medium (42.86%), and low (9.52%) categories
Developing a Five-Tier Diagnostic Test to Identify Students' Misconceptions in Science: An Example of the Heat Transfer Concepts	Anam et al. (2019)	Five-tier	The instrument used combines multiple choice questions with drawings. If students do not find a satisfactory answer, they can answer the question through drawing. Drawing will provide more in-depth information about students' reasoning ability and how to communicate their understanding
Identifying Misconceptions that Limit Student Understanding of Molecular Orbital Diagrams	Jenkins et al. (2019)	Combinatin of critical thinking and written inquiry activities.	In molecular orbital theory, the majority of students experience misconceptions in learning the stability of atomic oxygen. Most students are able to create molecular orbital diagrams but have difficulty interpreting the resulting diagrams
Identifying undergraduate students' misconceptions in understanding acid and base materials	Mubarak et al. (2020)	Three-tier	Some students do not understand acid-base theory, the concept of strong acid-weak acid, and the concept of acid dissociation
Developing a Three-Tier Diagnostic Instruments on Chemical Equilibrium (TT-DICE)	Jusniar et al. (2020a)	Three-tier	The development of TT-DICE diagnostic instrument is used to indentify students who have misconceptions and student who lack knowledge. The results of study indentified the occurrence of misconceptions in chemical equilibrium material on submaterial of dynamic equilibrium, heterogeneous equilibrium and factors that affect the of equilibrium
Investigations of Three-tier Diagnostic and Multiple Choice Tests on Chemistry Concepts with Response Change Behaviour (RBC)	Turkoguz (2020)	Three-tier	The percentage of the use of Response Change Behaviour (RBC) shows that each student has misconceptions on chemical concepts with various categories
Misconceptions in Rate of Reactions and their impact on Misconceptions in Chemical Equilibrium	Jusniar et al. (2020b)	Three-tier and interview	Misconceptions on reacton rate material cause misconceptons on chemical equilibrium material
Development of Structured Essay Diagnostic Test of Chemistry (SEDToC) to Investigate Senior High School Student's Misconception of Hydrolysis Material	Fitriza et al. (2020)	Essay Diagnostic Test of Chemistry (SEDToC)	The SEDToC instrument can reveal misconceptions on hydrolysis material withan average percentage of students who understand 64.00%, 16.00% misconceptions, and do not undersatand the material 23.00%
Using Guided Inquiry Learning with Multiple Representations to Reduce Misconceptions of Chemistry Teacher Candidates on Acid-Base Concept	Pikoli (2020)	Three-tier	The results show that Guided Inquiry Learning with Multiple Representations effective to reduce students' misconceptions on Acid-Base Concpet, that indicated by the reduction of students misconceptions at high category.
Identify Misconceptions on Reaction Rate Concept using Four-tier Multiple Choice (4TMC) Diagnostic Test Instument	Harahap et al. (2021)	Four-tier	Students experience misconceptions on reaction rate material with detail of the discussion of concentration (16.00%), temperature (19.00%), surface area (41.00%), dan catalys (24.00%)
Procedure for the Assessment of Cognitive Complexity:	Horvat et al. (2021)	Multiple choice and counted essay questions	The test results show that some students have not been able to distinguish the type of salt that underho hydrolysis and those

Article Title	Authors	Diagnostic Instrument	Research Results
Development and Implementation in the Topic "Hydrolysis of Salts"			that do not undergo hydrolysis. In addition, some students also experience misconceptions in applying the formula fot determining pH and pOH
Development of Structured Essay Diagnostic Test of Chemistry (SEDToC) on Acid-Base as an Instrument for Analysis of Student Learning Outcomes	Nurmaya et al. (2021)	Essay Diagnostic Test of Chemistry (SEDToC)	The SEDToC Instrument is proven to be able to indentify misconceptions and learning barriers in acid-base material
Effect of Concept Mapping Teaching Strategy on Students' Misconceptions about Chemical Bonding in River State	Etokeren et al. (2022)	Four-Tier & Interview	Most misconceptions occur in the covalent bonding subchapter. Concept mapping strategy was able to significantly improve misconceptions in chemical bonding. The pretest misconception percentage of of 89.50% dropped significantly to 11.20% in the posttest
The Effectiveness of Cognitive Conflict Based Chemistry Learning in Reducing Students' Misconceptions of Acid-Base Materials	Ningrum et al. (2022)	Multiple Choice Questions	The most misconceptions of acid material occur on the topic of determining pH. The application of cognitive conflict learning effectively reduces misconceptions from 53.95% to 15.49%
Identification of Misconceptions in Chemical Bonding Materials Using Three Tier Diagnostic Test	Sundari et al. (2021)	Three-tier	Misconcessions occurred in the chemical bonding material with a presentation of 72.53% of students experiencing misconceptions, 14.98% of students do not understand the concept, and the rest 12.48% of students understand the concept of chemical bonding.
Students' Conceptual Understanding in Chemistry Learning Using PhET Interactive Simulations	Rahmawati et al (2022)	Two-tier and interview	Some students still held misconceptions after using PhET Interactive Simulations. The analysis of interviews about chemical equilibrium showed that students had difficulty determining: (1) the effect of temperature on the equilibrium shift and the equilibrium constant and (2) the catalyst's effect on the forward and the reverse reaction rates.
Misconceptions on Basic Stoichiometry among the Selected Eleventh-Grade Students in the Urban Regions of The Gambia	Jammeh et al. (2023)	Survey questions	Students are able to understand the basic principles of stoichiometry, but need to develop their knowledge better to be able to solve stoichiometric problems
Addressing student misconceptions about atoms and examining instructor strategies for overcoming them	Kaya (2023)	Questionnaries and semi-structured interviews	A number of students have misconceptions about atomic concept and they are unable to understand it
Students' Misconceptions in Chemical Equilibria and Suggestions for Improved Instruction	Riddle et al. (2023)	Survey questions and Interview	Common misconceptions held by students on the chemical equilibrium, including the characteristics of a dynamic equilibrium, the reactants and products of a dynamic equilibrium, and the effect of conditions and catalyst on equilibrium
Development and Validation of a Four-Tier Diagnostic Instrument for Chemical Kinetics (FTDICK)	Habiddin et al. (2023)	Four-tier	The FTDICK instrument can reveal students' misconceptions about chemical kinetics material. Incorrect answers are thought to be due to lack of knowledge or misunderstanding
Identification of Students' Misconceptions and Understanding on Thermochemistry Material with Four-Tier Multiple-Choice Tests	Rosyidah et al. (2024)	Four-Tier Multiple-Choice	a profile of misconceptions about thermochemical material consisting of system and environment sub-concepts, types of systems, endothermic and

Article Title	Authors	Diagnostic Instrument	Research Results
			exothermic reactions, types of enthalpy, as well as changes in reaction enthalpy. About 15.00% of students understood the concept, 31% had misconceptions, and 54% did not understand
Analyzing Students' Misconceptions Based on Submicroscopic Level Representation in Elements, Compounds, and Mixtures	Arini et al. (2025)	Three-Tier and interview	Thera are 31.00% of students experience misconceptions in determining the concept of atoms, especially for like and unlike atoms in determining elements, compounds and mixtures, 29.00% in the difference in material changes when viewed from the shape of atoms owned, and 27.00% in changes in the constituent particles of elements, compounds and mixtures
Investigations misconceptions about acids and bases among pre-service science teachers	Shaafi et al. (2025)	Structured questionnaire	Three misconceptions exhibt the highst prevalence, namely the universal indicaor of strong alkali (71.70%), the calculation related concentratios of acids ad bases (69.30%), and procedural steps for preparing a solutions with a specified concentrations using the dilution method (65.80%)

Based on the analysis of the research results of relevant articles in Table 1, a representation of research on misconceptions in chemistry learning based on publication year is shown in Figure 2. Figure 2 illustrates the trend in the number of published articles on misconceptions in chemistry learning from 2019 to the present (September 2025). Based on Figure 2, from 2019 to 2025, the number of articles on misconceptions in chemistry learning tended to increase. The highest increase occurred in 2020. This is relevant because 2020 was the year of the Covid-19 pandemic, when students adapted to new learning habits such as online learning and distance learning (Puspitasari et al., 2021).

Figure 2. Research representation based on publication year

Definition of Misconception

Misconceptions is defined as a state of one's conceptual grasp in which there is an error or inconsistency between the concept and scientific understanding (Allen, 2019; Susilawati et al., 2022; Türkoguz, 2020; Üce et al., 2019). Misconceptions occur when the knowledge and ideas expressed by student are not well structured, resulting in incorrect understanding and inconsistent with the scientific concepts of experts (Soeharto et al., 2019). In chemistry learning, misconceptions occur when students are unable to understand abstract chemical concepts. The representation of chemical material consists of three level, namely macroscopic, submicroscopic, and symbolic. Research conducted by Alfitah et al. (2021) shows that macroscopic to submicroscopic representations are more eadily understood by students than symbolic to submicroscopic, macroscopic to symbolic, and submicroscopic to symbolic representations. Gkitzia et al. (2022) stated that students' inability to translate one form of representation to another is one of the causes of misconceptions in chemistry learning.

Diagnostic Instrument Used to Identify Misconceptions

Based on the analysis of the research results of relevant articles in Table 1, a representation of the diagnostic instruments used to identify misconceptions is shown in Figure 3.

Figure 3 shows that the diagnostic methods used to identify misconceptions in chemistry learning include multiple-choice questions, two-tier tests, three-tier tests, four-tier tests, five-tier tests, questionnaires, and interviews. The most frequently used instruments are three-tier tests and questionnaires, while the least frequently used are two-tier and five-tier tests. This is because three-tier tests are considered more valid than

two-tier tests in analyzing student misconceptions (Mubarak et al., 2020; Prodjosantoso et al., 2019). Multiple-choice diagnostic tests are considered easier, but essay-based diagnostic tests and questionnaires are considered capable of providing a more detailed and complex picture (Fitriza et al., 2020).

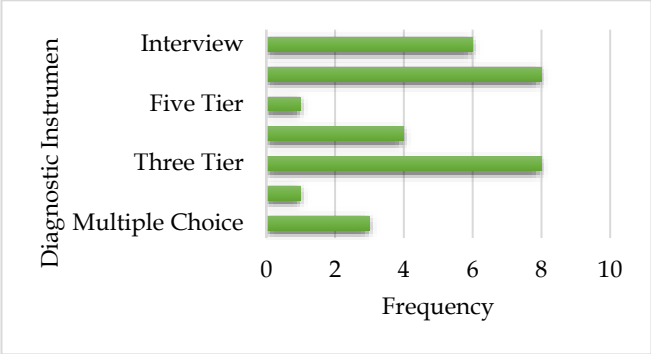

Figure 3. Representation of diagnostic instruments used to identify misconceptions

Multiple choice questions are the easiest instrument to use to diagnose student misconceptions (Anam et al., 2019; Liu et al., 2024). However, in-depth information about students' answers, conceptual understanding and thinking process cannot be obtained. The existence of limited answer choices in multiple choice questions also allows students to guess answers so that students cannot provide answers according to their own thinking patterns (Anam et al., 2019). The two-tier test consists of two tiers, the first tier is a multiple choice answer, and the second tier is the reason for the answer chosen in the second tier (Syaifuddin et al., 2022). However, the two-tier test instrument also allows students to choose answers randomly. The chosen answer is correct, but students cannot explain the reasons for the chosen answer, so the two-tier instrument cannot describe students' misconceptions in detail (Habiddin et al., 2021). The three-tier instrument adds one tier in the form of the level of confidence in the chosen answer (Jusniar et al., 2020b). When the answers and reasons given by students are wrong, but have a high level of confidence, it indicates misconceptions (Prodjosantoso et al., 2019; Mubarak &Yahdi, 2020; Jusniar et al., 2020).

Four tier diagnostic test and five tier diagnostic test are misconception diagnosis instruments developed to obtain a detailed picture of the misconceptions experienced by students. The four tiers diagnostic test consists of four tiers, namely the first tier in the form of multiple choice answers, the second tier in the form of the level of confidence in the answers in the first tier, the third tier in the form of reasons for choosing answers in the first tier, and the fourth tier in the form of the level of confidence in the reasons for choosing answers (Habiddin & Page, 2023; Setiawan & Fauziyah, 2020; Harahap & Novita, 2021; Eteroken & Abosede, 2022). The five tier diagnostic test consists of five tiers, including: the first tier is a conceptual multiple choice with five answer choices, the second tier is the level of confidence in the answers to the first tier, the third tier is a reason for the answer choice consisting of four reason choices, and one open reason , the fourth tier is the level of confidence in the reason, and the fifth tier is a representation that shows the causal relationship between the answer and reason chosen (Setiawan & Faoziyah, 2020). The five tiers diagnostic test instrument is considered as the development of an instrument that is able to describe student misconceptions in detail. This is because with the representation of the causal relationship to the answer and reason, it can be known that students' understanding is deep (Anam et al., 2019).

The use of two-tier diagnostic instruments is more practical for students to use on a large scale, facilitates assessment, and provides an explanatioan of students' reasoning (Suparwati, 2022). However, the results of the two-tier test do not adequately describe the misunderstanding of the learners' lack of knowledge (Anam et al., 2019). Three-tier test are considered more valid than two-tier tests in analyzing students' misconceptions (Mubarak & Yahdi, 2020; Prodjosantoso et.al, 2019). In its development, the misconceptions diagnostic instrument continues to experience development, namely the four-tier tess. However, the four-tier instrument is still considered unable to represent well the three levels of chemistry, so it was developed into a five-tier instrument which is considered to provide a clearer representation in identifying misconceptions experienced by students (Anam et al., 2019). Multiple choice based diagnostic tests are considered easier but eassy shaped diagnostic test are considered capable of providing a more detailed and complex picture (Fitriza et al., 2020; Nurmaya & Fitriza, 2021).

Misconception diagnostic instruments are constantly undergoing development to obtain more valid and detailed instruments. Several studies have developed misconceptions diagnostic instruments, including Three Tier Diagnostic on Chemical Equilibrium (TT-DICE), Four-Tier Diagnostic Instrument for Chemical Kinetikcs (FTDICK), Four Tier Multiple Choice (4TMC) diagnostic Test Intrument, and Structured Easy Diagnostic Test of Chemistry (SEDToC). The development of misconceptions diagnostic instruments are also combined with various research methods, one of which is the Certainty of Response Index (CRI) method which is a method to measure the level of trust or certainty of respondents in answering each question (Yunitasari et al., 2019; Qodriyah et al., 2020; Prihastyani et al., 2020).

Miscoceptions Finding and Their Causes

Based on the data analysis of relevant articles in Table 1**,** it is known that research on misconceptions in chemistry learning mostly occurred in the concept of acid-base and salt hydrolysis, reaction rate and chemical equilibrium, thermochemistry, and chemical bonding.

Based on research by Mubarak et al. (2020), it shows that the highest misconception experienced by students in acid-base material are located in the sub-chapter of the concept of acid-base strength with a percentage of 47.50%. Yunitasari et al. (2019) in their research using multiple representation-based diagnostic instrument with modified CRI techniques and interviews, stated that misconceptions in acid-base material occur because students tend to memorize and simplify concepts and do not pay attention to submicroscopic representations in the questions. Yolviansyah et al. (2022) stated that the occurrence of misconceptions in acid-base material will also cause misconceptions in the material of acid-base titration, salt hydrolysis and buffer solutions. Horvat et al. (2021) identified misconceptions about hydrolysis material and found that most of the misconceptions occurred in the pH concept. This proves that misconceptions that occur in acid-base material also cause misconceptions in salt hydrolysis material.

In research conducted by Jusniar et al. (2020) using a three-tier diagnostic instrument and interviews, it was discovered that the misconceptions experienced by students include: students assume that the reaction rate is defined as an increase in the number of reactants and a decrease in the number of products, the reaction rate is directly proportional to the index of a species in the chemical reaction equation, the catalyst accelerates the reaction rate by increasing the activation energy, and increasing temperature will increase the activation energy. Juniar et al. (2020) also stated that misconceptions that occur in reaction rate materials, if not immediately corrected, will have an impact on the occurrence of misconceptions in the chemical equilibrium, namely on the concepts of equilibrium state, dynamic equilibrium, heterogeneous equilibrium, and factors that affect equilibrium shifts. Reaction rate is a pre-requisite material that students must master before learning chemical equilibrium material. Habiddin et al. (2023) based on a four-tier diagnosis instrument which is accompanied by remaining confidence in the selected answer, the wrong answer is the answer with the lowest level of confidence, presumably due to lack of knowledge or misconceptions of the material.

Based on research by Sihaloho et al. (2021), it shows that in thermochemical material, the most misconceptions occur in the subchapter of exotherm and endotherm reactions. Students are only able to explain the meaning of exotherm and endotherm reactions textually, but are unable to provide examples and classify exotherm and endotherm reaction events in everyday life. Habidin et al. (2020) using a four-tier instrument also shows that there were misconceptions regarding thermochemical material in the system and environmental concepts sub-chapter. As many as 78.69% of students were able to understand open, closed and isolated systems, and only 57.38% of students were able to explain the concept of energy and matter exchange.

The research results of Prodjosantoso et al. (2019) show that misconceptions occur in the material of chemical bonding. Most misconceptions occur in the subchapters of ionic bonds and coordinating covalent bonds. Students who experience misconceptions in ionic bonds, assume that ionic bonds occur only because of the bond between metal elements and non-metal elements, while coordinating covalent bonds occur by transferring electrons (Warsito et al., 2021).

Comparison of misconceptions in chemistry learning across countries

The research data were also analyzed to determine the comparison of student misconceptions in chemistry learning across countries. This comparison includes findings of misconceptions regarding the chemical materials and diagnostic instruments used as presented in Table 2.

Table 2. Comparison of Misconceptions in Chemistry Learning Across Countries

Country	Researchers	Diagnostic Instrument	Misconception Findings in Chemistry Learning
Indonesia	Prodjosantoso et al. (2019), Anam et al. (2019), Fitriza et.al, (2020), Mubarak et al. (2020), Harahap et al. (2021), Ningrum et al. (2022), Rosydah et al. (2024), Arini et al. (2025)	Two-tier, three-tier, four-tier, five-tier tests and interview	Misconceptions in chemistry learning in Indonesia mostly occur in the material of reaction rates, chemical equilibrium, acid-base concepts, salt hydrolysis, thermochemistry and chemical bonding
Nigeria	Eteroken et al. (2022)	Four-tier and interview	Chemical Bonding
Amerika Serikat	Jenkins et al. (2019)	Written Inquiry	Orbital Diagram
Turki	Turkoguz (2020)	Three-tier	Thermochemistry, chemical kinetics, chemical equilibrium, acids and bases, and electrochemistry

Country	Researchers	Diagnostic Instrument	Misconception Findings in Chemistry Learning
	Kaya (2023)	Questionnaries and semi-structured interviews	Concept of stomd
Serbia	Horvat et al. (2021)	Multiple Choice and Essay	Salt Hydrolysis
Gambia, Afrika Barat	Jammeh et al. (2023)	Survey Questions	Stoichiometry
United Kingdom	Riddle et al. (2023)	Survey Questions and Interview	Chemical Equilibrium
Malaysia	Shaafi et al. (2025)	Structured questionnaire	Acids and bases

Based on the data in Table 2, it can be seen that the misconception diagnosis instruments used to identify misconceptions in chemistry learning do not show any significant differences. The majority of instruments used were the multitier type. The multiple-tier tests start from two-tier tests, three-tier tests, four-tier tests, and five-tier tests. The multiple-tier test is considered effective in determining the profile of misconceptions about chemistry across countries.

Misconceptions can be reduced or remidated by using vertain constructivist learning methods, startegies or models. One of the is remedial learning. Research conducted by Islamiyah et al. (2022) shows that three are six remedial learning strategies that can be used to reduce misconceptions in chemistry learning, including; POE, Guided Inquiry, MRCD, EMBER, Conceptual Learning, and ECIRR. Research conducted by (Makhrus et al. (2022) shows that learning using conceptual change model with a cognitive conflict approach (CCM-CCA) is eddective in reducing student misconceptions. The interview results showed that learning with CCM-CCA helped students change their conceptions from initially having misconceptions to understanding the concept. Research conducted by Suwasono et al. (2023) using Problem Based Learning (PBL) with contextual prblems shows that the reduction of student misconceptions before and after PBL learning with contextual problmes is 69.28%.

Conclusion

Based on the results of the literature review above, it can be concluded that the trends of research on student misconceptions in chemistry learning in the 2019-2025 period are still occurring. Misconceptions in chemistry learning occur in almost all chemical materials, but the most studied are the concepts of acids-bases and salt hydrolysis, reaction rates and chemical equilibrium, thermochemistry and chemical bonding. The diagnostic instruments used include two-tier tests, three-tier tests, four-tier tests, five-tier tests, questionnaires, multiple choice questions, and interviews. Development of diagnostic instrument was carried out to obtain valid and detailed instruments, such as TT-DICE, FTDICK, 4TMC Diagnostic Test Instrument, and SEDToC. The causes of misconceptions are due to internal and external factors. Internal factors include the discrepancy between students' preconceptions and experts' concepts of knowledge, while external factors include learning methods and teaching materials used by teachers. Misconceptions can be reduced or remediated by using certain methods, strategies or constructivist learning models, such as remedial learning, POE, Guided Inquiry, MRCD, Ember, Conceptual Learning, and ECIRR. The results of cross-country comparison studies showed no significant differences between the instruments used and the misconceptions found across countries. This research is limited to trend research regarding analysis of the causes of misconceptions in chemistry learning and diagnostic instruments used in the range 2019-2025, so that further research on misconceptions is a worthy study to continue to be researched and developed, developing more valid and detailed misconception diagnostic instruments, as well as developing methods, strategies and learning models to reduce and remediate misconceptions that occur.

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Conflicts of Interest
The authors declare no conflict of interest.

Author Contributions
Conceptualization, methodology, result and discussion, conclusion, and writing-original draft preparation, H.A.; resources, the data analysis, and writing-review and editing, A.F; the data analysis and proffreading, M.A.M.

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